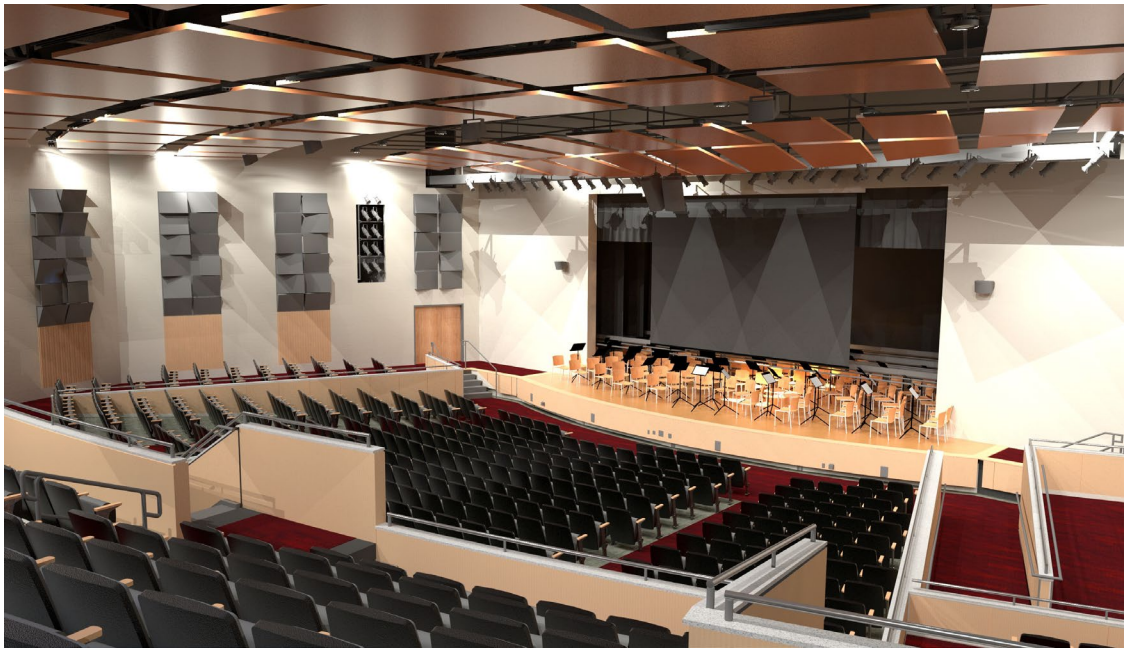

South High Community School

170 Apricot Street, Worcester, MA 01603

Final Bid Package

Volume IV of IV – Div. 21 – 33

January 31, 2019

MSBA
Massachusetts School Building Authority
40 Broad Street, Suite 500, Boston, MA 02111

OWNER
City of Worcester, MA
City Hall, 455 Main Street, Worcester, MA 01608

OPM
Heery International
80 Blanchard Road, Suite 108, Burlington, MA 01803

DESIGNER
Lamoureux Pagano & Associates, Inc.
108 Grove Street, Suite 300, Worcester, MA 01605

Prepared by:

LAMOUREUX · PAGANO
ARCHITECTS PROJECT MANAGERS

TABLE OF CONTENTS

VOLUME 1 *(DIVISIONS 00 THROUGH 01)*

VOLUME 2 ***(APPENDICES)***

APPENDICES

End - Table of Contents

DO NOT REMOVE
THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 21 00 01 - FIRE PROTECTION (TRADE CONTRACT REQUIRED)

PART 1 GENERAL

PART 2 PRODUCTS

PART 3 EXECUTION

PART 1 GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.02 TIME, MANNER AND REQUIREMENTS FOR SUBMITTING SUB-BIDS:

A. Sub-bids for work under this Section shall be for the complete work and shall be filed in a sealed envelope with the City of Worcester, Department of Public Works and Parks, Architectural Division, 50 Skyline Drive, Worcester, MA 01605 at time and place stipulated in the "Invitation to Bid/Notice to Contractors". The following shall appear on the upper left hand of the envelope:

1. Name of Sub-Bidder: _____
2. Project: SOUTH HIGH COMMUNITY SCHOOL
3. Sub-Bid for Section: 21 00 01 – FIRE PROTECTION

B. Each sub-bid submitted for work under this Section shall be on forms furnished by the City of Worcester as required by Section 44F of Chapter 149 of the General Laws, as amended. Sub-Bid forms may be obtained at the Department of Public Works and Parks, Architectural Division, 50 Skyline Drive, Worcester, MA 01605 in person, or by written request.

C. Sub-bids filed with the City of Worcester shall be accompanied by a BID BOND or CASH or CERTIFIED CHECK or a TREASURER'S or CASHIER'S CHECK issued by a responsible bank or trust company payable to the City of Worcester in the amount of five (5) percent of the bid. A sub-bid accompanied by any other form of bid deposit than those specified will be rejected.

D. Additional Requirements:

1. Sub-bidder's attention is directed to Massachusetts G.L. Chapter 149 §44H, as amended, which provides in part as follows:

2. Each sub-bidder shall list in Paragraph E of the "Form for Sub-bids" the name and bid price of each person, firm or corporation performing each class of work or part thereof for which the Section of the Specifications for that sub-subtrade requires such listing, provided that, in the absence of a contrary provision in the Specifications, any sub-bidder may, without listing any bid price, list his own name or part thereof and perform that work with persons on his own payroll, if such sub-bidders, after sub-bid openings, shows to the satisfaction of the Awarding Authority that he does customarily perform such class of work with persons on his own payroll and is qualified to do so. This Section of the Specifications requires that the following classes of work shall be listed in Paragraph E under the conditions indicated herein.

a. None

E. Trade Contract Required

1. The Work of this Trade Contract is shown on the following Drawings.

FP 1.1 , FP 1.2, FP 1.3, FP 1.4, FP 4.1, FP 4.2, FP 4.3, FP 4.4,, FP 4.5, FP4.6, FP4.7, FP4.8, FP4.9, FP4.10, FP4.11, FP4.12, FP7.1

2. Related items which may require coordination or impact work of this trade are shown on the following Drawings:

a. Existing Site : EX1.0, EX2.0, EX2.1, EX2.2, EX2.3, EX2.4, C1.0

b. Civil: C2.0, C3.0, C3.1, C3.2, C3.3, C3.4, C4.0, C4.1, C4.2, C4.3, C4.4, C5.0, C5.1, C5.2, C5.3, C5.4, C6.0, C6.1, C6.2, C6.3, C7.0, C7.1, C7.2, C7.3, C7.4, C8.0, C8.1, C8.2, C8.3, C8.4, C9.0, C9.1, C9.2, C9.3¸C9.4, C10.0, C10.1, C10.2, C10.3, C10.4, C10.5, C10.6, C10.7, C11.0, C11.1, C11.2, C11.3, C11.4, C11.5, C11.6, C11.7

c. Civil Athletic: CA1.1, CA2.1, CA2.2, CA3.1, CA3.2, CA3.3, CA4.1, CA4.2, CA4.3, CA4.4, CA4.5, CA4.6, CA4.7, CA4.8

d. Landscape: L1.0, L2.0, L2.1, L2.2, L2.3, L2.4, L2.5, L2.6, L2.7, L2.8, L2.9, L3.0, L3.1, L3.2, L3.3, L3.4, L3.5, L4.0, L4.1, L4.2, L4.3, L5.0, L5.1, L5.2, L5.3, L5.4, L5.5, L5.6

e. Structural: S1.1, S1.2, S1.3, S3.1, S3.2, S3.3, S3.4, S3.5, S3.6, S3.7, S3.8, S3.9, S3.10, S3.11, S3.12, S3.13 S3.14, S3.15, S3.16, S4.11, S4.12 ,S4.13, S4.14, S4.15, S4.16, S4.17, S4.18, S4.19, S4.20, S4.21, S4.22, S4.23, S4.24, S5.1, S5.2, S5.3, S5.4, S5.5, S5.6, S6.1, S7.1, S7.2, S7.3, S7.4, S7.5

f. Architectural Demolition AD1.0

g. Architectural: A1.1, A2.1, A2.2, A2.3, A2.4, A2.5, A3.0, A3.0A, A3.1, A3.2, A3.3, A3.4, A3.5, A3.6, A3.7, A3.8, A3.9, A3.10, A3.11, A3.12, A3.13, A3.14, A3.15, A3.16, A3.17, A3.18, A4.1, A4.2, A4.3, A4.4, A4.5 ,A4.6 ,A4.7 ,A4.8 ,A4.9, A4.10, A4.11, A4.12, A5.0, A5.1, A5.2, A5.3, A5.4, A5.5, A5.6, A5.7, A5.8, A5.11, A5.12 ,A6.1, A6.2, A6.3, A6.4 ,A6.5, A6.6, A6.7, A6.8, A6.11, A6.12, A6.13, A6.14, A6.15, A6.16, A6.17, A6.18, A6.21, A6.22, A6.23, A6.24, A6.25, A6.26, A6.27, A6.28, A6.29, A6.31, A6.32, A6.33, A6.34, A6.35, A7.1, A7.2, A7.3, A7.4, A7.5 ,A7.6, A7.7, A8.1, A8.2, A8.3 ,A8.4 ,A8.5 ,A8.6 ,A8.7, A8.8, A8.9, A8.10, A8.11, A8.12, A8.13, A8.14, A8.15, A8.16, A8.17, A8.18, A8.19, A8.20, A8.21, A8.22, A8.23, A8.24, A8.25, A8.26, A8.27, A8.28, A8.29, A9.1, A9.2, A9.3, A9.4, A9.5, A9.6, A10.1,A10.2, A10.3, A10.4, A11.1, A11.2, A11.3, A12.1, A12.2, A12.3, A12.4, A12.5, A12.6, A12.7, A12.8, A12.9, A12.10, A12.11, A12.12

h. Foodservice: K1.1, K1.2, K1.3, K2.1, K2.2, K2.3, K2.4, K3.1, K3.2, K3.3, K3.4, K3.5, K3.6, K3.7, K4.1, K4.2, K4.3, K4.4, K4.5, K4.6, K5.1, K5.2, K6.1, K6.2, K6.3, K6.4, K6.5

i. Plumbing: P2.1, P2.2, P2.3, P2.4, P3.1, P3.2, P3.3, P3.4, P3.5, P3.6, P3.7, P3.8, P3.9 ,P3.10, P3.11, P3.12, P3.13, P3.14, P3.15, P3.16, P4.1, P4.2, P4.3, P4.4, P4.5, P4.6, P4.7, P4.8, P4.9, P4.10

j. HVAC: H3.1, H3.2, H3.3, H3.4, H3.5, H3.6, H3.7, H3.8, H3.9, H3.10, H3.11, H3.12, H3.13, H3.14, H3.15, H3.16, H4.1, H4.2, H4.3, H4.4, H4.5, H4.6, H4.7, H4.8, H4.9, H4.10, H4.11, H4.12, H5.1, H5.2, H5.3, H6.1, H6.2, H6.3, H7.1, H7.2, H7.3,

k. Audio Visual: AV0.0, AV0.1, AV0.2, AV3.3, AV3.4, AV3.5, AV3.7, AV3.8, AV3.9, AV3.10, AV3.18, AV4.5, AV4.6, AV4.7, AV4.8, AV4.9, AV5.0, AV5.1, AV5.2, AV5.3, AV5.4, AV5.5, AV5.6, AV5.7, AV6.1, AV6.2, AV6.3, AV7.1, AV7.2, TL1, TL2, TL3, TL4, TR1, TR2, TR3, TR4

l. Electrical: E0.1, E0.2, E0.3A, E0.3B, E0.3C, E0.3D, E0.4A, E0.4B, E0.4C, E0.4D, E0.4E, E0.4F, E0.5, E0.6, E0.7, E0.8, E0.9, E1.1, E1.2, E1.3, E1.4, E1.5, E1.6, E1.7, E1.8, E1.9, E1.10, E1.11, E1.12, E1.13, E1.14, E2.1, E2.2, E2.2A, E2.3, E2.4, E2.4A, E2.4B, E2.5, E2.6, E2.7, E2.8, E2.9, E2.10, E2.11, E2.12, E3.1, E3.2, E3.3, E3.4, E3.5, E3.6, E3.7, E3.8, E3.9, E3.10, E3.11, E3.12, E3.13, E3.14, E3.15, E3.16, E3.17, E3.18, E4.1, E4.2, E4.3, E4.4, E4.5, E4.6, E4.7, E4.8, E4.9, E4.10, E4.11, E4.12, E5.1, E5.2, E5.3, E5.4, E5.5, E5.6, E5.7, E5.8, E5.9, E5.10, E5.11, E5.12, E5.13, E5.14, E5.15, E5.16, E6.1, E6.2, E6.3, E6.4, E6.5, E6.6A, E6.6B, E6.7A, E6.7B, E6.7C, E7.0, E7.1, E7.2, E7.3, E7.4, E7.5, E7.6, E7.7, E8.0A, E8.0B, E8.0C, E8.0D, E8.0E, E8.0F, E8.0G, E8.1A, E8.1B, E8.2A, E8.2B, E8.2C, E8.2D, E8.3A, E8.3B, E8.3C, E8.3D, E8.4A, E8.4B, E8.4C, E8.5A, E8.5B, 8.5C, E8.5D, E8.6A, E8.6B, E8.7, E8.8A, E8.8B, E8.8C, E9.01, E9.02, E9.03, E9.04, E9.05, E9.06, E9.07, E9.08, E9.09, E9.10, E9.11, E9.12, E9.13, E9.14, E9.15

3. The complete List of Drawings for the Project is provided in Section 00 01 15 – List of Drawings.

1.03 DESCRIPTION OF WORK

A. Commissioning: The FP system will be commissioned by an independent commissioning agent (CxA). The Fire Protection Trade-contractor shall review all commissioning requirements outlined in Sections 01 91 13 (General Commissioning Requirements), and shall provide all commissioning task labor and documentation, attend all required meetings, and provide all on-site assistance required by the CxA to properly complete their work.

1.

B. Alternates: Special attention is called to the fact that it shall be the responsibility of all the General and Trade-contractors to thoroughly examine all the alternates and evaluate for themselves as to whether or not these alternates in any way affect their respective section. In the event that a Contractor feels that any alternate(s) do reflect a cost difference, additional or a deduction in his bid proposal, then he shall so stipulate this sum and/or sums under the proper alternate(s) as provided for the bid proposals. Failure to do so will in no way relieve the hereinbefore stated contractors of their responsibilities regardless of what alternate(s) are selected at no extra cost will be charged to the Owner. Refer to Section 01 23 00, ALTERNATES for the list and description of Alternates.

C. Work Included: Provide labor, materials and equipment necessary to complete the work of this Section, including but not limited to the following:

1. New flow test using instruments calibrated within 6 months of the test date. Flow test shall occur between 9 am and 5 pm of a week-day (M-F), and shall be witnessed by the design Engineer-of-Record or local Fire Department. During certain times of year, the Apricot St main serves the Cherry Valley portion of Leicester as well as the Apricot St / Worcester area. Coordinate flow test time with the Worcester Water Department, so that it occurs simultaneously with Cherry Valley pumps operating at

full capacity.

2. Preparation of complete "Fire Protection Shop Drawings" and hydraulic calculations, stamped by a Mass. Professional Registered Engineer. No Fire Pumps will be permitted to be used in the shop drawings without written permission from the Owner's Project Manager.

    a. Shop drawings shall show the same portions of the building on each sheet as the bid set drawings, and each sheet shall include a blocked-out key-plan – showing what portion of the building is shown on that sheet.

    b. Shop drawings shall include the following design criteria.

        i) Name of Owner
        ii) Address of location
        iii) Point of compass
        iv) Full-height section for clarity
        v) Location of partitions
        vi) Location of fire walls
        vii) Occupancy / hazard of each room / space
        viii) Location of concealed spaces, closets, attics, and bathrooms
        ix) Locations where sprinklers are omitted.
        x) Size of city main in street, and whether dead-end or circulating. If dead end, direction and distance to nearest circulating main.
        xi) City main flow test results, and elevation of sprinkler system relative to test hydrant.
        xii) Make, type, model and K-factor of all sprinklers, including SIN numbers Temperature rating, and location of high temperature sprinklers.
        xiii) Total area protected by each system on each floor
        xiv) Number of sprinklers on each riser per floor
        xv) Pipe type and wall-thickness schedule
        xvi) Nominal pipe size and lengths (or center to center distances)
        xvii) Location and size of riser nipples
        xviii) Types of fittings and joints, and the location of all welds.
        xix) Type and location of hangers, sleeves, and braces
        xx) All control valves, check valves, drains, and test connections
        xxi) Make, model and size of alarm
        xxii) Kind and location of alarm bells
        xxiii) Flushing provisions
        xxiv) Hydraulic calculation data
        xxv) A graphic representation of the drawing scale.
        xxvi) Name and address of contractor
        xxvii) Hydraulic reference points shown on the drawings, corresponding to reference points used in the calculations
        xxviii) The minimum rate of water application, design area of water applications, and hose streams (inside and outside)
        xxix) The total water flow and pressure required at the flow-test gauge hydrant for each system.
        xxx) Relative elevation of sprinklers, junctions, and reference points.
        xxxi) If room design method is used, all unprotected wall openings throughout the floor.
        xxxii) Sizing calculations and details of sway bracing.

xxxiii) Manufacturer, size, and type of backflow preventor.
xxxiv) Size and location of hydrants, including size and number of hydrant outlets, outlet valves, hose houses, and static and residual hydrants used in the flow test.
xxxv) Size, location, and piping arrangement of FDCs
xxxvi) Ceiling / roof heights and slopes not shown in the full-height section.
xxxvii) Edition year of NFPA 13 to which the system was designed.

3. Complete and operating wet system per NFPA 13, the 9th Edition State Building Code, and local ordinances.

4. Supervise the installation and pressure testing of all underground piping and valves dedicated to Fire Protection service. Provide a completed, NFPA Materials and Test certificate for the underground FP-only piping.

5. The Fire Protection Trade-contractor's installation scope responsibility shall start underground, 10 ft outside the FP-service room, at the termination of the site-contractor's new 8" FP water entrance..

6. Provide standpipe hose stations on each floor as the building is erected.

7. New 8" backflow preventor. Backflow to include full-port, line-size, indicating control valves on either side and a valved pressure gauge on the city side.

8. 4 New combination sprinkler / standpipe risers, and 3 new standpipe-only risers.

9. New floor-control stations, each with check valve, pressure-relief valve, control valve. supervised tamper switch, supervised flow switch, and valved pressure gages located on each floor for all sprinkler / standpipe risers serving more than 1 floor.

10. Approved Seismic separation assembly and fire-stopping wherever FP piping crosses a building seismic separation joint / fire wall.

11. Main drain piping (size per NFPA) and auxiliary drains per NFPA 13 for complete draining of all new piping. Pipe main drains to the exterior of the building as shown. Alternate drain terminations proposed by the contractor must be explicitly approved by the Architect and the Engineer of record. Auxiliary drains shall be clearly labeled in the field, and noted clearly on the as-built drawings – see record drawing requirements.

12. Sprinkler heads per the sprinkler legend. Include sprinkler guards where specified.

13. Piping mains, cross mains, and branches, fittings and valves, flexible connectors, and expansion fittings. Include swing arms to center sprinklers in tiled ceilings.

14. New inspector's test-tees – one for each floor valve station - (not shown this set).

15. 2 New Fire Dept. Connections approved by the Worcester Fire Dept., for the new FP service. Pipe FDC ball drips to the exterior of the building. terminating with a 45 down FDCs shall include all inter-connecting piping required to serve all risers, plus 2 stage hose stations.

    a. Provide a supervised control valve and flow switch on the line to the stage

hose stations

16. New electric bell, mounted above the FDC (per the architectural elevations). Shall activate upon any fire alarm or sprinkler water-flow.

17. New identification signs at all new and existing control valves, Fire Dept connection, standpipe connection, test & drains, and sprinkler valve room.

    a. Valve signs shall indicate their function and normal position.

    b. All signs shall meet the 9th Edition State Building Code requirements), as well as NFPA 13, 2013 requirements.

18. Hangers and supports, sleeves, and escutcheons, including miscellaneous steel supports.. NOTE: all structural steel (except roof framing over 20' AFF) will be coated with cementitious fire-proofing or alternate. All FP beam and bar-joist clamps must be installed prior to fireproofing. Hanger spacing per the drawing schedule and NFPA 13.

19. Access panels for any devices or equipment installed in other-wise inaccessible locations (none required for bid-set layout)

20. Seismic Restraint on all mains, cross mains, and all branches 2-1/2" and over, installed per the drawing details and NFPA 13, (Lateral bracing may be omitted where hanger rods are less than 6" from top of pipe to building attachment).

21. Drilling for installation of hanger and sway-bracing inserts.

22. Core drilling, cutting, and patching for the Work of this Section per section 01 73 00.

23. 6 spare sprinklers of each type, along with sprinkler wrenches in 1 or more labeled spare sprinkler cabinet(s) located in the water room.

    a. Provide also – 5, additional sprinklers, 5, 1"x6' arm-overs, and 5, 1" hangers not shown on the floor or ceiling plans.

24. All tamper and alarm switches to be monitored by the Fire Alarm Control Panel provided by Division 26 00 00.

25. Shop drawings and submittals, coordination and record drawings. See Division 1 for coordination drawing requirements.

26. Hoisting Equipment: This trade contractor shall furnish, install and maintain in safe and adequate condition all mechanical hoisting equipment, rigging equipment, crane services, lift machinery, and operating personnel that are necessary for the proper execution of the Work of this Section, as referenced under Section 015000 - Temporary Facilities and Controls.

27. Staging, Planking and Scaffolding: This trade contractor shall obtain required permits for, and furnish, install, maintain in safe and adequate condition, and dismantle when no longer required, all staging, planking, scaffolding, portable ladders and mobile platforms, and tarpaulins for covering same that are necessary for the proper

execution of the Work in this Section.

i) Temporary enclosures and heat are specified in Section 01 50 00.

28. Fire-stopping of all rated wall, floor, and ceiling penetrations used by the Fire Protection Trade-contractor for any work completed under this Section. See section 07 84 00 for required methods and procedures. Sealing with non-combustible material, both sides of all FP pipe penetrations into:

    a. Classrooms, offices, media center, cafeteria, gymnasium, and music rooms (for sound control), or
    b. thru exterior walls (for water and air seal).

29. System flushing, and 2 hour hydrostatic and 24 hour air pressure tests on all new piping, per NFPA 13. Tests shall be witnessed by the Engineer or Worcester Fire Dept. Repair all defects.

30. System and equipment start-ups, and completed NFPA 13 test and acceptance reports . Repair all defects.

31. Assist Fire Alarm trade contractor in the testing of all FP flow switches, pressure switches, flow alarms and tamper switches. Submit signed off test report – see list of (47) devices requiring testing under section 3.17.

    a. Successful F/A testing of all FP trouble and alarm devices is a pre-requisite to FP substantial completion.
    b. Successful F/A testing of all FP trouble and alarm devices shall be repeated 1 year after substantial completion, and is a pre-requisite to ending the warranty period.

32. Pull all permits, pay all fees and obtain required inspections. Worcester building department permit application fees have waived by the City.

33. Refer to Division 1, particularly Sections 01 77 00 and 01 78 00 for Close-out document requirements. FP Close-out documentsshall include at minimum::

    a. As-built drawings and approved, record calculations.
    b. Operation and Maintenance Manuals
    c. Instructions to Owners personnel.
    d. Color coded, laminated, 8x11 floor plans at each floor valve station, showing the areas served by that control valve
    e. completed NFPA 13 test and acceptance reports for all above-ground FP systems, and underground, FP-only piping.
    f. Completed NFPA 13 General Information Sign

34. 1 year written warranty – starting as substantial completion.

35. Site Visit:

    a. Bidders are expected to examine and to be thoroughly familiar with all contract documents and with the conditions under which work will be carried out. The Awarding Authority (Owner) will not be responsible for errors, omissions and/or charges for extra work arising from General Contractor or

Filed Trade contractor's failure to familiarize themselves with the Contract Documents or existing conditions.

b. By submitting a bid, the Bidder agrees and warrants that he has had the opportunity to examine the site and the Contract Documents, that he is familiar with the conditions and requirements of both and where they require, in any part of the work a given result to be produced, that the Contract Documents are adequate and that he will produce the required results.

D. Alternates: Not Applicable.

E. Items to be Installed Only: Not Applicable.

F. Items to Be Furnished Only: Furnish the following items for installation by the designated Sections:

1. Section 03 30 00 – CAST-IN-PLACE CONCRETE:
   a. Sleeves, anchors, inserts, plates and similar items for fire protection systems.

2. Section 04 20 00 – UNIT MASONRY:
   a. Access doors in masonry openings.
   b. Schedule 40, galvanized-steel Sleeves at fire-wall.

3. Section 09 29 00 - GYPSUM BOARD:
   a. Access doors in gypsum board assemblies.

4. Section 09 51 00 – ACOUSTICAL CEILINGS:
   a. Access doors in acoustical panel ceilings.

G. Related Work: Refer to the following sections for required coordination.

1. Section 01 60 00 – PRODUCT REQUIREMENTS: Owner's proprietary products and requirements for the same (Window Sprinklers).

2. Section 00 73 00 – EXECUTION for cutting of holes OVER 4" diameter or square and patching

3. Section 09 29 00 – GYPSUM BOARD for coordination with gypsum ceilings.

4. Section 09 51 00 ACOUSTICAL CEILINGS for coordination with acoustical ceilings.

5. Section 23 00 00 HEATING, VENTILATING AND AIR CONDITIONING for coordination with HVAC piping and ductwork.

6. All Sections of Division 26 00 00 - ELECTRICAL WORK for fire alarm devices.

7. Section 31 23 33 EARTH MOVING for excavation and backfilling, including compacted sand backfill to 12 inches above crown of pipe.

1.04 QUALITY ASSURANCE

A. References to manufacturers and to catalog designations, are intended to establish

standards of quality for materials and performance but imply no further limitation of competitive bidding.

B. If Drawings or Specifications do not coincide with manufacturers' recommendations, alert Designer in writing before installation and request clarification.

C. All MEP work shall comply with all applicable Federal, State, and Local codes and standards and other authorities that have legal jurisdiction over the site.

1. If provisions of the Contract Documents conflict with any code, rule, or regulation, the latter shall govern.

2. Where the Contract requirements are in excess of applicable codes, rules or regulations, the Contract provisions shall govern.

D. Standards and References to be followed include:

1. 780 CMR Massachusetts State Building Code – 9th Edition,
2. International Code Council (ICC) International Mechanical Code (IMC) - 2015
3. National Fire Protection Association (NFPA) 13 (2013), 14 (2013), 25 (2011), 241.
4. 527 CMR 1 Massachusetts Comprehensive Fire Safety Code
5. Occupational Safety and Health Act (OSHA).
6. Factory Mutual Association (FM).
7. NFPA 70 (National Electric Code - NEC).(2014)
8. National Electrical Manufacturers Association (NEMA).
9. Environmental Protection Agency (EPA).
10. Commonwealth of Massachusetts Department of Environmental Protection (DEP).
11. Local Ordinances, Regulations of Town of Worcester
12. American National Standards Institute (ANSI).
13. American Society of Mechanical Engineers (ASME).
14. American Society for Testing and Materials (ASTM).
15. Underwriters' Laboratories, Inc. (UL).
16. American Insurance Association (A.I.A.) (formerly National Board of Fire Underwriters).

E. Modification of references: In each of the above listed codes, the Fire Protection Trade-Contractor shall consider the advisory provisions to be mandatory, i.e. substitute the word "shall" for "should" wherever it appears.

F. Installer Qualifications: Installations, repair, and servicing of equipment, piping, or accessories shall be performed only by qualified installers. The term "Qualified" means:

1. Journey-man's license in the trade
2. has worked on a minimum of 1 previous projects similar in size and scope to this project;
3. reads and follows the manufacturer's installation instructions;
4. is familiar with all safety precautions required; and
5. complies with all code and local Authority requirements.

Upon request, submit evidence of such qualifications to the Engineer.

G. The Fire Protection Trade-Contractor shall obtain all permits and arrange for all required inspections. Additional inspections required due to work not meeting the AHJ's

requirements shall be paid for by the Fire Protection Trade-Contractor. The Fire Protection Trade-Contractor shall comply with all Local Code Enforcement Officials' instructions ..

1.05 MATERIAL AND SUBSTITUTIONS

A. The design is based on the equipment listed in the drawing schedules and specifications. Equipment from other manufacturers can be substituted provided

1. it is equal or superior in performance and construction, "Construction" includes but is not limited to: type, quality, and thickness of materials; type and quality of paint finish; type and quality of electrical connections, controls and motors; and electrical or combustion efficiency.

2. the proposed- equipment submittals are approved by the engineer.

B. If the Fire Protection Trade-Contractor chooses to provide substitute equipment, he shall provide shop drawings, stamped by a registered engineer, for any system re-design required to accommodate the alternate equipment. Stamped shop drawings must be approved in writing by the Engineer-of-record prior to the start of construction.

C. Finish of materials, components and equipment shall be approved by the Architect and shall be resistant to corrosion and weather as necessary.

1.06 SUBMITTALS

A. Refer to Division I for details on submittal format and number of copies required.

B. Within 30 days after the notice to proceed, and before purchasing any materials or equipment, provide all required product submittals along with the respective suppliers name, phone number, and email address.

C. Obtain detailed manufacturer's installation instructions for all equipment provided under this Section, and include in the equipment submittal.

D. Product data on standard manufactured items shall include:

1. an illustration of the item to be furnished,
2. performance curves and charts,
3. electrical requirements.
4. efficiency ratings
5. details, size dimensions,
6. Cut sheets shall be clearly marked as to what model, options, and accessories are being proposed.

E. Prior to submission, the Fire Protection Trade-Contractor shall review each submittal, and certify in writing that it complies with the contract documents in all respects. Un-certified submittals will not be reviewed, and re-submission will be required.

F. Shop drawings and submittals shall be submitted a minimum of 2 weeks before the start of the respective work. The Fire Protection Trade-Contractor shall allow for this time period in scheduling his work, and no claim for delay will be granted for failure to comply with this requirement. Comply with requirements specified in Section 01 33 00 –

SUBMITTAL PROCEDURES.

G. Material and equipment requiring Submittals shall include but not be limited to:

1. Sprinkler floor-valve-station-check valves.
2. Fire Dept. connections – Sprinkler / Standpipe
3. Wet Sprinkler heads (each type, K-factor, and temperature rating used).
4. Dry Sprinkler heads (each type, K-factor, and temperature rating used).
5. Control Valves.
6. Pressure relief valves
7. Pipe and fittings.
8. Vane type Flow switches (wet system)
9. Tamper switches
10. Pressure gages
11. Fire department hose valves.
12. Hangers and supports.
13. Alarm devices
14. FDC check valves and ball drip
15. inspectors test
16. Double check-valve, detector-assembly backflow preventor
17. Seismic bracing, restraints, and attachments.
18. Drain and test connections
19. Auxiliary drain valves
20. Gages
21. ID signs, pipe labels, and valve tags, hydraulics signs, and general information sign
22. Fire-stopping
23. Escutcheons and wall-plates

H. Other submittals required:

1. Monthly requisitions for work completed and approved
    a. Submittals, Shop drawings and calculation requisitions will be approved to a maximum of 80% until the submittals are approved
    b. Piping Rough-in without bracing, restraints, sleeves, and fire-stopping / sound-sealing will be approved to a maximum of 70% .
    c. Piping Rough-in with bracing, restraints, sleeves, and fire-stopping / sound-sealing will be approved to a maximum of 85%
2. Coordination drawings
3. Signed off punch lists when work is ready for re-inspection.
4. Minimum 1 week notice to the Engineer of Record of scheduled tests including:
    a. flow test,
    b. backflow preventor forward-flow test,
    c. underground piping pressure testing and flushing, and
    d. above-ground pressure testing and flushing.
5. Minimum 1 week notice to the Engineer of Record of scheduled acceptance testing date and time. (Engineer to witness).
6. NFPA 13 test and acceptance reports and certificates, signed by the AHJ.

7. Complete and accurate as-built drawings and record calculations.

    a. Where the number of field-added-elbows exceeds 6 for any calculation, those elbows shall be added to the design calculation, and the revised calculation submitted for record.

1.07 CONTRACT DOCUMENTS

A. Drawings and Specifications are complementary to each other. Provide work specified and not shown, and work shown and not specified as though explicitly required by both.

B. Except where modified by a specific notation to the contrary, it shall be understood that the indication and/or description of any item, in the drawings or specifications or both, carries with it the instruction to furnish and install the item, regardless of whether or not this instruction is explicitly stated as part of the indication or description.

C. Items referred to in singular number in Contract Documents shall be provided in quantities necessary to complete work.

D. Drawings are diagrammatic. They indicate general arrangements of equipment, systems and other work. They do not show all offsets required for coordination nor do they show the exact routings and locations needed to coordinate with structure and other trades and to meet Architectural requirements. The purpose of the drawings is to indicate a systems concept, the main components of the systems, and the approximate geometrical relationships. Based on the systems concept, the main components, and the approximate geometrical relationships, the Fire Protection Trade-contractor shall provide all other components and materials necessary to make the systems fully complete and operational.

E. Data that may be furnished electronically by the Designer (on computer tape, diskette, or otherwise) is also diagrammatic. If furnished, such data is for convenience and generalized reference.

F. Information and components shown on riser diagrams but not shown on plans, and vice versa, shall apply or be provided as if expressly required on both.

1.08 DISCREPANCIES IN DOCUMENTS

A. Any inconsistencies, omissions, or conflicts shown on the FP plans shall be brought to the Engineer’s attention for clarification.

B. Where conflicts or potential conflicts exist and engineering guidance is desired, submit sketch of the problem to the Designer for review and direction.

C. If the required material, installation, or work can be interpreted differently from drawing to drawing, or between drawings and specs, request clarification, *or* provide that material, installation, or work which is of the higher standard.

D. Prior to installation of visible material and equipment, including access panels, field coordinate the exact locations with the Architect.

1.09 PROTECTION

A. At all times, protect all building structures, equipment and systems not designated for demolition.

1. Each Trade-contractor shall be held responsible for any injuries or damage done to the building premises, adjoining property, or to other Contractors' work resulting from the execution of his part of the work.

2. In case of dispute arising over the responsibility incurred by each Trade-contractor, it is agreed between the Owner and each Trade-contractor that such liability and extent of damage shall be determined by the Engineer, whose decision shall be final and binding on all parties.

B. Owner will not be responsible for any material or equipment before testing and acceptance.

1.10 COORDINATION

A. Check other trades Contract Drawings, shop drawings and approved submittals, and coordinate work with all other trades affecting, or affected by work of this section. Cooperate with such trades to assure the steady progress of all work under the Contract.

1. The Fire Protection Trade-Contractor shall furnish all information pertaining to his materials as to sizes, locations, means of support, to all other trades requiring such information.

2. Ensure that access openings leading to equipment are large enough to carry through routine maintenance items such as tools

B. Make reasonable modifications in layout and components needed to coordinate and prevent conflict with the work of other trades.

C. The Fire Protection Trade-Contractor shall, at all times, have a foreman on the project authorized to make decisions, coordinate work, and receive instructions. Once construction has begun, the foreman shall not be removed or replaced without the express approval of the Engineer.

D. Each Trade-contractor, at his own expense, shall relocate all uncoordinated installations if they interfere with the proper installation and mounting of other trades work, including hung ceilings, architectural design features, and structural finish.

E. See Division 1 for other Coordination Drawing Requirements. Coordination Drawings include but are not necessarily limited to:

1. Structure.
2. Partition/room layout.
3. Ceiling tile and grid.
4. Light fixtures.
5. Access panels.
6. Sheet metal, heating coils, boxes, grilles, and diffusers.
7. All heating piping and valves.
8. Smoke and fire dampers.
9. Soil, waste and vent piping.
10. Major water and medical gases.

11. Roof drain piping.
12. Major electrical conduit runs, panel-boards, feeder conduit and racks of branch conduit.
13. Above ceiling miscellaneous metal.
14. Sprinkler piping and heads.
15. Heat tracing of piping.

1.11 GUARANTEE AND 24 HOUR SERVICE

A. Guarantee Work of this Section in writing for one year following the date of beneficial occupancy by the User Agency.

1. The guarantee shall repair or replace defective materials, equipment, workmanship and installation that develop within this period, promptly and to Designer's satisfaction and correct damage caused in making necessary repairs and replacements under guarantee within Contract Price.

2. Use of systems provided under this Section for temporary services and facilities shall not constitute Final Acceptance of work nor beneficial use by User Agency, and shall not institute guarantee period.

3. If the equipment is used for temporary service prior to substantial completion, the bid price shall include an extended period of warranty covering the one-year of occupancy, starting from the initial date of beneficial occupancy by the User Agency.

B. Provide 24 hour service beginning on the date the project is first beneficially occupied by the User Agency, whether or not fully occupied, and lasting until the termination of the guarantee period. Service shall be at no cost to the Owner.

1. Service can be provided by the Fire Protection Trade-contractor or a separate service organization. Choice of service organization shall be subject to Designer and Owner’s Project Manager approval.

2. Submit name and a phone number that will be answered on a 24-hour basis each day of the week, for the duration of the service.

C. Replace material and equipment that require excessive service during the guarantee period. “Excessive” shall be as defined by the Designer.

D. At end of guarantee period, transfer manufacturers' equipment and material warranties still in force to User Agency. Submit copies of all equipment and material warranties to Designer before final payment.

E. This Paragraph shall not be interpreted to limit Owner’s Project Manager's rights under applicable codes and laws or under this Contract.

F. Part 2 Paragraphs of this Specification may specify warranty requirements that exceed those of this Paragraph.

G. If warranty problems cannot be rectified immediately to Owner’s Project Manager's satisfaction, immediately provide manufacturer's engineering and technical staff at site to analyze and rectify problems. Advise Designer in writing, describe efforts to rectify situation, and provide analysis of cause of problem. Follow Designer’s instructions.

1.12 RECORD DRAWINGS

A. The Record drawing set shall include a complete set of bid-set drawings plus all of the Fire Protection Trade-contractor's final-approved, shop drawings, plus all SKs issued by the design team.

B. Record documents shall also include a final, approved set of hydraulic calculations, with all submittal-phase comments addressed.

C. Color coded, laminated and framed, minimum-size 24x36 plans, showing the location of each riser and each zone-control-valve station.

1. Each control valve's service area shall be colored in a different, distinct color.
2. Permanently mount 1 plan in each lobby containing a Fire Alarm annunciator.
3. Control valve locations shall be high-lighted in yellow, with large-font call-outs pointing to the exact valve location, and stating the zone number.

D. The Fire Protection Trade-Contractor shall keep a hard copy of contract drawings at the site and mark any changes to drawings as changes are made. Record documents shall reflect all changes from the Contract Drawings, whether by approved submittal, Change Order, or by field conditions. As-built drawings shall also indicate existing conditions different from those shown.

E. Clearly Mark with minimum 4 point red red cloud, and yellow high-lighter, the location of all control valves, riser valves, pressure gages, flow switches, tamper switches, low-point drains, and spare sprinkler storage

F. Drawings shall show record condition of details, sections, riser diagrams, control changes and corrections to schedules. Schedules shall show actual manufacturer and make and model numbers of final equipment installation.

G. At the project completion, as-built drawings shall be submitted per Division I requirements. Availability of marked-up "As-built" drawings shall be a prerequisite to scheduling Final Inspection of this Contract.

H. Inaccuracies in the marked-up "As-Built" Drawings will be grounds for holding retainage until the discrepancies have been corrected.

I. After all of the Engineer's comments are addressed, the Fire Protection Trade-Contractor shall submit final set(s) of reproducible or electronic As-built drawings to the Engineer.

1.13 MAINTENANCE MANUALS

A. Before final payment, the Fire Protection Trade-Contractor will furnish to the Owner three, labeled, hard-cover, 3-ring binders each containing a complete set of manufacturer's equipment maintenance and operation instructions. Inscribe on the cover:

1. "Operation and Maintenance Manual", the name and location of the project, the name of the Fire Protection Trade-Contractor and the contract number

2. The manual shall have a typed Table of Contents with tab sheets placed before each section.

3. List of names, addresses, and phone numbers of all sub-contractors as well as the local representative for each item of equipment.

4. All instructions shall be legible and easily read, with large sheets of Drawings folded in

B. Each Manual shall include the following information:

1. Copy of all submitted-and-approved, final NFPA 13 material and test certificates.

    a. All forms shall be current, standard, NFPA 13 forms

    b. Include an Above-ground certificate for each riser.

    c. Include an Underground certificate for the FP-only feed into the building – installation, pressure testing, and flushing must all be supervised by the licensed FP trade-contractor..

    d. On each test certificate, individually list every alarm and tamper device to be tested, and initial each one as it is tested and passes. Use an “attached sheet” if required.

    e. Test every alarm device and tamper devise with the F/A trade-contractor, to ensure that alarms and tampers not only operate, but that the signal is properly received and responded to by the fire alarm system. Test the following:

        i) Main Riser control valve Tamper switch
        ii) Zone control valve tamper switches
        iii) Main riser Flow switch
        iv) Zone control valve flow switches
        Tamper switches on each flow switch cover

2. Copy of NFPA 25.

3. Description of systems

    a. List each piece of equipment with manufacturer, model number, and serial number. Model numbers shall be “complete” including any prefixes or suffixes denoting options and accessories.

    b. Descriptions of start-up, operating control sequences,, and shut-down

4. Color coded, 8x11 floor plan. Each riser and floor valve station’s service area shall be colored in a different, distinct color. Provide a laminated copy of these floor plans permanently attached to each riser and floor valve station.

5. Schedule of adjustment, care, and routine maintenance for each item of equipment.

6. Lubrication summary chart for all equipment requiring lubrication. If no equipment requires lubrication, provide a letter so stating.

7. List of recommended spare parts

8. Copies of all service contracts

1.14 INSTRUCTIONS TO OWNER'S PERSONNEL

A. The Fire Protection Trade-Contractor shall provide qualified, factory-trained, manufacturer's rep(s) to provide a minimum of 8 hours training to the owner's maintenance personnel in the proper operation, care, and maintenance of all equipment. All such training will be at the job site.

1. FP trade-contractor shall bring to the training:

   a. A sign in sheet - have all attendees print their name on the sign-in sheet
   b. A written list of all topics specified to be covered, with an "initial line" next to each, and an Owner's signature line at the bottom.

2. FP trade-contractor shall have the "lead" attendee initial each topic as it's covered, and sign at the bottom when all topics are completed.

3. Submit sign-in sheet and signed-off topics list with the training video.

B. Training must address all phases of NFPA 25 required maintenance, including but not limited to the following:

1. Explain the code requirement that sprinklers be a minimum of 18" above the top of all storage. Ask staff to keep an eye out for storage that is too close to sprinklers, and to ask the responsible persons to lower their storage height and keep it down..

2. Explain that FP maintenance per NFPA 25 is now a state law requirement. Maintenance must both be completed, and ***documented.***

3. On a full-size, printed set of As-built drawings, Mark with red pen, and yellow high-lighter, the location of all control valves, riser valves, pressure gages, flow switches, tamper switches, drains, and spare sprinkler storage to be checked as part of the maintenance program. Outline each building flow zone with a unique color , i.e. all spaces on riser 1, 1st floor zone 1 color, all spaces on riser 1, 2nd floor zone a 2nd color, all spaces on riser 1, 3rd floor zone a 3rd color, and similarly for riser 2.

4. Take personnel to the location of the spare sprinkler cabinet. Provide a list of the sprinkler types stored in the cabinets, and the quantity of each type, and show personnel what each type looks like and where it is used.

5. Take personnel to all pressure gage locations. Show them how to open the gage valve, and describe what the normal pressures should be. Tell them when and what action to take if pressures are "low".

6. Take personnel to all risers and flow switch locations and show them what a riser valve and flow switch look like, and how they operates. Tell and show them what flow zone each riser and flow switch alarms.

7. Take personnel to all control valve locations. Explain what a tamper switch is, and to call the Fire Dept. if they want to test the valves. Show them how to fully close and

then fully open each valve.

8. Take personnel to the back-flow preventor. Explain who to call to arrange for State-required inspections.

9. Describe to personnel what to look for in their annual inspection of sprinklers and piping for “loading”, damage, corrosion, and extra weight.

10. Take personnel to all areas with sprinklers that could be subject to freezing if automatic dampers fail open, or manual-dampers are left open. Show them how to tell of dampers are closed and who to contact if they are open..

11. Take personnel to the hydraulic name-plate locations. Explain the purpose and importance of the name-plates.

12. Take personnel to the main drain location, and explain how to arrange for the required, annual, full-flow test with the local fire dept.

13. Take personnel to the FDC – explain its purpose and how to look for damage.

C. Supply qualified personnel to operate equipment for a sufficient length of time to ensure that the Owner’s representatives are properly qualified to take over operation and maintenance procedures. The Owner shall determine which (if any) systems require additional instructions beyond the minimum number of hours in paragraph A. Duration of instructions shall take equipment through complete cycle of operation (at least five working days).

D. Make a video recording of the Owner training, and provide 2 copies to Owner on CD or DVD (owner’s preference)

1.15 SEISMIC RESTRAINTS

A. Seismic bracing and restraints are required by these contract documents.

B. Install bracing and restraints for all Fire Protection equipment, accessories, piping, and components in accordance with NFPA 13, with the following exceptions:

1. Cable-bracing shall not be used in exposed areas such as mechanical spaces.

2. Piping shall be run close enough to the deck (intermediate floors) or roof structure (top floor) to brace or restrain using pipe or cable 10’ or less in length.

1.16 FLOW TEST AND SPRINKLER WORKING PLANS

A. The initial flow test performed during the schematic design phase showed insufficient flow and pressure to meet the new schools requirements.

1. In order to avoid a fire pump and water storage tanks, the City of Worcester is replacing the Apricot St water main.

2. This work will not be completed until after the project is bid – thus the construction documents are not based on any actual “flow test” results.

3. The construction document pipe sizing is based on expected available flow and pressure calculated by the City's engineering consultant – Tata and Howard.

B. This trade contractor shall provide, as soon as possible after being contracted, a new flow test in conjunction with the local water department and witnessed by the engineer of record.

1. Flow and gage hydrants shall be as shown on the bid-set documents.

2. Use only test equipment calibrated within the last year. Submit calibration test reports for the engineer's review, prior to the flow test.

3. Provide a detailed report – including: a cover sheet with the contractors contact info, time and date of test, a to-scale sketch showing the location and elevation of all flow and pressure hydrants, actual pitot readings, as well as translated flow and pressure results

C. Definition: Working plans are the installation shop drawings required by NFPA Standard 13 and 780 CMR 9th Edition, 9.01.2.1 #2 and normally prepared by the installing Trade-contractor.

D. Electronic bid-set files are available to facilitate the preparation of the sprinkler shop drawings. These files are solely for the use of the Fire Protection Contractor and may not be a full representation of the Scope of Work. These files are available from Lamoureux Pagano Architects Associates, Inc. (LPA), upon signing of LPA's consent form.

E. Prepare working plans and calculations according to the requirements of NFPA Standard 13.

For all risers, maintain a minimum 10 psi safety zone between available pressure and design pressure at design flow.

1. Working plans and hydraulic calculations shall be prepared by a NICET-certified Level III or IV automatic sprinkler system engineering technician or be stamped by a professional engineer registered in the jurisdiction of the Project.

F. Working Plans shall be stamped and signed by a Professional Engineer when required by the approving authority.

G. Submit working plans to the authorities having jurisdiction for approval, including:

1. Building Department.
2. Fire Department.
3. User Agency's Insurance Underwriter.
4. Designer.

H. Deviation from the approved plans will require re-approval by the reviewing authorities.

I. Prepare sprinkler head layout plans on reflected ceiling plans for submission to the Designer before submission of the working plans.

J. Submit working plans and hydraulic calculations to the Designer in one complete

package, after review by the other authorities having jurisdiction. Plans submitted without review stamps or hydraulic calculations will be returned without review.

PART 2 PRODUCTS

2.01 GENERAL

A. New products: Except as specified otherwise, material and equipment shall be new. Provide all components required or recommended by OSHA.

B. Standard Products: Material and equipment shall be the standard products of a manufacturer regularly engaged in the manufacture of the products for at least 3 years. See other specification sections for any exceptions.

C. Multiple Units: When two or more units of materials or equipment of the same type or class are required, these units shall be products of one manufacturer.

D. Nameplates: Each item of equipment shall have a name-plate bearing the manufacturer's name, address, model number, and serial number, plus compliance labels, and any other information needed for identification securely affixed in conspicuous places; the nameplate of the distributing agent alone is not acceptable. The nameplates shall be kept clean and readable at all times.

E. Asbestos products or equipment or materials containing asbestos shall not be used.

2.02 MATERIALS AND EQUIPMENT

A. Do not order or deliver any materials until all submittals, required in the listed Specification Sections included as part of this Filed Trade-contract, have been received and approved by the Architect.

B. The Fire Protection Trade--Contractor shall be responsible for the ordering, handling, and security all materials and equipment required for a complete job. Each Trade-Contractor shall be solely responsible for ensuring that sufficient materials are on site so that the work can proceed in a smooth, continuous fashion.

C. Each Trade-contractor shall be responsible for his work until its completion and final acceptance, and he shall replace any work or materials that have been damaged, lost, or stolen without additional cost to the Owner

D. Each Trade-Contractor shall verify all existing site conditions and material needs before starting work on any task and before ordering delivery of any materials and/or equipment. Each Trade-Contractor shall coordinate the time of delivery of all equipment and materials and have a designated representative present to sign for the receipt of all equipment and materials.

2.03 DELIVERY, STORAGE, AND HANDLING

A. Upon delivery, each Trade-Contractor shall move their materials to their proper storage site. It will be the Trade-Contractor's responsibility to arrange with the G.C. for storage areas.

B. Carefully store materials and equipment which are not immediately installed after delivery

to site. It shall be each trade's responsibility to store their materials in an orderly and clean manner. If stored on-site in open or unprotected areas, all equipment and material shall be kept off the ground by means of pallets or racks, and covered with tarpaulins.

C. Deliver pipes and tubes with factory-applied end-caps. Maintain end-caps through shipping, storage, and handling to prevent pipe-end damage and prevent entrance of dirt, debris, and moisture.

D. Protect all materials and equipment from moisture and dirt and extreme temperatures. Store in the manufacturers carton or crate until installation.

2.04 LABELING AND IDENTIFYING

A. All labeling systems shall meet ANSI 13.1 requirements.

B. Provide labels on all new equipment and new distribution systems provided under this contract. Coordinate equipment numbers with the User Agency's maintenance personnel. Stencils shall be at least 2 inches high and of a color to provide a contrast with the equipment finish.

C. Above-ceiling valves and drains: Where-ever control valves or low-point drains are installed above a ceiling, provide a valve (or drain) tag and valve (or drain) label installed on the "best" ceiling tile to move to access that valve or drain. Note exact location (within 1 ceiling tile) of above-ceiling valves and drains on the record drawing set.

D. Piping Systems:

1. Piping systems may be identified with stenciling or with approved snap-on covers. Markers shall be equal to Seton Setmark.

    a. Pipe marking for outside diameters of 6 inches or greater may be springs or metal bands secured to the corners at each end of the semi-rigid plastic marker to hold each end of the marker firmly against the pipe.

2. Labeling shall be applied on the apparatus in full view and shall be a color that is in sharp contrast with the background. The apparatus shall be thoroughly cleaned (and painted, if necessary) before labeling is applied. Letters shall not be less than 1 ½" in height. Arrows shall not be less than 9" long.

3. Provide labels and arrows showing normal direction of flow:

    a. Near each valve and control device.

    b. Near each branch, excluding short take-offs for fixtures and terminal units.

    c. Near locations where pipes pass through walls, floors, ceilings, or enter inaccessible enclosures.

    d. Near major equipment items and other points of origination and termination.

    e. Spaced at a maximum of 15-foot intervals along each run.

4. Marker letter sizes shall be as follows:

Outside Diameter	Size of Letters:	Length of Color Code:
1-1/4 inch and smaller	1/2 inch	8 inches
1-1/2 inch to 2 inch	3/4 inch	8 inches
2-1/2 inches to 6 inches	1-1/4 inch	12 inches

5. Marker Text and colors shall be as follows:

Service	Identification	Color Code
Wet System Piping	Fire Protection - Wet	Red
Standpipe	Standpipe	Red
FDC	FDC	Red
Drain Piping	Fire Protection - Drain	Red

E. Equipment:

1. Equipment markings shall be prominently displayed on each normally visible side of equipment. Equipment intended for installation in finished area shall have markings located behind normally used access panels mounted so as to be readily found.

2. Install engraved plastic laminate sign or equipment marker on equipment, using the equipment name and number shown on the drawings and in the maintenance manuals. Laminate signs shall have minimum

   a. 1/4-inch -high lettering for the name of unit, (example Riser 1 Check Valve) where viewing distance is less than 2 feet,

   b. 1/2-inch -high for distances up to 6 feet and

   c. proportionately larger lettering for greater distances.

   d. Provide secondary lettering 2/3 to 3/4 of the principal lettering size.

F. Valves: All new valves shall have near circular brass or engraved plastic valve tags of at least 1-¼" in diameter, attached with brass hooks (beaded chain is not acceptable) to each valve stem.

1. Valve tags shall have ¼" high lettering for service designation over 1/2" high consecutively numbered valve identification.

2. Plastic valve tags shall be color coded as specified for piping identification.

3. Service designations shall be as follows:

Fire Protection System:	Designation:
a. Wet Systems	FP
b. Standpipe	STP
c. FDC	FDC
d. Drain	D

4. Valve numbers:.

    a. The numbers of each service shall be consecutive, and shall correspond to numbers indicated on the valve charts.
    b. All valve numbers shall also be shown on the record drawings.

G. Adjusting: Relocate identifying devices which become visually blocked by work of this Division or other Divisions.

2.05 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering fire protection system products which may be incorporated in the work include, but are not limited to, the following:

1. Control Valves and Tamper Switches:

    a. Fairbanks
    b. Jenkins
    c. Kennedy Valve, Division of ITT Grinnell Valve Co., Inc.
    d. Stockham

2. Swing Check Valves:

    a. Fairbanks
    b. Jenkins
    c. Kennedy Valve, Division of ITT Grinnell Valve Co., Inc.
    d. Star Sprinkler Corp.
    e. Stockham

3. Grooved Mechanical Fittings:

    a. Stockham
    b. Victaulic
    c. Grinnell

4. Water Flow Indicators:

    a. Potter
    b. Reliable Automatic Sprinkler Co., Inc.
    c. Star Sprinkler Corp.
    d. Victaulic Company of America
    e. Viking Corp.

5. Alarm Check Valve, Riser Check Valve,

a. Reliable Automatic Sprinkler Co., Inc.
b. Star Sprinkler Corp.
c. Viking Corp.

6. Fire Department Connection Valve and Interior Hose Connections:

a. Guardian Fire Equipment, Inc.
b. Star Sprinkler Corp.
c. Viking Corp.

7. Sprinkler Heads

a. Automatic Sprinkler Corp. Of America
b. Firematic Sprinkler Devices, Inc.
c. Globe Fire Equipment Co.
d. Guardian Fire Equipment, Inc.
e. ITT Grinnell
f. Reliable Automatic Sprinkler Co., Inc.
g. Tyco Fire Products
h. Viking Corp

8. Backflow Preventor

a. Watts
b. Ames
c. Zurn

9. Hangers and Sway Brace Components

a. Tolco
b. Afcon
c. Viking
d. Reliable

2.06 PIPING, FITTINGS AND JOINTS

A. GENERAL

1. Pipe and fittings shall conform to the latest ANSI, ASTM, NFPA and AWWA Standards including latest amendments.

2. Each length of pipe, each pipe fitting, and/or device used in the piping systems shall have cast, stamped or indelibly marked on it, the maker's name or mark, weight and quality of the product when such marking is required by the approved standard that applies. Pipe and fittings shall conform to the latest ANSI, ASTM, NFPA and AWWA Standards including latest amendments.

3. Piping and fittings specified as “coated” shall be factory coated.

4. All joints shall be line-size, with an equal or greater pressure rating as the pipe.

B. Where ever steel or iron metals are joined to copper, brass or bronze, they shall be separated by a dielectric nipple, or flanges with dielectric gasket. No dielectric unions

permitted.

C. All equipment and materials used shall be listed for the use required and for a minimum of 175 psi.

D. Buried Fire Service Entrance: Ductile iron, Class 52, cement-lined with mechanical joints.

1. Pipe: ANSI/AWWA C151-A21.51.

2. Cement Lining: ANSI/AWWA C104-A21.4.

3. Fittings: ANSI/AWWA C110-A21.10.

4. Gasket: ANSI/AWWA C111-A21.11.

E. Service Entrance Piping:

1. Black steel Schedule 4O, ASTM A53 with flanged, threaded, or grooved joints.

2. Black steel Schedule 10, ASTM A135 light-wall with roll-grooved fittings – size 2-1/2" and over ONLY.

F. Wet System Piping:

1. Steel:

a. 2 inches and smaller: ASTM 135 Schedule 40 black steel with roll-grooved or threaded joints;

b. larger than 2 inches: ASTM 135 Schedule 10 light-wall with roll grooved joints

c. Sizes 1-inch through 3-inches may be Allied galvanized XL threadable light-wall steel pipe with threaded joints and fittings.

2. Copper: Type L or K copper with 95-5 soldered or brazed joints in compliance with NFPA 13. Provide dielectric fittings between copper and ferrous piping.

3. Exposed piping inside of hose cabinets shall be galvanized or chrome plated.

G. Fittings:

1. Flexible Sprinkler Connectors – shall be braided stainless steel, UL listed and FM approved for the design length, bend radius, and number of elbows to be used.

2. Ductile Iron: ASTM A-536.

3. Malleable Iron: ANSI B16.3.

4. Steel: ANSI B16.11.

5. Cast Iron: ANSI B16.4. (Not for use in dry system.)

H. Grooved Fittings and Couplings:

1. Grinnell Fig. 7000, Gustin-Bacon No. 105 or Victaulic Firelock or Style 75. Use manufacturers friction loss data in hydraulic calculations

2. Both Flexible and rigid couplings required, per NFPA 13.

3. Compatibility: Grooved ends, Couplings and fittings shall meet ANSI / UL 213 standard grooved dimensions for fire protection service.

2.07 JOINING MATERIALS

A. Welding Materials: Comply, with Section II, Part C, ASME Boiler and Pressure Vessel Code for welding materials appropriate for the wall thickness and chemical analysis of the pipe being welded.

B. Brazing Filter Metals: AWS A5.8, Classification Bag1 (Silver).

C. Solder Filter Metals: ASTM B 32, 95-5 Tin Antinomy.

D. Gasket Materials: Thickness, material, and type suitable for fluid or gas to be handled, and design temperatures and pressures.

2.08 SLEEVES AND PENETRATIONS,

A. Sleeve Types

1. Pipe sleeves passing thru or under below grade beams and footings, shall be ductile iron, three sizes larger than the pipe being served. Sleeve shall be a minimum of six feet in length.

2. Pipe sleeves through floors, exterior walls and fire-rated construction shall be galvanized Schedule 40 steel pipe.

    a. Piping penetrations through fire rated construction shall comply with a listed fire rated assembly as detailed in the UL Fire Resistance Directory.

3. Pipe sleeves through non-fire-rated partitions shall be 26 g. galvanized steel.

B. Water-proofing: Sleeves Through Exterior Foundation Walls and Floor Slabs on Grade: shall have a continuous-welded flange water stop and waterproof caulking assembly by Link-Seal or Sure-Seal.

C. Sleeve Sizing:

1. Annular Space Requirements: Sleeves shall be sized to provide a uniform clearance around the pipe / insulation cover:

    a. 1” for pipe 3-1/2” and under
    b. 1” for pipe 4” and over with listed flexible coupling on both sides of the structure, within 1’ of the penetration.
    c. 2” for pipe 4” and over without flexible coupling
    d. Annular space around penetrations thru fire rated assemblies shall be in

compliance with the Listed Assembly.

2.09 FIRE STOPPING

A. Materials shall be asbestos-free, complying with UL 1470 and UL Fire Resistance Directory.

B. Submit installation instructions with the fire-stopping submittal.

C. See Section 07 84 00 for specific product requirements.

2.10 INSERTS AND ESCUTCHEONS

A. Provide anchors and inserts as necessary for attachment of equipment supports and hangars.

B. Inserts shall be individual or strip type of pressed steel construction with accommodation for removable nuts and threaded rods up to 3/4 inch diameter, permitting lateral adjustment. Individual inserts shall have an opening at the top to allow reinforcing rods up to 2 inch diameter to be passed through the insert body. Strip inserts shall have attached rods with hooked ends to allow fastening to reinforcing rods.

C. Inserts shall permit adjustment of bolt in one horizontal direction and shall develop strength of bolt when installed in properly cured concrete.

D. Concrete anchors used to secure either hangers or sway brace assemblies to the building structure shall be in accordance with ACI 355.2, and installed per manufacturer's instructions.

E. Unless otherwise specified herein, escutcheons shall be cast brass chrome plated type and provided with a set screw to properly hold escutcheon in place.

2.11 GENERAL DUTY VALVES

A. Valve ends specified below as "threaded" or "flanged", may also be groove-end if attaching to grooved piping of the specified wall thickness.

B. Gate valves, 2 inches and smaller shall be outside screw and yoke, bronze, rising stem, wedge disc type, threaded, conforming to MSS SP-80. Gate valve 2-1/2 inches and larger shall be iron body, bronze trim, outside screw and yoke, flanged, UL/FM listed conforming to MSS SP-70. All valves shall be UL listed for at least 175 psi working water pressure (wwp).

C. Globe and angle valves may be used as auxiliary valves (drain valves, test valves, trim valves and valves on compressed air piping) for diameters not over 2 in. They shall be bronze, rising stem, with bronze disc, threaded, conforming to MSS SP-80 Class 150.

D. Butterfly valves 3 in. and larger shall be lug style, ductile iron body, ductile iron nickel plated disc, stainless steel stem, gear operated, with a position indicator, U4 listed for 175 psi conforming to MSS SP-67.

1. For diameters 2-1/2 in. and smaller, if the valve requires a supervisory tamper switch, only valves listed with the supervisory attachment may be used. These

valves shall have bronze body with threaded ends, stainless steel disc and stem, visual position indicator and a built-in tamper proof supervisory switch rated 10 amps, 115 VAC. Valve listed pressure rating shall be 175 psi

2. Wherever the valve's position shall be supervised by a supervisory switch (tamper switch).

E. Check valves shall be swing type except as noted. Valves 2 inches and smaller shall be bronze, regrinding type with renewable disc, screwed caps, threaded, class 150 conforming to MSS SP-80. Check valves 2-1/2 inches and greater shall be iron body, bronze trim, bolted cover, flanged, conforming to MSS SP-71, UL listed for 175 psi

2.12 SPECIALTY VALVES

A. Riser Check Valve: 175 psig working pressure, designed for horizontal or vertical installations, and have cast iron, flanged inlet and outlet, bronze grooved seat with O-ring seals, single hinge pin and latch design. Provide trim sets for bypass, drain, electric sprinkler alarm switch, pressure gauges, retarding chamber, drip cut assembly piped without valves separate from main drain line, and fill line attachment with strainer.

B. Pressure Relief Valves – minimum ½" size, rated to operate at 175 psi, UL listed for FP service

C. Hose Valves: 175 psig working pressure, straight or angle pattern suitable for the application, bronze body gate valve with 2-1/2" FNPT inlet and combination 2-1/2" / 1-1/2" FMST outlet, and cap and chain. Install all hose valves centered in hose cabinet

D. Roof Hydrants: Free-standing, cast-brass, back-angle body, with male hose threads and caps and chains. With rough chrome cover sleeve and roof-water-proofing-boot. Provide hand-wheel and sight window to confirm valve operation. Cast-brass plate lettered, "HYDRANT". 4" inlet, and 2, 2-1/2" outlets, mounted a minimum of 36", and a maximum of. 60" above finished roof. Provide normally closed, manual drain valve and ball drip, both piped to standpipe drain riser below roof.

E. Roof Hydrant Valve Control: Free-standing, with hand-wheel mounted 46" +/- above finished roof, and sight-window to confirm extension-stem-turning.. With Brass cap, brass sleeve, brass base plate, and roof-water-proofing-boot. Provide extension stem of sufficient length to run from hand-wheel to non-rising-stem gate valve below roof line. Provide tamper switch at non-rising-stem gate-valve.

2.13 GAUGES

A. General

1. Pressure Gauges shall be as manufactured by U.S. Gauge Ashcraft, Trerice or equal.

2. The accuracy of all gauges shall be within one percent of the scale range.

3. All gauges shall be selected to read at mid-scale under normal operating conditions.

B. Pressure Gauges

1. Gauges shall be installed with suitable ¼ turn, "T" handle gauge cocks to permit servicing. All gauges shall be minimum 3-1/2-inch diameter, dial type, stainless steel

case aluminum peaker ring, phosphor bronze, bourdon tube, 1/4 inch forged brass N.P.T. male socket connection with wrench flats, white lithographed steel dial with black numbers and graduation. Dial graduations shall read in "PSIG".

2.14 BACKFLOW PREVENTION DEVICES

A. Double Check-type backflow preventers shall have bronze body construction, removable bronze seats, stainless steel internal parts, bronze-bodied ball valve test cocks, non-rising stem gate valves with union or flanged connections between the valves and the device itself, inlet and outlet pressure gauges and comply with requirements of ASSE Standard 1013. Size as indicated on the Drawings.

1. Furnish one (1) spare parts kits for each size of device to be installed.

2. Furnish one (1) test kit for use with the reduced pressure devices. The test kit shall be contained in its own carrying case.

2.15 AUTOMATIC SPRINKLERS

A. Sprinkler Heads:

1. Window sprinklers: The Window sprinkler listed in the drawing legends is an Proprietary Product. Refer to section 01 60 00 for Owner's proprietary product requirements.
2. Flat-plate, concealed type in all ceilings This includes dry concealed pendants in walk-in coolers and freezers.
3. Fusible link type uprights where exposed
4. Other styles as indicated or required by the drawings or application.
5. Except where otherwise indicated, provide standard coverage sprinklers with nominal 1/2 inch NPT connections
6. Where sprinklers with a higher K-factor than 5.6 are indicated, they shall have a minimum ¾ inch NPT connection – to prevent accidental replacement with a K5.6 coverage sprinkler.
7. Sprinklers shall be "intermediate" temperature rating through-out, except where code required to be high temperature.
8. Provide sprinkler guards on all exposed upright sprinklers in the gym, storage rooms, mechanical rooms, under stairs and under open-joist mezzanines.

B. Sprinkler Heads Finishes: Provide heads with the following finishes:

1. Specialty ceilings: Architect to choose sprinkler finish colors from the full range of standard colors offered. Finishes must coordinate all with ceilings, including black, dark red, and metallic ceilings. Architect to provide color samples to be matched.

2. Standard Ceilings: Upright, Pendent, and Sidewall Styles: chrome plated in finished spaces, exposed to view; rough bronze finish for heads in unfinished spaces and not exposed to view.

3. Concealed Style: rough brass, with white, flat cover plate.

C. Sprinkler Head Cabinet and Wrench: finished steel cabinet, suitable for wall mounting, with hinged cover and space for 6 spare sprinkler heads of each type, K-factor, and temperature rating on the project. Include in the cabinet, a typed, laminated list of all

spare sprinklers in the cabinet, including sprinkler type and SIN, K-factor, temperature rating, and locations they are used.

2.16 FIRE DEPARTMENT HOSES AND RACKS

A. None required – per Worcester Fire Dept.

2.17 FIRE DEPARTMENT CONNECTIONS

A. Wall Type Siamese Connections: Polish cast brass or chrome, flush wall type, with wall escutcheon and two-way connections. Connection sizes shall be 2, 2-1/2-inch outlets and a 4 inch female inlet, having NH standard threads, for the connection size indicated, as specified in NFPA 1963. Inlet shall have a clapper valve, and plug and chain. Unit shall have wall escutcheon of cast brass, finish to match connections, labeled in raised letters:

1. “AUTO SPKLR - FDC,”.

2.18 ALARM DEVICES

A. General: Types and sizes shall mate and match piping and equipment connections.

B. Wet System Water Flow Indicators: Vane type water-flow detector, rated to 250 psig; designed for horizontal or vertical installation; have 2-SPDT circuit switches to provide isolated alarm and auxiliary contacts, 7 ampere 125 volts AC and 0.25 ampere 24 volts DC; complete with factory-set, field-adjustable retard element to prevent false signals, and tamper-proof cover which sends a trouble signal when cover is removed.

C. Supervisory Switches (for valves): SPST, normally closed contacts, designed to signal valve in other than full open position.

D. Electric Bell: UL listed and FM approved, 24 VAC, 90 dBA volume, suitable for outdoor use, mounts to standard 4x4 box, red-powder coating. Potter PBA248 or approved equal.

2.19 PIPE AND HANGER SUPPORTS

A. Provide pipe supports, sway braces, hangers, and clamps conforming to NFPA 13 and listed by UL and approved by FM. [Provide protection of piping against earthquake damage in accordance with NFPA 13.]

B. Provide pipe stands, supports, hangers and other supporting appliances as necessary to support work required by Contract Documents. All components of the hanger support system shall comply with the standards set forth in MSS-SP58 and MSS-SP69 (Manufacturers Standardization Society) latest publication.

C. Hanger Types

1. Provide galvanized hangers and hardware for steel and plastic piping.

a. Hangers for uninsulated steel or cast iron piping shall be Carpenter & Patterson Figure 1A galvanized-steel adjustable band type or Carpenter &

Patterson Figure 100 galvanized-steel clevis type

b. Extension type split ring hangers with wall plates shall be equal to Carpenter & Patterson Figures 81, 81-CT, 90-CT and 85, 85-CT plates for iron, steel and copper.

c. Perforated strap hangers are not acceptable.

D. Hanger rods shall be sized in accordance with the recommended load capacities of ASTM Specifications Designation A-107, latest amendment.

E. Exposed rods, clamps and hangers shall be electro-galvanized coated.

2.20 ACCESS PANELS

A. Furnish access doors and frames for walls and ceilings to applicable trades for installation. Minimum size 16x16 for ease of access and maintenance.

See section 08 31 00 for product specifications.

PART 3 EXECUTION

3.01 SEQUENCING AND SCHEDULING

A. Pre-Bid Conference: Bidders are strongly encouraged to attend the Pre-Bid conference; refer to INVITATION TO BID for time and date.

B. Phasing: Refer to Section 01 10 00 - SUMMARY, and Drawings for phasing and milestone completion requirements which affect the General Contractor's Work and the Work of this Trade-contractor.

C. Extra payment will be allowed ONLY for additional work caused as-built conditions substantially different than shown on the drawings. No extra payment will be allowed for additional work caused by unfamiliarity with site conditions that are visible or readily construed by experienced observer.

1. Report conditions that might affect work adversely in writing to the Designer.

2. Do not proceed with work until defects have been corrected and conditions are satisfactory. Commencement of work shall be construed as complete acceptance of existing conditions and preparatory work.

D. The Fire Protection Trade-contractor shall layout all work and be responsible for the accuracy of same. Conditions at the project site shall be the determining factor for all measurements, runs, bends, and offsets.

E. Each Trade-contractor shall furnish all sleeves, frames, supports, inserts, and other accessories required for their work so that the General Contractor may build them into place.

1. Each Trade-contractor shall coordinate the installation of supporting devices, chases, openings, sleeves and inserts he requires.

2. The size and location for openings, sleeves, and inserts required by each Trade-contractor shall be checked by that Trade-contractor.

3. In case of failure to provide sufficient information in proper time, resulting in openings, sleeves or inserts that were not installed or were incorrectly located, provide cutting and patching or have same done, at own expense and to full satisfaction of Designer.

F. Provide information requested by others as to sizes, number and locations of concrete housekeeping pads necessary for floor-mounted equipment provided under this Section.

G. Coordinate connection of all electrical wiring prior to testing and final inspections..

H. Coordinate installation of identifying devices after completion of covering and painting where devices are applied to surfaces.

3.02 ROUGH-IN

A. Avoid interference with structure and with the work of other trades.

B. Verify final locations for rough-ins with field measurements and with the requirements of the actual equipment to be connected.

C. Each Trade-contractor shall make all measurements, both horizontal and vertical, off reference points established by the General Contractor and be responsible for correct laying out of work.

D. In the event of discrepancies between actual measurements and those indicated, notify Designer in writing and do not proceed with work until written instructions have been issued by Designer.

E. Install all work so that parts requiring periodic inspection, maintenance, and repair are readily accessible. Install concealed devices in locations freely and fully accessible through access doors.

1. Furnish access doors for all concealed items, of sufficient size for proper maintenance. See section 2.20 for product requirements.

2. All access doors shall be installed by the G.C. or other Trade-contractors as specified in 1.03.E.

3.03 CUTTING AND PATCHING

A. Section 01 73 00 defines what cutting and patching will be done by the General Contractor, and what will be done by Trade-contractors in the MEP trades.

B. All work and materials shall be installed in such a manner and at such time to keep cutting and patching to a minimum.

C. Each Trade-contractor shall do all drilling required for the installation of their hangers.

D. Coring – refer to Section 01 73 00 for all coring-related requirements.

E. All pipe cutting and threading shall be done in a location approved by the Engineer.

1. No pipe cutting or threading shall be done on completed, exposed concrete floor slab, unless necessary.

2. If necessary, the Trade-contractor shall cover the entire working area with canvas and plastic tarps.

F. Perform all cutting, fitting, and patching required to:

1. Provide for the installation or inspection of ill-timed Work.

2. Remove and replace defective work or work not conforming to requirements of the Contract Documents.

3. Remove samples of installed Work as specified for testing.

G. Protect the structure, furnishings, finishes, and adjacent materials not scheduled to be removed.

H. Patch existing finished surfaces and building components using new materials that match existing materials and Installers experienced with the materials and methods required.

I. Reference Section 01 73 29 for additional requirements.

3.04 FIRE STOPPING

A. Fire-stop all holes through fire-resistive assemblies used by this Trade-contractor work under this contract.

B. Refer to section 07 84 00 FIRE-STOPPING for installation methods.

C. Sound-sealing: - Seal all openings used by this Trade-contractor into or out of offices, classrooms, the library, the gym, and the cafeteria to minimize sound transmission. Sealant shall be non-combustible.

D. Use of existing openings:

1. “No wall”: If a wall ends at the ceiling, no sleeve, fire-stop, or sound-seal is required where the fire protection piping passes above the wall

2. Existing openings in walls larger than 4 square feet shall be considered “no wall”.

3. If this Trade-contractor chooses to pass their piping thru an opening provided by others, this Trade-contractor shall fire-stop (if required) or sound-seal (if required) the entire hole – regardless of size.

3.05 MECHANICAL INSTALLATIONS – GENERAL REQUIREMENTS

A. General

1. Refer to Division I for additional quality assurance, testing & inspection requirements.

2. Where an installation of any item will be visible, and locations are not shown on the FP or architectural plans or elevations, submit an RFI (request for information) to the Architect for direction as to exact location.

3. Install all equipment according to manufacturer's installation instructions.

4. Provide supplementary or miscellaneous items, accessories, devices and materials obviously necessary for a sound, secure and complete installation.

5. Install systems, materials, and equipment to provide the maximum headroom possible, and clearing doors and passageways in accordance with code requirements, unless specifically shown at a lower height.

6. Install systems, materials, and equipment neatly, level and plumb, (unless pitch to drain is required), and parallel and perpendicular to other building systems and components.

7. Suspended Equipment and distribution systems shall be installed concealed except in mechanical rooms and areas where no ceiling exists.

8. Installations shall operate safely and without leakage, undue wear, noise, vibration, corrosion or water hammer.

9. All automatic control devices shall be adjusted for proper operation.

B. Installation Only Items

1. Obtain final roughing dimensions or other information as needed for complete installation of items furnished under other Sections or by User Agency.

2. Where the Fire Protection Trade-contractor is required to install items which it does not purchase, it shall:

   a. Coordinate their delivery, and be responsible for their unloading from delivery vehicles and for their safe handling and field storage up to the time of installation.

   b. Carefully examine such items upon delivery. Claims that any of these items have been received in such condition that their installation will require procedures beyond the reasonable scope of work of the Fire Protection Trade- contractor will be considered only if presented in writing within one week of their date of delivery. Unless such claims have been submitted this contractor shall be fully responsible for the complete reconditioning or replacement of the damaged items.

   c. This trade shall be responsible for: any necessary field assembly, internal connections, mounting in place, and their connection to building systems including the purchase and installation of all terminating fittings necessary to adapt and connect them to the building systems.

C. Equipment

1. Verify site conditions and dimensions of equipment to ensure equipment can be

properly installed and maintained without disassembly. Provide all manufacturer's recommended service clearances.

2. Install equipment to properly distribute equipment loads on building structural members or equipment supports provided under other Sections.

3. Provide cuts, weights, and other pertinent data required for proper coordination of equipment support provisions and installation.

4. Install equipment giving right-of-way to piping systems installed at a required slope.

5. Install isolation valves and unions or flanges on the upstream and downstream side of each piece of equipment arranged to allow servicing, maintenance, and equipment removal without system shutdown.

D. Piping

1. Install piping approximately as shown on the bid set drawings, or as shown in approved shop drawings.

2. Piping shall be installed as straight and direct as possible, and be neatly spaced to allow min. 1" clearance between pipe and all other materials.

3. All piping shall be pitched to ensure proper drainage – per NFPA 13. Provide auxiliary drains per NFPA 13 at all low points making it possible to drain the water from all sections of each piping system without cutting the pipe.

4. If temperature swings shall exceed 40 degrees F, provide swing joints to allow for expansion and contraction. Anchor piping to ensure proper direction of expansion and contraction.

5. Cut pipe square and to exact lengths. Re-cut any pipe that is accidentally cut shorter or longer than required.

6. Install branch connections to mains using tee fittings in main. Where space permits, takeoff shall come out the top of the main.

7. Install dielectric nipples or insulating flange gaskets, anywhere piping of dissimilar metals is joined.

8. Threaded pipe: Apply appropriate tape or thread compound to the external pipe threads. Assemble joint wrench tight.

    a. Small fittings shall be taper thread.

    b. Screwed pipe shall be reamed smooth before installation.

    c. Not more than three threads shall remain exposed outside each fitting after the joint has been made up.

    d. Each length of pipe shall be hammered and all scale shall be blown out before assembling.

e. Threaded joints shall not be caulked to prevent or stop leaks.

9. Testing: Test all FP pipe with water to 200 psi. Piping shall hold pressure for 2 hours with no drop in pressure. All piping pressure tests to be witnessed by the engineer or Authority Having Jurisdiction (AHJ).

10. Piping or other apparatus shall not be installed in such a manner as to interfere with the full swing of the doors and access to other equipment.

11. Change pipe sizes with reducing fittings. Bushings will not be allowed unless specifically approved.

12. Any piece of pipe six inches or less in length shall be considered as a nipple.

E. Valves

1. Provide a union or bolted-fitting connection within approximately 12” of each valve.

2. Examine valve interior and threads for cleanliness and form. Do not attempt to repair defective valves; replace with new valves.

3. Locate valves for easy access and provide separate support where necessary.

4. Install valves in a position to allow full stem movement. Where possible, install valves with the stem at or above the center of horizontal pipe.

5. Adjust or replace any leaking valve packing after piping systems have been tested and put into service. Replace valves if leak persists.

6. Location of Valves: Install valves where indicated on the drawings and as follows:

a. At building service entrance,
b. Base of all risers,
c. On the upstream and downstream side of the backflow preventor.
d. At all floor valve stations
e. At all drain points draining over 5 gallons.

7. Valves shall be located to permit easy operation, replacement or repair.

F. Sleeves and Escutcheons

1. Sleeves

a. In finished areas where pipe is exposed, install sleeves flush with the finish floor,

b. In mechanical rooms, and janitor's closets extend sleeves at least 4 inches above finish floor.

c. Sleeves through interior masonry or non-masonry walls or partitions shall be set flush with the finished surfaces of the wall or partition.

d. Make pipe penetrations watertight where passing through exterior walls,

slabs on grade and over crawl spaces, and waterproofed floors.

e. Provide an airtight acoustical barrier where pipes / sleeves pass through floors, walls, and ceilings of noisy spaces, such as mechanical rooms, music rooms, gymnasiums, auditoriums, and heavy traffic corridors.

2. Escutcheons

a. Escutcheons shall be installed around all exposed pipe passing through a finished floor, wall or ceiling. Escutcheons shall fit snugly around the bare pipe.

b. Escutcheons shall be installed around all sprinklers (except concealed pendants) penetrating a ceiling.

c. Escutcheons shall completely cover the hole for a neat and finished look.

G. Hangers

1. All piping and equipment shall be supported from the building structure and not from other piping, ductwork, conduit or ceiling suspension. Support shall be by means of approved hangers and supports, so arranged as to provide for expansion and contraction.

2. Hanger locations: Provide hangers:

a. Per the maximum o.c. spacing shown on the drawings hanger schedule.
b. Within two feet of all changes in direction (horizontal and vertical)
c. On both sides of concentrated loads independent of the piping.
d. Within 2' of each equipment connection, to eliminate strain on connection points
e. Hangers near equipment shall permit the removal of equipment, valves and accessories with a minimum of dismantling and without requiring additional pipe support after these items are removed.

3. Hangers shall be located and adjusted to distribute loads equally on attachments, maintain proper pitching of pipe, and to prevent vibration and to secure piping in place.

a. Pipe pitch shall *not* be achieved by shims or other non-approved methods.

4. Vertical risers shall be firmly supported by riser clamps, properly installed to relieve all weight from the fittings.

a. All vertical pipe shall also be supported at its base.

b. Friction clamps installed above floor slabs shall not be supported from or rest on floor sleeves.

5. Each Trade-contractor shall provide all necessary structural steel required to firmly and substantially support their equipment and distribution systems.

a. Structural steel and hardware shall conform to standard ASTM specifications

b. All supplementary steel, including factory fabricated channels and associated accessories shall be subject to the approval of the Engineer.

6. Installation of hangers which permit wide lateral motions of any pipe will not be acceptable.

   a. Vertical hanger rods to support piping from the structure or supplementary steel shall not exceed four feet in total length.

   b. Piping with over 14” of lateral movement shall be braced to prevent such movement.

7. Where piping is supported from beams, support parallel pipes from different beams.

   a. Retaining straps shall be provided with all beam clamps.

3.06 ADJUSTMENTS

A. After completion of the installation work and equipment start-ups, perform the necessary adjustments to systems installed under this Section. Submit verification that systems are operating as intended.

3.07 PIPE APPLICATIONS

A. Install Schedule 40 steel pipe with threaded joints or roll-grooved ends with grooved mechanical couplings..

B. Install Schedule 10 steel pipe only for pipe 2-1/2” and larger, with roll-grooved ends with grooved mechanical couplings.

3.08 FIRE PROTECTION PIPING INSTALLATIONS

A. Locations and Arrangements: So far as practical, install piping as indicated by approved “Working Plans”.

B. Coordinate “Working Plans” with other trades – do not run FP piping over any electrical or control panels. Adjust routing and sprinkler locations to avoid obstructions to sprinkler spray.

C. Install all beam and bar-joist clamps required for FP pipe hangers, bracing or restraints before steel is fire-proofed.

D. Run all piping as high as possible - within bar-joists, and a minimum of 2’ above the ceiling where-ever feasible.

E. All run-outs and drops to individual sprinklers are 1" unless noted otherwise. Riser nipples to single branches shall be branch size, and one size larger than branch size if feeding 2 equal size branches.

F. Where flexible sprinkler head connectors are used, comply with both UL and FM limits for maximum elbows and minimum bend radius.

1. Provide a pre-printed label on each flexible connector anchoring component, limiting the re-location of the sprinkler – see NFPA 13 2013 9.2.1.3.3.4 for suggested text

G. Grooved pipe couplings listed as "flexible" couplings shall be provided at the top and bottom of each riser (below the 4-way bracing), within 24" of building expansion joints (one side only), Grooved-pipe couplings not specified as "flexible" shall be "rigid" type.

H. Install flanges or flange adaptors on valves, apparatus, and equipment having 2-1/2 inch and larger connections.

I. Hangers and Supports: Comply with the requirements of NFPA 13. Hanger and support spacing and locations for piping joined with grooved mechanical couplings shall be in accordance with the grooved mechanical coupling manufacturer's written instructions, for rigid systems.

J. Seismic Bracing: Provide protection from earthquake damage in accordance with NFPA 13.

1. All C-clamp type fasteners for pipe hangers shall have a restraining strap. C-clamp type fasteners not permitted for seismic restraint, unless part of a listed system.

2. All mains and cross mains (regardless of size) and all branch piping 2-1/2" or larger shall be braced longitudinally within 40 ft. of the end of line (EOL) and max. 80' o.c. from there on.

3. Where hanger rods are more than 6" from the attachment to building structure to top of pipe, lateral bracing shall also be installed – within 6 ft of the EOL, and max. 40' o.c. from there on.

4. Provide vertical and lateral restraint within 3' of the end-of-line, for all branches carrying 2 or more sprinklers.

K. Make connections between underground and above-ground piping using an approved transition piece strapped or fastened to prevent separation.

L. Test and Drains: Install test connections sized and located in accordance with NFPA 13 complete with shutoff valve. Test connections may also serve as drain pipes.

M. Pressure Gages:

1. Pressure gauges shall be installed in such a manner as to cause a minimum restriction to the flow in the pipes and so that they can be easily read from the floor.

2. Install valve-pressure gage on:

a. the service entrance (before the back-flow)
b. the riser or feed main (after the riser check valve)
c. at or near each test connection.
d. On both sides of each floor-valve station control valve.

3. Provide gage with a connection not less than 1/4 inch and having a ¼-turn valve, arranged for draining pipe between gage and valve. Install gages to permit removal, and where they will not be subject to freezing.

N. Flow and Tamper Switches shall be furnished and mechanically installed by the fire protection Trade-contractor. All wiring will be done under Division 28.- Fire Alarm.

3.09 PIPE JOINT CONSTRUCTION

A. End Treatment: After cutting pipe lengths, remove burrs and fins from pipe ends.

B. Welded Joints: AWS D10.9, Level AR-3.

C. Threaded Joints: Conform to ANSI B1.20.1, tapered pipe threads for field cut threads. Join pipe, fittings, and valves as follows:

1. Note the internal length of threads in fittings or valve ends, and proximity of internal seat or wall, to determine how far pipe should be threaded into joint.

2. Align threads at point of assembly.

3. Apply appropriate tape or thread compound to the external pipe threads.

4. Assemble joint to appropriate thread depth. When using a wrench on valves, place the wrench on the valve end into which the pipe is being threaded.

5. Damaged Threads: Do no use pipe with threads which are corroded, or damaged. If a weld opens during cutting or threading operations, that portion of pipe shall not be used.

D. Flanged Joints: Align flanges surfaces parallel. Assemble joints by sequencing bolt tightening to make initial contact of flanges and gaskets as flat and parallel as possible. Use suitable lubricants on bolt threads. Tighten bolts gradually and uniformly to appropriate torque specified by the bolt manufacturer.

E. Mechanical Grooved Joints: Roll grooves on pipe ends dimensionally compatible with the couplings. No cut grooves permitted.

F. Brazed Joints: Comply with the procedures contained in the AWS “Brazing Manual.”

a. WARNING: Some filler metals contain compounds which produce highly toxic fumes when heated. Avoid breathing fumes. Provide adequate ventilation.

G. Soldered Joints: Comply with the procedures contained in the Copper Development Association “Handbook for Fire Sprinkler Systems.”

3.10 VALVE INSTALLATION

A. General: Install fire protection specialty valves, fittings, and specialties in accordance with the manufacturer’s written instructions, NFPA 13, and the authority having jurisdiction.

B. Gate Valves: Install supervised-open gate valves so located to control all sources of water supply except fire department connections. Where there is more than one control valve, provide permanently marked identification signs indicating the portion of the

system controlled by each valve.

C. Install check valves in each water supply connection.

D. Alarm Check Valves: Install valves in the vertical position, in proper direction of flow including the bypass check valve and retard chamber drain line connection. Install valve trim in accordance with the valve manufacturer's appropriate trim diagram. Test valve for proper operation.

E. Install Hose valves centered in hose cabinets. Where 26x26 cabinet is specified, installation must allow a 12" spanner wrench to be turned 360 degrees inside the cabinet.. .

3.11 SPRINKLER HEAD INSTALLATIONS

A. All sprinkler locations shown on the drawings have been carefully coordinated by the Architect for aesthetics and to avoid conflicts with other trades. Locations shall not be changed without written approval of both the Architect and the FP Engineer of Record. If layout shown must be modified to provide proper sprinkler coverage per code, notify the Engineer of Record immediately in writing

B. All ceiling-sprinklers in square ceiling tiles shall be centered in all directions, unless specifically shown otherwise. All sprinklers in rectangular-ceiling tiles shall be centered in all directions, in 1 (square) end of the tile.

C. Use proper tools to prevent damage during installations.

D. Use proper length nipples, to provide minimum required clearance from ceilings, and near-by obstructions. Install all uprights as close to the deck as possible, without being obstructed by adjacent construction. Where roof deck corrugations are over 3" deep, sprinkler distance below deck is measured to high point of deck.

E. Provide escutcheon's that completely cover ceiling openings, and sprinkler frame.

F. Provide minimum length of dry sprinkler inside heated space per NFPA Table 8.4.9.1.a.

1. For sprinklers extending outside the building, use outside temperatures of -10, and above ceiling temperatures of 40 F (minimum dry pipe inside heated space 14")

2. For sprinklers extending into walk-in coolers / freezers, use the cooler temperature, and above-ceiling temperature of 40 F.

G. Sprinkler temperature ratings shall be per NFPA 13: including (but not limited to):

1. Intermediate temperature through-out, except where high temperature are required.

2. High temperature: within 7 ft of heating equipment pressure relief valves; within 7 ft of unit heater discharge; around commercial kitchen cooking equipment, and over extra hazard spaces

H. Provide sprinkler guards for all sprinklers in the gym, mechanical spaces, under stairs, under open-joist mezzanines, in storage rooms, and where exposed and located less than 10 ft above the floor.

I. Install dry sprinklers in the 1" NPT outlet or run of a threaded Tee fitting. Do not install in a threaded elbow.

J. Upright sprinklers – install as close to the deck as possible, without creating an obstruction by adjacent trades or building structure.

3.12 FIRE DEPARTMENT CONNECTION INSTALLATIONS

A. Install automatic ball-drip valves at the check valve on the fire department connection to the mains. Pipe the drip valve outside the building, or to a floor or indirect drain, terminating below the strainer..

B. Install mechanical sleeve seal at pipe penetration in outside walls. Both sides of exterior wall penetration must be air and water sealed.

C. Install with centerline of FDC between 18" and 4' above grade.

3.13 BACKFLOW PREVENTER PERMIT AND INSTALLATION

A. All backflow prevention devices shall be approved, permitted, installed, maintained, and tested in accordance with the requirements of the State and the Local Water Authority.

B. Backflow preventer type, application, and installation shall comply with the Commonwealth of Massachusetts, Department of Environmental Protection (DEP) Drinking Water Regulations 310 CMR 22.00.

C. Prior to installation, the Trade-contractor shall submit a design data sheet, with plans showing the method of protecting the water system, and secure approval from the Local Water Authority, or its designee. This shall not be done until the Trade-contractor has secured the permit for the work, and shop drawings have been approved.

D. Mount backflow prevents horizontal at heights and with clearances per DEP regulations.

1. Double check and Reduced pressure backflow preventers shall be installed between 36 inches to 48 inches above the floor with a minimum of 12 inches clear space from back wall and 3'0" in front.

2. Provide indirect waste piping with funnel to receive discharge from backflow preventer vents and spill through air gap into floor drain.

E. Immediately upon installation, the Trade-contractor shall have the backflow preventer tested by a "Certified Backflow Prevention Device Tester", and the results recorded on the Local Water Authority's Inspection and Maintenance Report Forms. Within 14 days after the installation, the Trade-contractor shall notify the reviewing authority to arrange inspection of the installation.

F. Three (3) copies of each application and all subsequent correspondence, including the final permit, shall be forwarded to the Designer for record. Availability of final approvals or permits shall be prerequisite to scheduling a final inspection of the fire protection work.

3.14 PAINTING AND FINISHING

A. Damage and Touch Up: After installation, equipment and accessories with factory primed or finished surfaces shall be cleaned, and thoroughly inspected by the Fire Protection Trade-contractor.

1. Repair marred or damaged factory-painted or galvanized finishes with materials and procedures to match original factory finish.

2. All items so repaired and refinished shall be brought to the attention of the Designer and Owner's Project Manager for inspection and approval.

B. Materials and workmanship shall be equal to the requirements specified under Section 09 91 00 PAINTING.

C. Surfaces which will be inaccessible for painting after installation shall be painted before installation.

D. Surfaces to be painted shall be thoroughly cleaned of all scale, rust, dirt, oil and other foreign matter and shall be completely dry before applying paint.

E. Nameplates on all equipment shall be cleaned and left free of paint.

F. All unpainted, uncoated non-insulated, non-galvanized, ferrous metal surfaces on miscellaneous steel, supports, and accessories, furnished and installed by this Trade-contractor, shall be painted as follows by this Trade-contractor.

1. Concealed and Exposed - one prime coat of metal primer.

3.15 CLEAN-UP

A. At the end of each working day, the Fire Protection Trade-Contractor shall remove all his/her equipment, tools, and materials to the designated storage area, and leave all work areas in a reasonably clean condition.

B. Refer to section 01 73 00 for recycling and waste disposal requirements. Include any required costs in the bid price.

C. After completion of the work, all tools and other equipment shall be removed from the site. All excess materials shall be removed and the site left broom clean.

D. The Fire Protection-Trade-contractor shall thoroughly clean all piping and equipment inside and out before placing it in operation. All equipment, pipe, valves and fittings shall be cleaned of grease, metal cuttings and sludge which may have accumulated by operation of the system for testing.

E. If any part of a system should be stopped or damaged by any foreign matter after being placed in operation, the system shall be disconnected, cleaned, and reconnected by the installing contractor at no additional cost to the Owners.

3.16 SIGNAGE

A. Provide durable, permanently installed, readily visible from 10' away, and AHJ approved signs as follows .

1. "Building Sprinkler Control Valves" in 2-1/2" high letters on all valve-room doors.

2. "Auto Stdpipe / Sprinkler" in 1" high letters on all sprinkler fire dept. connections .

3. "Test and drain" and "for (area served)" in 2" high letters on all main and auxiliary drains.

    a. Where the area drained cannot be described on the sign, provide a color-coded, laminated, 8x11 plan showing the area drained by this drain.

4. “Control Valve” and “for (area served)” on all control valves.

5. General Information Sign – per NFPA 13 2013

6. List of spare sprinklers in spare sprinkler cabinet, with type, SIN, temperature rating, K-factor, and general description of the area where each sprinkler is used, such as “offices and classrooms”, “gym”, “walk-in-coolers”.

7. "Design hydraulics summary on each riser. Include:

    a. Location / description of area(s) calculated
    b. Number of sprinklers calculated.
    c. flow test gpm and pressures,
    d. design gpm and pressure.

8. Provide a color code, laminated, 8.5”x11” floor plan at each riser control valve, zone control valve, zone drain, and main drain, showing the area served. Drain color coding shall exclude areas that must be drained by other, auxiliary drains.

3.17 TESTING AND FLUSHING

A. Flush, test, and inspect all FP piping installed by this contractor. Assist Fire Alarm trade contractor in the testing of all FP flow switches, pressure switches, flow alarms and tamper switches.

1. Successful F/A testing of all FP trouble and alarm devices is a pre-requisite to FP substantial completion.

2. Successful F/A testing of all FP trouble and alarm devices shall be repeated 1 year after substantial completion, and is a pre-requisite to ending the warranty period.

3. Devices to be tested:

    a. FP service room - Backflow control valve tamper switches (Qty 2)
    b. FP service room – Main flow switch
    c. FP service room – Main flow switch cover tamper switch
    d. FDC – front main entrance – electric bell
    e. FDC – rear main entrance – electric bell
    f. Riser A 1st floor Zone Control valve Station (ZCV) control valve tamper switch
    g. Riser A 2nd[t] floor ZCV control valve tamper switch
    h. Riser A 3rd floor ZCV control valve tamper switch

i. Riser A Stair A-2 Roof Hydrant control valve tamper switch
j. Riser A Stair A-3 Roof Hydrant control valve tamper switch
k. Riser AB 1st floor ZCV control valve tamper switch
l. Riser AB 2nd floor ZCV control valve tamper switch
m. Riser AB 3rd floor ZCV control valve tamper switch
n. Riser AB Stair B-1 Roof Hydrant control valve tamper switch
o. Riser B1 ground floor ZCV control valve tamper switch
p. Riser B1 1stfloor ZCV control valve tamper switch
q. Riser B1 2nd floor ZCV control valve tamper switch
r. Riser B1 Stair B-2 Roof Hydrant control valve tamper switch
s. Riser B2 ground floor ZCV control valve tamper switch
t. Riser B2 1stfloor ZCV control valve tamper switch
u. Riser B2 2nd floor ZCV control valve tamper switch
v. Riser B2 Stair B-3 Roof Hydrant control valve tamper switch
w. Riser B2 Stair B-4 Roof Hydrant control valve tamper switch
x. Riser A 1st floor ZCV flow switch
y. Riser A 2ndt floor ZCV flow switch
z. Riser A 3rd floor ZCV flow switch
aa. Riser AB 1st floor ZCV flow switch
bb. Riser AB 2nd floor ZCV flow switch
cc. Riser AB 3rd floor ZCV flow switch
dd. Riser B1 ground floor ZCV flow switch
ee. Riser B1 1stfloor ZCV flow switch
ff. Riser B1 2nd floor ZCV flow switch
gg. Riser B2 ground floor ZCV flow switch
hh. Riser B2 1stfloor ZCV flow switch
ii. Riser B2 2nd floor ZCV flow switch
jj. Riser A 1st floor ZCV flow switch cover tamper switch
kk. Riser A 2ndt floor ZCV flow switch cover tamper switch
ll. Riser A 3rd floor ZCV flow switch cover tamper switch
mm. Riser AB 1st floor ZCV flow switch cover tamper switch
nn. Riser AB 2nd floor ZCV flow switch cover tamper switch
oo. Riser AB 3rd floor ZCV flow switch cover tamper switch
pp. Riser B1 ground floor ZCV flow switch cover tamper switch
qq. Riser B1 1stfloor ZCV flow switch cover tamper switch
rr. Riser B1 2nd floor ZCV flow switch cover tamper switch
ss. Riser B2 ground floor ZCV flow switch cover tamper switch
tt. Riser B2 1stfloor ZCV flow switch cover tamper switch
uu. Riser B2 2nd floor ZCV flow switch cover tamper switch

B. Inspect the installation of, and witness the flushing and testing of all FP-only underground piping installed by the site contractor (site contractor to perform actual underground flushing and pressure testing.). Provide a NFPA 13 underground test and materials certificate based on witnessing the work..

1. General Contractor shall certify that the site contractor has thoroughly flushed the main underground loop per the following criteria prior to flushing the FP-only service line:

2. All main underground loop piping shall be flushed out an open, 4” hydrant butt, or maximum-15’-long, 4” hose, Flush out of the hydrant closest to the mid-point of the loop.

3. 1 side of the main underground loop piping shall be flushed at a time, to ensure maximum water velocity thru that half-loop.

4. Flush for a minimum of 30 seconds per 100 ft of underground pipe.

C. Flushing FP-only service line into building:

1. The FP service line shall be flushed out a hose manifold that provides a combined, minimum 45 square inches of free-cross-sectional area. Options include:

   a. 3, 4" hoses
   b. 7, 3" hoses
   c. 10, 2-1/2" hoses.

2. Maximum length per hose: 50 ft.

3. Flush for a minimum of 30 seconds per 100 ft of FP-only underground length.

D. Flush, test, and inspect interior systems in accordance with NFPA 13 and the State Building Code. All labor, materials, instruments, devices and power required for testing and flushing shall be provided by this Trade-contractor.

1. Prior to testing, the system shall be thoroughly flushed with clean water.

2. Flushing and pressure testing shall be performed in the presence of the Designer or Owner's Project Manager and such other Authorities Having (legal) Jurisdiction (AHJs).

3. No piping in any location shall be closed up, furred in, or covered before testing and approval by the Local AHJ and Owner's Project Manager. Where portions of piping systems are to be covered or concealed before completion of the project, those portions shall be tested separately in the manner specified for the entire system.

E. This Trade-contractor shall notify the Designer, Owner's Project Manager and all AHJs, a minimum of 1 week in advance of flushing or any required tests, so they may be present to witness the tests

F. Test Criteria: -

1. Piping shall be pressure tested, and when directed by the Designer, Local Fire Department or Owner's Project Manager shall be tested for stability of support.

G. Test Procedures:

1. Test piping prior to installation of ceilings, to permit easy inspection of all joints.

2. Subject piping to a two-hour water-pressure test at 200 psi per N.F.P.A. and the User Agency's Insurance Underwriter. Air-pressure test is not an acceptable substitute. Piping shall be repaired until such tests show no leaks. Where required, and depending on the building timing and schedule, the system may be required to be tested without final swing elbows and heads installed. In this case, a second test will be required upon installation of swing elbows and heads.

3. Results of tests shall be recorded and submitted using the forms in NFPA #13, for review by the Engineer. The Material and Test Certificate shall also be sent to the Owner's Project Manager and User Agency's Insurance Underwriter.

4. Material and test certificates must be signed by the Owner's Project Manager prior to and upon completion of testing. Final test reports must be approved in writing by local authorities.

5. This Trade-contractor shall ensure that the underground piping from the street main and service entry piping has been tested to 200 psig in accordance with NFPA 24 requirements. This shall be recorded separately from the interior piping. Coordinate this with the site water piping installer.

H. Failed Tests, Re-testing, and Damage Caused by Testing:

1. Repair, or if directed by the Fire Protection Engineer of Record or Owner's Project Manager, replace any defective work with new work without extra cost to the Owner or Engineer. Repeat tests until the work is proven to meet the requirements specified herein.

2. Caulking of screwed joints or holes in piping will not be acceptable.

3. Any piping or equipment that has been left unprotected and subject to mechanical or other injury in the opinion of Owner's Project Manager shall be retested.

4. Restore to its finished condition any work, provided by other Contractors, damaged or disturbed by tests. The Fire Protection Trade-contractor shall engage the original Contractor to do the work of restoration to the damaged or disturbed work.

I. Testing with Other Systems:

1. Provide all necessary and appropriate personnel to participate in and coordinate fire protection systems with all fire alarm testing, or other systems testing which may interface with fire protection system.

2. Participation shall include all preliminary testing prior to official testing, and any re-testing if required.

J. Insurance Compliance: Where Insurance Service Office (ISO) approval is required, the Fire Protection Trade-Contractor shall be sure that:

1. That plans and calculations are sent for review to ISO, 100 Newport Avenue, CS1700, Quincy, MA 02269, and that all required changes are made.

2. The certificate covering materials and tests is filed with ISO.

3. That ISO has been given the proper notification, and that they are present for the 2" main drain test.

4. That the underground test certificate is filed with ISO. Coordinate with the Site Contractor.

3.18 INSPECTION OF WORK

A. The Fire Protection Engineer of Record will check the completed installation either sequentially as different parts are completed, or when the entire installation is complete, at the sole option of the Designer.

B. Prior to the Fire Protection Engineer of Record 's final inspection, the Fire Protection Trade-Contractor shall submit a letter signed by an officer of the company stating that:

1. he is an officer of the company,

2. he has personally inspected the installation to be checked,

3. the date of his inspection,

4. the installation is complete and tested and ready to be inspected by the Fire Protection Engineer of Record, and that all required test reports have been submitted.

C. Items noted as deficient during the inspection will be compiled in a “punch list”, and issued to the Fire Protection Trade-Contractor.

1. The fire-protection contractor shall notify the engineer in writing when all punch items are believed to be complete.

2. If the engineer identifies punch items still not completed, the contractor shall have a qualified installer on site during all subsequent inspections by the engineer, to ensure that all remaining issues are fully understood as to location and work required.

3. All punch items must be satisfactorily completed prior to final payment.

3.19 SPARE STOCK

A. Provide a Spare-Sprinkler Cabinet with 6 spare sprinkler heads of each type, K-factor, and temperature rating on the project. Include in the cabinet, a typed, laminated list of all spare sprinklers provided, including sprinkler type and SIN, K-factor, temperature rating, and locations they are used.

END OF SECTION

SECTION 21 08 00

COMMISSIONING OF FIRE SUPPRESSION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this section.

1.2 SUMMARY

A. This section includes commissioning process requirements for Fire Suppression systems, assemblies, and equipment.

B. Related Sections:

1. Division 01 Section "General Commissioning Requirements" for general commissioning process requirements.

1.3 DESCRIPTION

A. Refer to Division 01 Section “General Commissioning Requirements” for the description of commissioning.

1.4 DEFINITIONS

A. Refer to Division 01 Section “General Commissioning Requirements” for definitions.

1.5 SUBMITTALS

A. Refer to Division 01 Section “General Commissioning Requirements” for CxA’s role.

B. Refer to Division 01 Section “Submittals” for specific requirements. In addition, provide the following:

C. Certificates of readiness

D. Certificates of completion of installation, prestart, and startup activities.

E. O&M manuals

F. Test reports

1.6 QUALITY ASSURANCE

A. Test Equipment Calibration Requirements: Contractors will comply with test manufacturer's calibration procedures and intervals. Recalibrate test instruments immediately after instruments have been repaired resulting from being dropped or damaged. Affix calibration tags to test instruments. Furnish calibration records to CxA upon request.

1.7 COORDINATION

A. Refer to Division 01 Section "General Commissioning Requirements" for requirements pertaining to coordination during the commissioning process.

PART 2 - PRODUCTS

2.1 TEST EQUIPMENT

A. All standard testing equipment required to perform startup, initial checkout and functional performance testing shall be provided by the contractor for the equipment being tested. For example, the fire protection contractor of Division 21 shall ultimately be responsible for all standard testing equipment for the plumbing system in Division 21.

B. Special equipment, tools and instruments (specific to a piece of equipment and only available from vendor) required for testing shall be included in the base bid price to the Owner and left on site, except for stand-alone data logging equipment that may be used by the CxA.

C. Proprietary test equipment and software required by any equipment manufacturer for programming and/or start-up, whether specified or not, shall be provided by the manufacturer of the equipment. Manufacturer shall provide the test equipment, demonstrate its use, and assist in the commissioning process as needed. Proprietary test equipment (and software) shall become the property of the Owner upon completion of the commissioning process.

D. All testing equipment shall be of sufficient quality and accuracy to test and/or measure system performance with the tolerances specified in the Specifications. If not otherwise noted, the following minimum requirements apply: Temperature sensors and digital thermometers shall have a certified calibration within the past year to an accuracy of 0.5°F and a resolution of + or - 0.1°F. Pressure sensors shall have an accuracy of + or - 2.0% of the value range being measured (not full range of meter) and have been calibrated within the last year.

PART 3 - EXECUTION

3.1 GENERAL DOCUMENTATION REQUIREMENTS

A. With assistance from the installing contractors, the CxA will prepare Pre-Functional Checklists for applicable commissioned components, equipment, and systems.

B. Red-lined Drawings: The contractor will verify all equipment, systems, instrumentation, wiring and components are shown correctly on red-lined drawings. Preliminary red-lined drawings must be made available to the Commissioning Team for use prior to the start of Functional Performance Testing. Changes, as a result of Functional Testing, must be incorporated into the

final as-built drawings, which will be created from the red-lined drawings. The contracted party, as defined in the Contract Documents will create the as-built drawings.

C. Operation and Maintenance Data: Contractor will provide a copy of O&M literature within 45 days of each submittal acceptance for use during the commissioning process for all commissioned equipment and systems. The CxA will review the O&M literature once for conformance to project requirements. The CxA will receive a copy of the final approved O&M literature once corrections have been mad by the contractor.

D. Demonstration and Training: Contractor will provide demonstration and training as required by the specifications. A complete training plan and schedule must be submitted by the contractor to the CxA four weeks (4) prior to any training. A training agenda for each training session must be submitted to the CxA one (1) week prior the training session

3.2 CONTRACTOR'S RESPONSIBILITIES

A. Perform tests that are specified in the Division 21.

B. Attend construction phase coordination meetings.

C. Participate in Fire Suppression systems, assemblies, equipment, and component maintenance orientation and inspection as directed by the CxA.

D. Provide information requested by the CxA for final commissioning documentation.

E. Include requirements for submittal data, operation and maintenance data, and training in each purchase order or sub-contract written.

F. Prepare preliminary schedule for Fire Suppression system orientations and inspections, operation and maintenance manual submissions, training sessions, flushing and cleaning, equipment start-up, and task completion for owner. Distribute preliminary schedule to commissioning team members.

G. Update schedule as required throughout the construction period.

H. Assist the CxA in all verification and functional performance tests.

I. Provide measuring instruments and logging devices to record test data, and provide data acquisition equipment to record data for the complete range of testing for the required test period.

J. Gather operation and maintenance literature on all equipment, and assemble in binders as required by the specifications. Submit to CxA 45 days after submittal acceptance.

K. Coordinate with the CxA to provide 48-hour advance notice so that the witnessing of equipment and system start-up and testing can begin.

L. Participate in, and schedule vendors and contractors to participate in the training sessions.

M. Provide written notification to the CM/GC and CxA that the following work has been completed in accordance with the contract documents, and that the equipment, systems, and sub-system are operating as required.
   1. Life Safety/Fire Suppression equipment including pumps, piping, and all other equipment furnished under this Division.

2. Automatic sprinkler and standpipe systems.
3. Fire stopping in fire rated construction, including caulking, gasketing and sealing of smoke barriers.

N. The equipment supplier shall document the performance of his equipment.

O. Provide a complete set of red-lined drawings to the CxA prior to the start of Functional Performance Testing.

P. Equipment Suppliers
1. Provide all requested submittal data, including detailed start-up procedures and specific responsibilities of the Owner, to keep warranties in force.
2. Assist in equipment testing per agreements with contractors.
3. Provide information requested by CxA regarding equipment sequence of operation and testing procedures.

Q. Refer to Division 01 Section “General Commissioning Requirements” for additional contractor responsibilities.

3.3 CxA'S RESPONSIBILITIES

A. Refer to Division 01 Section “General Commissioning Requirements” for CxA’s Responsibilities.

3.4 TESTING PREPARATION

A. Certify in writing to the CxA that Life Safety/Fire Suppression systems, subsystems, and equipment have been installed, calibrated, and started and are operating according to the Contract Documents.

B. Certify in writing to the CxA that Life Safety/Fire Suppression instrumentation and control systems have been completed and calibrated, that they are operating according to the Contract Documents, and that pretest set points have been recorded.

C. Set systems, subsystems, and equipment into operating mode to be tested (e.g., normal shutdown, normal auto position, normal manual position, unoccupied cycle, emergency power, and alarm conditions).

D. Inspect and verify the position of each device and interlock identified on checklists.

E. Check safety cutouts, alarms, and interlocks with smoke control and life-safety systems during each mode of operation.

F. Testing Instrumentation: Install measuring instruments and logging devices to record test data as directed by the CxA.

3.5 GENERAL TESTING REQUIREMENTS

A. Provide technicians, instrumentation, and tools to perform commissioning test at the direction of the CxA.

B. Scope of Life Safety/Fire Protection testing shall include entire Fire Suppression installation. Testing shall include measuring capacities and effectiveness of operational and control functions.

C. Test all operating modes, interlocks, control responses, and responses to abnormal or emergency conditions.

D. The CxA along with the Fire Suppression contractor shall prepare detailed testing plans, procedures, and checklists for Fire Suppression systems, subsystems, and equipment.

E. Tests will be performed using design conditions whenever possible.

F. Simulated conditions may need to be imposed using an artificial load when it is not practical to test under design conditions. Before simulating conditions, calibrate testing instruments. Provide equipment to simulate loads. Set simulated conditions as directed by the CxA and document simulated conditions and methods of simulation. After tests, return settings to normal operating conditions.

G. The CxA may direct that set points be altered when simulating conditions is not practical.

H. The CxA may direct that sensor values be altered with a signal generator when design or simulating conditions and altering set points are not practical.

I. If tests cannot be completed because of a deficiency outside the scope of the Fire Suppression system, document the deficiency and report it to the Owner. After deficiencies are resolved, reschedule tests.

J. If the testing plan indicates specific seasonal testing, complete appropriate initial performance tests and documentation and schedule seasonal tests.

3.6 FIRE SUPPRESSION SYSTEMS, SUBSYSTEMS, AND EQUIPMENT TESTING PROCEDURES

A. Equipment Testing and Acceptance Procedures: Testing requirements are specified in individual Division 21 sections. Provide submittals, test data, inspector record, and certifications to the CxA.

B. Fire Suppression Distribution System Testing: Provide technicians, instrumentation, tools, and equipment to test performance of sprinkler distribution systems.

C. The work included in the commissioning process involves a complete and thorough evaluation of the operation and performance of all components, systems and sub-systems. The following equipment and systems shall be evaluated:

Fire Suppression Systems
Fire suppression systems

3.7 DEFICIENCIES/NON-CONFORMANCE, COST OF RETESTING, FAILURE DUE TO MANUFACTURER DEFECT

A. Refer to Division 01 Section “General Commissioning Requirements” for requirements pertaining to deficiencies/non-conformance, cost of retesting, or failure due to manufacturer defect.

3.8 APPROVAL

A. Refer to Division 01 Section “General Commissioning Requirements” for approval procedures.

3.9 DEFERRED TESTING

A. Refer to Division 01 Section “General Commissioning Requirements” for requirements pertaining to deferred testing.

3.10 OPERATION AND MAINTENANCE MANUALS

A. The Operation and Maintenance Manuals shall conform to Contract Documents requirements as stated in Division 01.

B. Refer to Division 01 Section “General Commissioning Requirements” for the AE and CxA roles in the Operation and Maintenance Manual contribution, review and approval process.

3.11 TRAINING OF OWNER PERSONNEL

A. Refer to Division 01 Section “General Commissioning Requirements” for requirements pertaining to training.

END OF SECTION 21 08 00

SECTION 22 00 00

PLUMBING

(Filed Sub-Bid Required)

PART 1 - GENERAL

1.1 PUBLICLY BID TRADE CONTRACTOR

A. Sub-bids for work under this Section shall be for the complete work and shall be filed in a sealed envelope with the City of Worcester, Department of Public Works and Parks, Architectural Division, 50 Skyline Drive, Worcester, MA 01605 at time and place stipulated in the “Invitation to Bid/Notice to Contractors”. The following shall appear on the upper left hand of the envelope:

Name of Sub-Bidder: *Print Name of Sub-bidder*

Project: SOUTH HIGH COMMUNITY SCHOOL

Sub-Bid for Section: 22 00 00 - PLUMBING

B. Each sub-bid submitted for work under this Section shall be on forms furnished by the City of Worcester as required by Section 44F of Chapter 149 of the General Laws, as amended. Sub-Bid forms may be obtained at the Department of Public Works and Parks, Architectural Division, 50 Skyline Drive, Worcester, MA 01605 in person, or by written request.

C. Sub-bids filed with the City of Worcester shall be accompanied by a BID BOND or CASH or CERTIFIED CHECK or a TREASURER’S or CASHIER’S CHECK issued by a responsible bank or trust company payable to the City of Worcester in the amount of five (5) percent of the bid. A sub-bid accompanied by any other form of bid deposit than those specified will be rejected.

D. Additional Requirements:

1. Sub-bidder's attention is directed to Massachusetts G.L. Chapter 149 §44H, as amended, which provides in part as follows:
2. Each sub-bidder shall list in Paragraph E of the "Form for Sub-bids" the name and bid price of each person, firm or corporation performing each class of work or part thereof for which the Section of the Specifications for that sub-subtrade requires such listing, provided that, in the absence of a contrary provision in the Specifications, any sub-bidder may, without listing any bid price, list his own name or part thereof and perform that work with persons on his own payroll, if such sub-bidders, after sub-bid openings, shows to the satisfaction of the Awarding Authority that he does customarily perform such class of work with persons on his own payroll and is qualified to do so. This Section of the Specifications requires that the following classes of work shall be listed in Paragraph E under the conditions indicated herein.
   Sub-Subs required:

Class of Work	Reference Spec.	Paragraphs
Insulation	22 00 00	2.10; 3.14

E. The work to be completed by the Trade Contractor for the work of this Section is shown on the following listed Drawings, not just those pertaining particularly to this Trade

Contract, unless specifically called out otherwise, regardless of where among the Drawings it appears:

1. The Work of this Trade Contract is shown on the following Drawings:
   P2.1, P2.2, P2.3, P2.4, P3.1, P3.2, P3.3, P3.4, P3.5, P3.6, P3.7, P3.8, P3.9, P3.10, P3.11, P3.12, P3.13, P3.14, P3.15, P3.16, P4.1, P4.2, P4.3, P4.4, P4.5, P4.6, P4.7, P4.8, P4.9, P4.10

2. Related items which may require coordination or impact work of this trade are shown on the following Drawings:
   EX1.0, EX2.0, EX2.1, EX2.2, EX2.3, EX2.4, C1.0, C2.0, C3.0, C3.1, C3.2, C3.3, C3.4, C4.0, C4.1, C4.2, C4.3, C4.4, C5.0, C5.1, C5.2, C5.3, C5.4, C6.0, C6.1, C6.2, C6.3, C7.0, C7.1, C7.2, C7.3, C7.4, C8.0, C8.1, C8.2, C8.3, C8.4, C9.0, C9.1, C9.2, C9.3¸C9.4, C10.0 C10.1, C10.2, C10.3, C10.4, C10.5, C10.6, C10.7, C11.0, C11.1, C11.2, C11.3, C11.4, C11.5, C11.6, C11.7, CA1.1, CA2.1, CA2.2, CA3.1, CA3.2, CA3.3, CA4.1, CA4.2, CA4.3, CA4.4, CA4.5, CA4.6, CA4.7, CA4.8, L1.0, L2.0, L2.1, L2.2, L2.3, L2.4, L2.5, L2.6, L2.7, L2.8, L2.9, L3.0, L3.1, L3.2, L3.3, L3.4, L3.5, L4.0, L4.1, L4.2, L4.3, L5.0, L5.1, L5.2, L5.3, L5.4, L5.5, L5.6, S1.1, S1.2, S1.3, S3.1, S3.2, S3.3, S3.4, S3.5, S3.6, S3.7, S3.8, S3.9, S3.10, S3.11, S3.12, S3.13 S3.14, S3.15, S3.16, S4.11, S4.12, S4.13, S4.14, S4.15, S4.16, S4.17, S4.18, S4.19, S4.20, S4.21, S4.22, S4.23, S4.24, S5.1, S5.2, S5.3, S5.4, S5.5, S5.6, S6.1, S7.1, S7.2, S7.3, S7.4, S7.5, AD1.0, A1.1, A2.1, A2.2, A2.3, A2.4, A2.5, A3.0, A3.0A, A3.1, A3.2, A3.3, A3.4, A3.5, A3.6, A3.7, A3.8, A3.9, A3.10, A3.11, A3.12, A3.13, A3.14, A3.15, A3.16, A3.17, A3.18, A4.1, A4.2, A4.3, A4.4, A4.5, A4.6, A4.7, A4.8, A4.9, A4.10, A4.11, A4.12, A5.0, A5.1, A5.2, A5.3, A5.4, A5.5, A5.6, A5.7, A5.8, A5.11, A5.12, A6.1, A6.2, A6.3, A6.4, A6.5, A6.6, A6.7, A6.8, A6.11, A6.12, A6.13, A6.14, A6.15, A6.16, A6.17, A6.18, A6.21, A6.22, A6.23, A6.24, A6.25, A6.26, A6.27, A6.28, A6.29, A6.31, A6.32, A6.33, A6.34, A6.35, A7.1, A7.2, A7.3, A7.4, A7.5, A7.6, A7.7, A8.1, A8.2, A8.3, A8.4, A8.5, A8.6, A8.7, A8.8, A8.9, A8.10, A8.11, A8.12, A8.13, A8.14, A8.15, A8.16, A8.17, A8.18, A8.19, A8.20, A8.21, A8.22, A8.23, A8.24, A8.25, A8.26, A8.27, A8.28, A8.29, A9.1, A9.2, A9.3, A9.4, A9.5, A9.6, A10.1, A10.2, A10.3, A10.4, A11.1, A11.2, A11.3, A12.1, A12.2, A12.3, A12.4, A12.5, A12.6, A12.7, A12.8, A12.9, , A12.10, A12.11, A12.12, K1.1, K1.2, K1.3, K2.1, K2.2, K2.3, K2.4, K3.1, K3.2, K3.3, K3.4, K3.5, K3.6, K3.7, K4.1, K4.2, K4.3, K4.4, K4.5, K4.6, K5.1, K5.2, K6.1,K6.2, K6.3, K6.4, K6.5, FP1.1, FP1.2, FP1.3, FP1.4, FP4.1, FP4.2, FP4.3, FP4.4, FP4.5, FP4.6, FP4.7, FP4.8, FP4.9, FP4.10, FP4.11, FP4.12, FP7.1, P2.1, P2.2, P2.3, P2.4, P3.1, P3.2, P3.3, P3.4, P3.5, P3.6, P3.7, P3.8, P3.9, P3.10, P3.11, P3.12, P3.13, P3.14, P3.15, P3.16, P4.1, P4.2, P4.3, P4.4, P4.5, P4.6, P4.7, P4.8, P4.9, P4.10, H3.1, ,H,3.2, H3.3, H3.4, H3.5, H3.6, H3.7, H3.8, H3.9, H3.10, H3.11, H3.12, H3.13, H3.14, H3.15, H3.16, H4.1, H4.2, H4.3, H4.4, H4.5, H4.6, H4.7, H4.8, H4.9, H4.10, H4.11, H4.12, H5.1, H5.2, H5.3, H6.1, H6.2, H6.3, H7.1, H7.2, H7.3, AV0.0, AV0.1, AV0.2, AV3.3, AV3.4, AV3.5, AV3.7, AV3.8, AV3.9, AV3.10, AV3.18, AV4.5, AV4.6, AV4.7, AV4.8, AV4.9, AV5.0, AV5.1, AV5.2, AV5.3, AV5.4, AV5.5, AV5.6, AV5.7, AV6.1, AV6.2, AV6.3, AV7.1, AV7.2, TL1, TL2, TL3, TL4, TR1, TR2, TR3, TR4, E0.1, E0.2, E0.3A, E0.3B, E0.3C, E0.3D, E0.4A, E0.4B, E0.4C, E0.4D, E0.4E, E0.4F, E0.5, E0.6, E0.7, E0.8, E0.9, E1.1, E1.2, E1.3, E1.4, E1.5, E1.6, E1.7, E1.8, E1.9, E1.10, E1.11, E1.12, E1.13, E1.14, E2.1, E2.2, E2.2A, E2.3 ,E2.4 ,E2.4A, E2.4B, E2.5, E2.6, E2.7, E2.8, E2.9, E2.10, E2.11, E2.12, E3.1, E3.2, E3.3, E3.4 , E3.5, E3.6, E3.7, E3.8, E3.9, E3.10, E3.11, E3.12, E3.13, E3.14, E3.15, E3.16, E3.17, E3.18, E4.1, E4.2, E4.3, E4.4, E4.5, E4.6, E4.7, E4.8, E4.9, E4.10, E4.11, E4.12, E5.1, E5.2, E5.3, E5.4, E5.5, E5.6, E5.7, E5.8, E5.9, E5.10, E5.11, E5.12, E5.13, E5.14, E5.15, E5.16, E6.1, E6.2, E6.3, E6.4, E6.5, E6.6A, E6.6B, E6.7A, E6.7B, E6.7C, E7.0, E7.1, E7.2, E7.3, E7.4, E7.5, E7.6, E7.7, E8.0A, E8.0B, E8.0C, E8.0D, E8.0E, E8.0F, E8.0G, E8.1A, E8.1B, E8.2A, E8.2B, E8.2C, E8.2D, E8.3A, E8.3B, E8.3C, E8.3D, E8.4A, E8.4B,

E8.4C, E8.5A, E8.5B, E8.5C, E8.5D, E8.6A, E8.6B, E8.7, E8.8A, E8.8B, E8.8C, E9.01, E9.02, E9.03, E9.04, E9.05, E9.06, E9.07, E9.08, E9.09, E9.10, E9.11, E9.12, E9.13, E9.14, E9.15

3. The complete List of Drawings for the Project is provided in Section 00 01 15 – LIST OF DRAWINGS.

1.2 SCOPE

A. Perform work and provide material and equipment as required for a complete and operational plumbing system as shown on the Drawings and as specified in this Section. Completely coordinate with work of other trades and provide for complete and fully functional installation.

B. The work shall include, but is not limited to, the following major items of work:

1. Sanitary waste and vent systems within the building to 10 ft. 0 in. outside the building installed with all incidentals necessary for a complete operational system. The system shall include all piping, traps, flanges, seals, cleanouts, structural support (carriers, hangers), roof terminals, fixtures, floor drains and such other standard accessories as are necessary for a complete approved system.

2. Garage waste and vent systems within the building to gas/sand trap outside the building installed with all incidentals necessary for a complete operational system. The system shall include all piping, traps, flanges, seals, cleanouts, structural support (carriers, hangers), roof terminals, trench drain and such other standard accessories as are necessary for a complete approved system. Gas/sand trap is furnished and installed by the Site Contractor, but piped by the Plumbing Contractor.

3. Grease waste and vent system within the building to exterior grease interceptor inlet and outlet installed with all incidentals necessary for a complete operational system. The system shall include all piping (especially sanitary tees within grease interceptor), traps, flanges, seals, cleanouts, structural support (carriers, hangers), roof terminals, fixtures, floor drains, floor sinks, interior grease interceptors with flow control fittings, floor access panel for flow control valve and such other standard accessories as are necessary for a complete approved system. The exterior grease interceptor is furnished and installed by the Site Contractor, but piped by the Plumbing Contractor.

4. Storm drainage system within the building to 10 ft. 0 in. outside the building installed with all incidentals necessary for a complete operational system. The system shall include all roof drains with primary and overflow drains, emergency overflow terminations (i.e. downspout nozzles), piping, traps, flanges, seals, cleanouts, structural support (hangers), insulation, and such other standard accessories as are necessary for a complete approved system. New roof drains and emergency roof drains shall be furnished and installed by the Plumbing Subcontractor. The canopy primary roof drains will require electric heat trace.

5. Cold water system connecting each and every fixture, device, and item of equipment requiring cold water within the building including the water service entrance. The system shall be installed with all incidentals necessary for a complete operational system and shall include all piping, pressure reducing valves, insulation, valves, stops, hydrants, backflow preventers, vacuum breakers, gauges, structural support (hangers), water hammer arresters, trap primer valves, hose bibbs, sillcocks and such other standard or specified accessories as are necessary for a complete

approved system. This Contractor's work shall begin at flange provided by the Site Subcontractor.

6. Hot water system connecting each and every fixture, device, and item of equipment requiring hot water within the building. The system shall be installed with all incidentals necessary for a complete operational system and shall include gas-fired hot-water boilers, storage tanks, electric water heaters, all piping, insulation, valves, stops, backflow preventers, vacuum breakers, gauges, recirculation pumps, tempering/mixing valves, structural support (hangers, etc.), water hammer arresters, thermometers, dedicated gas-fired tank type water heater for lab hot water system, and such other standard or specified accessories as are necessary for a complete approved system.

7. Tempered hot water system connecting each and every emergency fixture requiring tempered hot water within the building. The system shall be installed with all incidentals necessary for a complete operational system and shall include emergency plumbing fixtures, emergency thermostatic mixing valves, all piping, valves, gauges, recirculation pumps, structural support (hangers, etc.), thermometers, and such other standard or specified accessories as are necessary for a complete approved system. Tempered water lines for the science room emergency fixtures shall be recirculated back to the mixing valve, not the water heater. Note: since the water temperature in this system should be between 60˚F and 70˚F, no pipe insulation is required per code.

8. Natural gas piping system connecting each and every fixture, device, and item of equipment requiring gas within the building from the outdoor gas meter. The system shall be installed with all incidentals necessary for a complete operational system and shall include all natural gas piping, valves, stops, drips, pressure reducing valves, vents to atmosphere from water heaters and heating boilers (verify if required), gas regulators, gauges, structural support (hangers), science room gas turrets, science room emergency gas shut-offs, kitchen carbon monoxide detection system with solenoid valve and such other standard or specified accessories as are necessary for a complete approved system.

    a. In both kitchens, in addition to the gas panel with associated sensors and solenoid valve with interlocks, the plumber shall provide an electrical relay panel with EPO's (Emergency Power Off Buttons). The intent is to have the same manufacturer of these panels so that they can be interlocked easier. The electrical contractor shall:
        - Provides power to gas panel and relay panel and wiring from relay panel to shunt trip circuit breaker.
        - Provides contact closure from fire alarm panel to gas panel to shut off solenoid valves in the event that fire alarm system provided CO or natural gas detector is activated.
        - Fire alarm system will not monitor the gas panel alarms.

9. Acid waste and vent system within the building as indicated on the Drawings. System shall be installed with all incidentals necessary for a complete operational system and shall include an active pH neutralizing system with a tank mounted in a concrete vault with FRP cover, p-trap mounted after neutralizing tank with probe, chemical storage tanks with containment, pumps and mixers and interconnecting piping and wiring, pH monitoring system, all corrosion resistant piping, traps, running trap, shut-off valve, flanges, seals, cleanouts, structural supports (hangers), roof terminals, and such other standard accessories as are necessary for a complete approved system. Acid

waste piping shall continue to 10 ft. 0 in. beyond the building foundation before connecting to the sanitary waste piping.

10. Compressed air system for the Auto/Diesel Garage connecting each and every gas air outlet to the compressed air system. The system shall be installed with all incidentals necessary for a complete operational system and shall include all compressed air piping, valves, filters, flexible connectors, quick-connect fittings, air safety shut-off valves, electric drain valve, and such other standard accessories as are necessary for a complete approved system. The air compressor with integral air dryer and the air receiver tank are provided under the garage equipment package.

11. Radon system connecting to the underground piping and rising through the building to a ventilation mast with two inline fans for each system (6 systems total). The system shall be installed with all incidentals necessary for a complete operational system and shall include all perforated PVC piping below grade, solid PVC piping above grade in the building, stainless steel mast above the roof, radon fans (furnished by HVAC Contractor to Plumber for installation), guy wires, supports, and such other standard or specified accessories as are necessary for a complete approved system.

12. Plumbing Subcontractor (i.e. licensed gas-fitter) shall be responsible for furnishing and installing the flue and combustion air piping for the domestic hot water heaters (boilers and tank-type water heater). The HVAC Subcontractor shall be responsible for installing the flue for the heating boilers, but they shall be installed by a licensed gas-fitter on their staff and the HVAC Company shall have a gas-fitters license. Flues shall be installed with all incidentals necessary for a complete system in order for the domestic hot water heaters/boilers to operate properly and shall include all piping, drip legs, pipe tees for condensate collection, structural supports, and vent terminals per manufacturer's instructions. All flue and combustion air piping shall be labelled. Coordinate combustion air piping termination into louver plenum with the HVAC Contractor.

13. Provide all plumbing fixtures and equipment as required by drawings and as specified. All laboratory faucets and accessories (including gas turrets; dishwasher, refrigerator and ice maker connections) are by the Plumbing Subcontractor. All laboratory sinks are specified by the architect under laboratory casework. All fume hoods are by others and will have integral cup sink, faucet and gas outlet.

14. All rough plumbing and final connections to all items of equipment furnished by others requiring water, gas, drain, and waste connections. Furnish and install all traps with cleanouts and heavy duty brass loose key angle valve supply stop kits. The plumbing contractor is responsible for installing kitchen equipment that requires plumbing.

15. Furnish Access Panels to G.C. for installation by others.

16. Provide all Outdoor Restroom and Storage Building plumbing including fixtures, electric water heater, floor drains, hose bibs, domestic water service, oil interceptor and all other plumbing indicated. The plumbing systems shall be installed with all incidentals necessary for a complete operational systems

17. The Plumbing Subcontractor shall be responsible for furnishing and installing all items in accordance with the National & Massachusetts Fuel Gas Code and Massachusetts State Plumbing Code. Plumbing fixtures and equipment shall be Massachusetts Plumbing Board Product Approved and shall have a product approval number.

18. This Contractor shall be responsible for all seismic control for the entire plumbing piping system and equipment (school used for emergency shelter).

19. Obtain all permits and approvals required for work under this Section.

C. Alternates: Special attention is called to the fact that it shall be the responsibility of all the General and Subcontractors to thoroughly examine all the alternates and evaluate for themselves as to whether or not these alternates in any way affect their respective section. In the event that a Contractor feels that any alternate(s) do reflect a cost difference, additional or a deduction in his bid proposal, then he shall so stipulate this sum and/or sums under the proper alternate(s) as provided for the bid proposals. Failure to do so will in no way relieve the hereinbefore stated contractors of their responsibilities regardless of what alternate(s) are selected at no extra cost will be charged to the Owner. Refer to Section 01 23 00, ALTERNATES for the list and description of Alternates.

D. Reference to Drawings: Work specified in Plumbing is subject to provisions of Section 44A to 44L inclusive, of Chapter 149 of General Laws of Massachusetts, as amended, and are indicated on all of the Contract Drawings. The Plumbing Work is shown on drawings P2.1, P2.2, P2.3, P2.4, P3.1, P3.2, P3.3, P3.4, P3.5, P3.6, P3.7, P3.8, P3.9, P3.10, P3.11, P3.12, P3.13, P3.14, P3.15, P3.16, P4.1, P4.2, P4.3, P4.4, P4.5, P4.6, P4.7, P4.8, P4.9 and P4.10.

1. The Plumbing Subcontractor shall refer to all the Drawings enumerated in the List of Drawings on the title sheet for a full comprehension of the work to be done and for conditions affecting the location and placement of his equipment and materials. These Drawings are intended to be supplementary to the Specifications and any work indicated, mentioned, or implied in either is to be considered as specified by both. Should the character of the work herein contemplated or any matter pertaining thereto be not sufficiently explained in the Specifications or Drawings, the Plumbing Subcontractor may apply to the Architect-Engineer for further information and shall conform to such when given, as it may be consistent with the original intent. The Architect-Engineer reserves the right to make any reasonable changes in location prior to installation at no expense to the Owner. All lines are diagrammatic and exact locations are subject to the approval of the Architect-Engineer.

2. Before submitting his bid, the Plumbing Subcontractor shall visit the site with the Drawings and Specifications and shall become thoroughly familiar with all conditions affecting his work since the Plumbing Subcontractor will be held responsible for any assumption he may make in regard thereto.

3. The Plumbing Subcontractor shall, at all times, have a foreman or superintendent on the project authorized to make decisions and receive instructions as if the Plumbing Subcontractor himself were present. The foreman or superintendent shall not be removed or replaced without the express approval of the Architect-Engineer after construction work begins. The Plumbing Subcontractor shall employ only competent and experienced workmen at a regular schedule in harmony with the other tradesmen on the job. The Plumbing Subcontractor shall also exercise care and supervision of his employees in regard to proper and expeditious layout of his work.

E. EXAMINATION OF SITE AND DOCUMENTS

1. Bidders are expected to examine and to be thoroughly familiar with all contract documents and with the conditions under which work will be carried out. The Awarding Authority (Owner) will not be responsible for errors, omissions and/or

charges for extra work arising from General Contractor or Filed Subcontractor's failure to familiarize themselves with the Contract Documents or existing conditions. By submitting a bid, the Bidder agrees and warrants that he has had the opportunity to examine the site and the Contract Documents, that he is familiar with the conditions and requirements of both and where they require, in any part of the work a given result to be produced, that the Contract Documents are adequate and that he will produce the required results.

2. Pre-Bid Conference: Bidders are strongly encouraged to attend the Pre-Bid conference; refer to INVITATION TO BID for time and date.

F. Related Work: The following items are not included in this Section and will be performed under the designated Sections:

1. SECTION EXECUTION.

   a. Cutting, patching, and drilling of holes larger than 4", except installation of pipe supports and fastenings.
   b. All patching.

2. SECTION - EARTHWORK

   a. All excavation and backfill.

3. SECTION - WATER UTILITIES.

   a. Site distribution water piping, including stub-ups into building and hydrants.
   b. Site irrigation system after the connection from the plumbing system within the school
   c. Quick Connects and associated piping around field for cooling and washing down the synthetic turf after the connection from the plumbing system within the toilet/storage building.

4. SECTION - STORM DRAINAGE UTILITIES.

   a. Downspouts.

5. SECTION - CAST-IN-PLACE CONCRETE.

   a. All concrete work.
   b. Thrust blocks.

6. SECTION - ROOFING AND FLASHING.

   a. Vent flashings at the roof.

7. SECTION - PAINTING.

   a. All painting.

8. SECTION - EQUIPMENT.

9. SECTION 23 00 00 - HEATING, VENTILATING, AND AIR CONDITIONING.

a. A/C condensate waste lines above finish floor slabs.
b. Furnish Radon System Fans.

10. SECTION 26 00 00 - ELECTRICAL.

a. Electrical connections and disconnect switches for boilers and water heaters and all plumbing systems with power.
b. Wiring of circulating pumps and controls.
c. Wiring of time clocks, solenoid valves, motors, controls and starters.
d. Wiring of relay panels in kitchen with associated Emergency Power Off buttons (EPO's).
e. Refer to paragraph 2.43 Electrical Work for systems that need to be wired, but are included under the plumbers responsibility for hiring the Electrical Subcontractor.

G. The awarded Plumbing Contractor must have the required qualifications for the installation of specialty piping systems. These systems include laboratory/acid waste and vent piping, pH neutralization system, radon systems, compressed air systems and all flue venting. If the plumber does not have these qualifications, then the work must be installed by a licensed and qualified plumber.

H. The Plumbing Subcontractor must comply with the requirements of the following sections:

1. SECTION 01 74 19 – CONSTRUCTION WASTE MANAGEMENT
2. SECTION 01 81 13– SUSTAINABLE DESIGN REQUIREMENTS
3. SECTION 01 81 19– INDOOR AIR QUALITY MANAGEMENT
4. SECTION 01 91 00 - COMMISSIONING

It shall be the Plumbing Subcontractors responsibility to submit all documentation required of these sections pertaining to division 22 00 00 work. For Section 01 91 00 - Commissioning, division 22 00 00 must provide all personnel as required to fully coordinate with the commissioning agent. The hours of training and instruction outlined in division 22 00 00 requirements shall be in addition to those tests and requirements outlined in Commissioning section and required to the fulfill commissioning obligations.

I. Extent: The work required under this Section, without limiting the generality thereof, includes the furnishing of all labor, materials, equipment, and services necessary for, and reasonably incidental to, the complete installation of all piping, valves, boilers, storage tanks, pumps, fixtures, insulation of piping, gas and electric water heaters, grease and solids interceptors, acid neutralizing tank and monitoring equipment, oil interceptor and all other materials, equipment, and labor necessary, whether or not such items are specifically indicated on the Drawings or in the Specifications, to complete the plumbing system in all respects ready for continuous and trouble free operation.

J. Intent: It is the intent of the Contract Documents to include all work and materials necessary for erecting complete, ready for continuous use, all plumbing systems as shown on the accompanying Drawings or as hereinafter described. These Drawings shall be taken in a sense as diagrammatic; sizes of pipes and methods of running them are shown, but it is not intended to show every offset and fitting, nor every structural difficulty that will be encountered during the installation of the work.

1.3 CODES, STANDARDS AND REFERENCES

A. All materials and workmanship shall comply with the latest editions of all applicable Codes, Local and State Ordinances, Industry Standards and Regulations.

B. The Plumbing Subcontractor shall notify the Architect/Engineer of any discrepancies between the Contract Documents and applicable Codes, Standards, etc…

C. In the event of a conflict, the most stringent requirements shall apply.

D. The following Codes, Standards and References shall be utilized as applicable:

1. Massachusetts State Building Code, 9th Edition.
2. National Electric Code (NEC).
3. Environmental Protection Agency (EPA).
4. Commonwealth of Massachusetts Department of Environmental Protection (DEP).
5. Local Ordinances, Regulations of City of Worcester.
6. National Fire Protection Association (NFPA).
7. Insurance Services Organization (ISO).
8. American National Standards Institute (ANSI).
9. American Society of Mechanical Engineers (ASME).
10. American Society for Testing and Materials (ASTM).
11. American Welding Society (AWS).
12. Commercial Standards, U.S. Department of Commerce (CS).
13. National Electrical Manufacturers Association (NEMA).
14. American Gas Association (AGA).
15. Underwriters' Laboratories, Inc. (UL).
16. Massachusetts Uniform State Plumbing Code.
17. Massachusetts Architectural Access Board (MAAB).
18. American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE).
19. Manufacturers Standardization Society of the Valve and Fitting Industry (MSS).
20. Americans with Disabilities Act (ADA).
21. WaterSense Certification for Urinals and Urinal Flush Valves as well as Shower Valves and Shower Heads only.
22. NSF61G

Note: Special attention is called to the issue of compliance with NSF 61G (lead-free) requirements for all components of the plumbing system determined to be for 'drinking water' applications. In the context of these project, it shall be assumed that all Lavatory Faucets, regardless of method of operation (ie: manual, metering, electronic) shall be considered drinking water applications. Note that this also includes valves, thermometer wells and pressure gauge tees.

1.4 COORDINATION

A. Before starting work, visit site and examine conditions under which work shall be performed including preparatory work by others. Report conditions which might adversely affect the work in writing to the Architect. Do not proceed with the work until the defects have been corrected and conditions are satisfactory. Commencement of work shall be construed as acceptance of preparatory work and existing conditions.

B. Completely coordinate with work of other trades and provide for complete and fully functional installation. Although not specifically shown, provide supplementary or miscellaneous items, devices, appurtenances and materials incidental to or necessary for sound, secure and complete installation.

C. Coring, cutting and/or patching of all openings and holes 4" diameter and under required for the installation of the Plumbing in the building shall be performed by the Plumbing Subcontractor and all coring, cutting and/or patching of openings greater than 4" diameter shall be performed by the General Contractor in accordance with Section 01 73 00. The Plumbing Subcontractor shall be responsible for firestopping all penetrations in accordance with Section 07 84 00 Firestopping.

D. All piping and equipment running within trusses must be supported from top chord of truss at panel point. For any alternate configurations or for heavy pieces of equipment coordinate fully with structural engineer for support location before installation.

1.5 GUARANTEE

A. Guarantee work performed under this Section in accordance with Division 1, General Requirements. Operation of systems or equipment for temporary services does not constitute beginning of guarantee period.

B. The Contractor also agrees to furnish service of the equipment for the above period, such service to be rendered quickly and promptly at the request of the Owner. This shall not be misconstrued to include routine maintenance.

C. For the water heaters and boilers throughout the school, provide extended 3-year warranty and maintenance contract. Contract shall cover all parts and labor for all components of the equipment as well as all routine maintenance specified by the manufacturer included but not limited to checking system components for proper operation and any possible leaks, cleaning of system components, clean condensate trap and change acid neutralizer cartridges for each boiler, inspect ignition and flame sensing electrodes, check controls and restart systems so that they are in working order for the entire 3-year period.

1.6 CONTRACT DOCUMENTS

A. Plumbing drawings do not limit responsibility of determining full extent of work required by Contract Documents. Locations shown on drawings shall be checked against construction proper.

B. Drawings are diagrammatic and indicate general arrangement of systems and work of this Contract.

1.7 DISCREPANCIES IN DOCUMENTS

A. Where Drawings or Specifications indicate discrepancies or are unclear, advise Architect in writing before award of Contract. Otherwise, Architect's interpretation of documents shall be final and no additional compensation shall be permitted due to discrepancies or unclear items.

B. Where Drawings or Specifications do not coincide with recommendations of the manufacturer of a material or piece of equipment, this shall be brought to the attention of the Architect in writing before installation of item in question. Otherwise, make changes in installation as Architect requires without additional cost to the Owner.

1.8 MECHANICAL AND ELECTRICAL COORDINATION DRAWINGS

A. Refer to Section 01 31 00 Progress Management and Coordination for coordination drawing requirements. Coordination drawings are required for this project.

1.9 RECORD DRAWINGS

A. Maintain record drawings during construction in accordance with the General Conditions of the Contract.

1.10 PERMITS, FEES, RULES AND REGULATIONS

A. Refer to Bidding and Contracting Requirements, including Document - GENERAL CONDITIONS and Documents - SUPPLEMENTARY CONDITIONS, for requirements all of which shall be included as part of this Specification.

B. Give the proper Authorities all requisite notices or information relating to the work under this Section. Obtain and pay for all fees, licenses, permits and certificates. Comply with the rules and regulations of all Local, State and Federal Authorities having jurisdiction, the Codes, Standards, recommended practices and manuals of the National Fire Protection Association, I.S.O., and the Public Utilities Companies serving the building.

1.11 NATURAL GAS SERVICE

A. This section shall expedite the Owner's application to Eversource Gas Company, supplier for the new gas service, meter and regulator for the building. The owner shall pay all gas company charges. The work of this section shall begin at the outlet side of the gas meter. Regulator shall be set to provide sufficient gas pressure to the most pressure-demanding device. The contact at Eversource is Tom Angelo.

1.12 SUBMITTALS

A. Refer to Section - SUBMITTALS for submittal provisions and procedures.

B. Submit shop drawings and product data through Submittal Exchange system (e-copies) or other Construction Management Software to Architect for approval (hard copies are not necessary unless requested). Any deviation from the Contract Documents, or proposed substitution of materials or equipment for those specified, must be requested by the Contractor in a separate letter, whether the deviations are due to field conditions, standard shop practices or other cause. Where any deviation or substitution is permitted, the Contractor shall fully coordinate all related changes to Architectural, Structural, Fire Protection, HVAC, Electrical or other work, and shall accomplish these related changes at no additional cost to the Owner. Refer to the general submittal requirements. Colors of all materials shall be as selected by the Architect-Engineer from the standard color ranges of each manufacturer from samples submitted as per below.

C. Submit shop drawing or product data for the following:

1. Plumbing fixtures, faucets, flush valves and accessories.
2. Piping, valves and accessories.
3. Floor drains, floor sinks, trench drains, roof drains, wall hydrants (hose bibs), freeze proof sill cocks and roof hydrants.
4. Gas fired boilers and associated controls.
5. Domestic hot water storage tanks.
6. Gas fired storage type water heater and associated controls for Science Classrooms.
7. Mini-Tank point-of-use electric water heaters.

8. Outdoor Restroom and Storage Building tank-type electric water heater.
9. Thermal Expansion Tanks.
10. Circulating pumps and controls.
11. Pre-assembled high-low thermostatic water mixing valve or Digital mixing valve.
12. Emergency Shower & Eyewash/Facewash Thermostatic Mixing Valves (i.e. science room and individual at various locations throughout).
13. Tempering Valves for restroom groups and for Science Room water heater.
14. Pipe insulation.
15. Acid resistant piping.
16. Active pH neutralizing system with chemical feeds to adjust the pH of the effluent, p-trap with probe & pH monitoring panel with recording device.
17. Floor Access Panels/Hatches for Acid Neutralizing system components and for grease interceptor flow control fittings.
18. Radon system piping and installation of exhaust fans.
19. Pressure gauges and thermometers.
20. Expansion compensators (if not standard expansion loops).
21. Backflow preventers including domestic water service entrance x 2, science room cold water piping, janitor room chemical dispensers on cold water, kitchen appliances as required, site irrigation systems, and boiler water feed.
22. Pressure reducing valves.
23. Access Panels.
24. Time-clocks, solenoid valves, automatic trap primer valves (automatic and electronic) with air gap fittings.
25. Pipe identification labels.
26. Cleanouts.
27. Domestic hot water boiler and gas-fired water heater flue and combustion air piping.
28. Interior Grease Interceptors.
29. Solids Interceptors.
30. Oil Interceptor.
31. Piping hangers and seismic bracing.
32. Compound water meter for main school, water meter for site irrigation system, and water meter for outdoor restroom and storage building.
33. Gas Pressure Regulators.
34. CO and Flammable Gas Detection System for the kitchen including panel, detectors, manual reset relay and gas solenoid valve.
35. Air compressor system related accessories including refrigerated air dryer, air filters, piping, valve, and quick connect fittings. Air compressor by FF&E.
36. Science room fixtures including faucets, gas/air turrets, piping for sinks and piping for all equipment including ice makers, glass washers, refrigerators, fume hoods, etc…
37. Water Sub-Meters with pulse output to BMS.
38. Gas Sub-Meters with pulse output to BMS.
39. Coordination drawings.

Do not release for shipment, deliver, or install any equipment or material without prior approval of the Architect-Engineer.

1.13 DELIVERY, STORAGE, AND HANDLING

A. Delivery: The Plumbing Subcontractor shall provide for the delivery of all his materials and fixtures to the building site when required so as to carry on his work efficiently and to avoid delaying his work and that of other trades.

B. Storage and Handling: The Plumbing Subcontractor shall, at all times, fully protect his work and materials from injury or loss by others. Any injury or loss, which may occur,

shall be made good without expense to the Owner. The Plumbing Subcontractor shall be responsible for the proper protection of all his materials until the building is accepted by the Owner.

1.14 CONTINUITY OF SERVICE AND SCHEDULING OF WORK

A. Refer to the overall scheduling of the work of the project. Schedule work to conform to this schedule and install work to not delay nor interfere with the progress of the project.

1.15 CERTIFICATES OF APPROVAL

A. Upon completion of all work, furnish, in duplicate, certificates of inspection.

1.16 OPERATING AND MAINTENANCE INSTRUCTIONS

A. Prior to the final inspection, the Plumbing Subcontractor shall provide to the Architect three (3) sets of operating and maintenance instructions. The Architect-Engineer shall review the instructions for completeness prior to turning them over to the Owner.

B. Instructions: The Plumbing Subcontractor shall provide qualified, factory-trained manufacturers' representative to give detailed instruction to assigned Owner personnel in the operation and complete maintenance for all equipment. All such training will be at the job site. Training must be provided on the operation of major equipment and fixture maintenance. The pH neutralizing system care & maintenance shall be addressed as well as the various mixing valves throughout the building. A comprehensive run-through of the CO systems for the multiple kitchens needs to be performed. Also, the science room Natural Gas Service Panels need to be tested to ensure proper operation. General fixture maintenance for the flush valves, faucets, shower valves, water coolers, etc. should be included.

1. The CO Detection Systems must be tested to ensure they do not activate the fire alarm, especially in the event of a power outage. These must be completely independent of the fire alarm system although the CO Detectors can be used by both systems via wiring.
2. Science Room Gas Shut-Off Valves and remote gas-shut-off buttons must be tested for every science lab/classroom to ensure the gas is properly shut-off to the room.

C. Factory Start-Up: The Plumbing Subcontractor shall provide factory start-up of the gas-fired domestic hot water boilers and domestic hot water heater. A factory start-up checklist shall be submitted for approval with the close-out documents. Note: The small electric water heaters do not require factory start-up.

D. Provide name, address, and telephone number of the manufacturer’s representative and service company for each piece of equipment so that the source of replacement parts and service for each item of equipment can be readily obtainable.

1.17 SEISMIC RESTRAINTS

A. Installation of Plumbing equipment, accessories and components shall be in accordance with the Seismic Requirements identified in the 9th Edition of the Massachusetts State Building Code. Note that the code exception based on the following may not apply to meet Emergency Shelter requirements:
Mass State Building Code → IBC 2009 → Section 16.13.1 → ASCE 13.1.4 (2)

B. Provide seismic bracing as required by the Commonwealth of Massachusetts building code 780 CMR, 9th edition, Chapter 16. Plumbing Subcontractor shall hire a seismic consultant to comply with requirements of the code. All equipment and piping shall be seismically supported regardless of it is exempt by 780 CMR Chapter 16. For the purposes of seismic design, the entire Plumbing system shall be presumed to have a seismic importance factor of 1.5.

1.18 ENVIRONMENTAL REQUIREMENTS

A. Recycled Content: Provide products manufactured from recycled content, to be measured and documented according to Massachusetts CHPS.

B. Low Volatile Organic Compounds (VOCs): Adhesives used on site must meet the VOC limits of the California South Coast Air Quality Management District Rule #1168. Sealants used as filler must meet or exceed Bay Area Air Quality Management District Regulation 8, Rule 51.

1.19 SEQUENCING

A. Phasing: Refer to Section 01 10 00 - SUMMARY, and Drawings for phasing and milestone completion requirements which affect the Construction Manager's Work and the Work of this Trade Contractor.

B. Coordinate work of this Trade Contract with that of other trades, affecting or affected by this work, and cooperate with the other trades as is necessary to assure the steady progress of work.

C. Do not order or deliver any materials until all submittals, required in the listed Specification Sections included as part of this Trade Contract, have been received and approved by the Architect.

D. Before proceeding with installation work, inspect all project conditions and all work of other trades to assure that all such conditions and work are suitable to satisfactorily receive the work of this Section and notify the Architect in writing of any which are not. Do not proceed further until corrective work has been completed or waived.

PART 2 - PRODUCTS

2.1 PRODUCTS CRITERIA

A. Standard Products: Material and equipment shall be the standard products of a manufacturer regularly engaged in the manufacture of the products for at least 3 years. See other specification sections for any exceptions.

B. Multiple Units: When two or more units of materials or equipment of the same type or class are required, these units shall be products of one manufacturer.

C. Nameplates: Nameplate bearing manufacturer's name or identifiable trademark shall be securely affixed in a conspicuous place on equipment, or name or trademark cast integrally with equipment, stamped or otherwise permanently marked on each item of equipment.

D. Asbestos products or equipment or materials containing asbestos shall not be used.

E. Lead free products shall be used for all piping, fittings, valves, faucets and any other component that comes in contact with potable water.

F. Plumbing equipment, fixtures and valves shall each have a Massachusetts Plumbing Board product approval number which can be found on the Acceptable Plumbing Products website. The Plumbing Contractor will be expected to produce the approval numbers for any and all equipment, fixtures and valves during the submittal process and at installation for anyone who asks (i.e. the Plumbing Inspector, Plumbing Engineer, etc…). Products without a Massachusetts Plumbing Product Approval code will be rejected and will not be allowed on the job-site. Plumbing product approval numbers shall be included in the close-out documents. Piping is not required to be MA Plumbing product approved since it is not included on the website.

2.2 PLUMBING FIXTURES - SCHOOL

A. Provide plumbing fixtures as specified herein. Fixture trim, traps, faucet, escutcheons and waste pipes exposed to view in finished spaces shall be I.P.S. brass with polished chromium plating over nickel finish. Fixtures shall have manufacturer's label or trademark indication first quality.

B. Fixtures with wall outlet flanges shall be set proper distance from floor or wall to make first-class joint with closet setting compound or gasket.

C. Mounting heights shall be as shown on architectural details.

D. Each individual fixture shall be provided with supply stops for each water service. Supply stops and supply risers shall be lead-free to meet NSF-61G.

E. Exposed piping below handicap lavatories and sinks shall be insulated with PVC coated insulation similar to Truebro LavGuard 2, McGuire Mfg. Co. Inc., Plumberex Specialty Products Pro-Extreme, ProFlo Trap Covers for Ferguson Enterprises or approved equal. The product shall be rigid high-impact, stain-resistant PVC, 1/8” constant wall thickness with internal ribs, have UV protection, and have an E-Z Tear-To-Fit trim feature. The color shall be china white and shall be Compatibility #100 series to fit all 1-1/4” or 1-1/2” cast brass or tubular P-trap assemblies and 3/8” or ½” angle stop assemblies.

F. Fixture Schedule: Unless otherwise specified, fixtures shall be as follows (Note: Manufacturer and Model numbers are provided to set standard of fixture) :

1. China Fixtures including Water Closets, Urinals and Lavatories: American-Standard, Kohler Company, Zurn ZPPG, Eljer Plumbingware Inc., Crane Plumbing, Sloan Valve Company or equal.
2. Manual Flush Valves: Sloan Valve Company, Zurn ZPPG, Delta Faucet Company, Moen Commercial or equal.
3. Manual Lavatory Faucets: Symmons Industries Inc., Delta Faucet Company, Moen Commercial, American Standard, Zurn ZPPG, Chicago Faucets or equal.
4. Multi-Station Lavatories with integral faucet spouts: Bradley Corporation, Sloan Valve Company, Willoughby Industries Inc., Intersan or equal.
5. Countertop Sinks: Elkay Sales Inc., Just Manufacturing Co., Kohler Company, Kindred Commercial or equal.
6. Countertop Sink Faucets: Symmons Industries Inc., American Standard, Zurn ZPPG, Chicago Faucets, Moen Incorporated, Delta Commercial or equal.

7. Water Coolers: Elkay Sales Inc., Halsey Taylor, Oasis Corporation, Haws Corporation, Filtrine or equal.
8. Mop Receptor: Crane Plumbing/Fiat Products, Stern-Williams Co. Inc., Zurn ZPPG, E.L. Mustee & Sons, Florestone Products Co. or equal.
9. Mop Receptor Faucets: Moen Commercial, Crane Plumbing/Fiat Products, Stern-Williams, American Standard, Chicago Faucets, Speakman Co. or equal.
10. Shower Stall: none required. There are no pre-fabricated shower stalls.
11. Shower Bases: Fiat Products, Swan, Florestone, or equal.
12. Shower Valves: Bradley Corporation, Symmons Industries Inc., Zurn ZPPG, Powers (a Watts Industries Co.), Leonard Valve Co., Delta Commercial or equal.
13. Clothes Washer Connections: Symmons Industries Inc., Sioux Chief, Oatey or equal.
14. Emergency Fixtures: Guardian Equipment, Bradley Corporation, Speakman Company, Haws, Acorn Engineering Company, or equal.

P-1 Wall Hung Water Closet – Non-Handicap: American Standard #3351.128 “Afwall FloWise” (Kohler model #K-4325 “Kingston”), High Efficiency 1.28 gpf (HET), vitreous china, wall hung, EverClean anti-microbial surface, condensation channel, direct-fed siphon jet, elongated bowl, 1-1/2” top spud, 2-1/8” ballpass fully glazed trapway, 10”x12” water surface area, 100% factory flush tested.
Sloan Royal model #111-1.28; exposed water closet flushometer for floor mounted or wall hung top spud bowls. Flushometer shall be quiet, exposed, diaphragm type, chrome plated for left or right hand supply, water closet type with the following features:

- PERMEX™ synthetic rubber diaphragm with dual filtered fixed bypass.
- ADA compliant metal oscillating non-hold-open handle with triple seal handle packing.
- 1” I.P.S. screwdriver Bak-Chek® angle stop with free spinning vandal resistant stop cap.
- Adjustable tailpiece.
- High back pressure vacuum breaker flush connection with one-piece bottom hex coupling nut
- Spud coupling and flange for 1-1/2” top spud.
- Sweat solder adapter with cover tube and cast wall flange with set screw.
- High copper, low zinc brass castings for dezincification resistance.
- Non-Hold-Open handle, fixed metering bypass and no external volume adjustment to ensure water conservation.
- Flush accuracy monitored by CID™ Technology.
- Diaphragm, stop seat and vacuum breaker molded from PERMEX™ rubber compound for chloramines resistance.

Bemis #495SSC extra heavy weight, thermoset fireproof material, elongated, open front seat, less cover with integral molded-in bumpers, self-sustaining and external check hinge feature 300 series stainless steel posts that hold seat in any raised position up to 11 degrees beyond vertical, color white. Church #9500SSCT, Kohler #K-4731, or approved equal.
Zurn Industries, Jay R. Smith, Josam or equal hub and spigot combined waste fitting and chair carrier supports, with adjustable extensions, rear foot support and face plate with foot support & feet bolted to floor, with seat mounting height to be 15” above finished floor.

P-2 Wall Hung Water Closet – Handicap: Same as P-1 except mounted 18” floor to rim. Modify flush valve to allow clearance for grab bar installation.

P-3 Floor Mounted Water Closet – Pre-Kindergarten - Handicap: American Standard #2282.001 “Baby Devoro Flowise” (Kohler model #K-4321 “Primary”),

high efficiency, low consumption 1.28 gallons per flush (gpf), vitreous china, siphon jet action, round front bowl, 1-1/2" top inlet spud, fully glazed trapway, floor mounted, 10" rough-in, 10-1/4" high bowl, bolts and bolt caps, 100% factory flush tested, white.
Sloan Royal model #111-1.28; exposed water closet flushometer for floor mounted or wall hung top spud bowls. Flushometer shall be quiet, exposed, diaphragm type, chrome plated for left or right hand supply, water closet type with the following features:

- PERMEX™ synthetic rubber diaphragm with dual filtered fixed bypass.
- ADA compliant metal oscillating non-hold-open handle with triple seal handle packing.
- 1" I.P.S. screwdriver Bak-Chek® angle stop with free spinning vandal resistant stop cap.
- Adjustable tailpiece.
- High back pressure vacuum breaker flush connection with one-piece bottom hex coupling nut
- Spud coupling and flange for 1-1/2" top spud.
- Sweat solder adapter with cover tube and cast wall flange with set screw.
- High copper, low zinc brass castings for dezincification resistance.
- Non-Hold-Open handle, fixed metering bypass and no external volume adjustment to ensure water conservation.
- Flush accuracy monitored by CID™ Technology.
- Diaphragm, stop seat and vacuum breaker molded from PERMEX™ rubber compound for chloramines resistance.

Olsonite #126-CC institutional weight, solid plastic, round, open front seat, less cover with external check hinge, color white. Church #1580C, Bemis, or approved equal.

P-4 Wall Hung Urinal – Non-Handicap: American Standard #6590.001 "Washbrook FloWise 0.125 GPF Ultra High Efficient Urinal (Kohler model #K-4904-ET "Bardon"), vitreous china, low consumption 0.125 GPF, flushing rim, elongated 14" rim from finished wall, washout flush action, extended sides for privacy, ¾" inlet spud, outlet connection threaded 2" inside (NPTF), strainer included, ,meets ANSI flush requirements for 0.125 GPF.
Sloan Royal model #186-0.125; exposed high efficiency manual urinal flushometer for top spud high efficiency urinals. Flushometer shall be quiet, exposed, diaphragm type, chrome plated, urinal type with the following features:

- Dual linear filtered bypass diaphragm .
- ADA Compliant metal oscillating Non-Hold-Open handle with triple seal handle packing
- 3/4" I.P.S. screwdriver Bak-Chek® angle stop with free spinning vandal resistant stop cap.
- Adjustable tailpiece.
- High back pressure vacuum breaker flush connection with one-piece bottom hex coupling nut
- Spud coupling and flange for 3/4" top spud.
- Sweat solder adapter with cover tube and cast wall flange with set screw.
- High copper, low zinc brass castings for dezincification resistance.
- Non-Hold-Open handle, fixed metering bypass and no external volume adjustment to ensure water conservation.
- Flush accuracy monitored by CID™ Technology.
- Diaphragm, handle packing, stop seat and vacuum breaker molded from PERMEX™ rubber compound for chloramines resistance.

Provide Zurn #Z1222 concealed carrier, Jay R. Smith, Josam or equal carrier, with bearing and hanger plates,(vandalproof trim) or provide carrier as required to suit construction, with feet bolted to floor. Install with rim at 24" above finished floor.

P-5 Wall Hung Urinal - Handicap: Same as P-5 except mounted 17" floor to rim.

P-6 Wall Hung Lavatory – Non-Handicap: American-Standard #0954.004 "Murro" wall-hung bathroom sink (Kohler model #K-1997 "Brenham"), 22" deep x21-1/4" wide, vitreous china, wall hung, rear overflow, 4" faucet hole centers, recessed self-draining deck, for concealed arm support.
Chicago Faucets model #3400-E39VPABCP deck mounted hot and cold water manual metering mixing sink faucet, 4" fixed centers, polished chrome plated, 4-3/4" center to center integral cast brass spout, 0.35 GPM vandal proof non-aerating spray, #MVP metering adjustable cycle time closure cartridge, ½" NPSM supply inlet and coupling nut for 3/8" or ½" flexible riser. This product meets ADA ANSI/ICC A117 requirements and is tested and certified to industry standards: ASME A112.18.1M, Certified to NSF/ANSI 61.
Chicago #STC-11-11-AB Heavy Duty lead-free, loose key stops and supplies with flexible riser and flange. 1-1/4" x 1-1/2" polished chrome plated cast brass adjustable "P" trap, cleanout plug, extension to wall with escutcheon.
Concealed arm carrier support with foot support to suit construction. Install with rim at 30" maximum above finished floor.

P-7 Wall Hung Lavatory –Handicap: American-Standard #0954.004 "Murro" wall-hung bathroom sink (Kohler model #K-1997 "Brenham"), 22" deep x21-1/4" wide, vitreous china, wall hung, rear overflow, 4" faucet hole centers, recessed self-draining deck, for concealed arm support.
Chicago Faucets model #3400-E39VPABCP deck mounted hot and cold water manual metering mixing sink faucet, 4" fixed centers, polished chrome plated, 4-3/4" center to center integral cast brass spout, 0.35 GPM vandal proof non-aerating spray, #MVP metering adjustable cycle time closure cartridge, ½" NPSM supply inlet and coupling nut for 3/8" or ½" flexible riser. This product meets ADA ANSI/ICC A117 requirements and is tested and certified to industry standards: ASME A112.18.1M, Certified to NSF/ANSI 61.
Chicago #STC-11-11-AB Heavy Duty lead-free, loose key stops and supplies with flexible riser and flange. 1-1/4" x 1-1/2" polished chrome plated cast brass adjustable "P" trap, cleanout plug, extension to wall with escutcheon.
Concealed arm carrier support with foot support to suit construction. Install with rim at 34" maximum above finished floor.
Insulate cold water, hot water, and waste beneath lavatory. Refer to paragraph 2.2.E for additional information.

P-8 Countertop Sink – Classroom - Handicap: Elkay model #LRADQ1919-65-3 "Lustertone" 19-1/2"x19" nominal, single 16"x13-1/2" bowl, 18-gauge type 304 stainless steel, self-rimming countertop sink; highest quality; seamlessly drawn from nickel bearing stainless steel; bowl depth = 6-1/2"; 1-3/4" radius coved corners; exposed surfaces hand blended to a lustrous highlighted satin finish; bowl and faucet deck are recessed 3/16" below outside edge of sink; underside fully protected by a heavy duty Sound Guard undercoating; 3-1/2" drain opening; faucet holes on 8" centers; 3 faucet holes; Quick-Clip.
Chicago model #201-RSGN8AE35VPXKABCP two handle deck mounted sink faucet with restricted swing spout, ceramic cartridges, 1.5 gpm pressure compensating Softflo vandal-resistant aerator, 8" fixed centers, 8" reach, 2-3/8" vandal proof lever handles, ceramic ¼ turn operating cartridge, ADA compliant.
Elkay model #LK35 Standard Cup Strainer, fits 3-1/2" opening (4-1/2" top diameter), stainless steel conical strainer basket with flex stem and rubber stopper, C.P. brass, 1-1/2" O.D. tailpiece.
Provide point-of-use mixing valve for this fixture.

Chicago #STC-11-11-AB Heavy Duty lead-free, loose key stops and supplies with flexible riser and flange. 1-1/2" x 1-1/2" polished chrome plated cast brass adjustable "P" trap, cleanout plug, extension to wall with escutcheon.

P-9 Countertop Sink – Planning Room - Handicap: Elkay model #LRADQ1919-65-3 "Lustertone" 19-1/2"x19" nominal, single 16"x13-1/2" bowl, 18-gauge type 304 stainless steel, self-rimming countertop sink; highest quality; seamlessly drawn from nickel bearing stainless steel; bowl depth = 6-1/2"; 1-3/4" radius coved corners; exposed surfaces hand blended to a lustrous highlighted satin finish; bowl and faucet deck are recessed 3/16" below outside edge of sink; underside fully protected by a heavy duty Sound Guard undercoating; 3-1/2" drain opening; faucet holes on 8" centers; 3 faucet holes; Quick-Clip.
Chicago Faucets model #201-A3I7ABCP deck mounted 8" fixed centers concealed hot and cold water sink faucet, 9-1/2" L type swing spout, 2.2 GPM aerator, 4" vandal proof wrist-blade handles, Quaturn compression operating cartridge, ½" NPSM supply inlets and coupling nut for 3/8" or ½" flexible riser, ECAST design for reduced lead content.
Elkay model #LK35 Standard Cup Strainer, fits 3-1/2" opening (4-1/2" top diameter), stainless steel conical strainer basket with flex stem and rubber stopper, C.P. brass, 1-1/2" O.D. tailpiece.
Chicago #STC-11-11-AB Heavy Duty lead-free, loose key stops and supplies with flexible riser and flange. 1-1/2" x 1-1/2" polished chrome plated cast brass adjustable "P" trap, cleanout plug, extension to wall with escutcheon.

P-10 Art Classroom Sink – Non-Handicap: Elkay model #ELU281610 "Lustertone" Undermount Sink 30-1/2"x18-1/2" overall, single 28"x16" bowl, 18-gauge type 304 stainless steel, under- counter mounted sink; highest quality; seamlessly drawn from nickel bearing stainless steel; bowl depth = 10"; 1-3/4" radius coved corners; exposed surfaces hand blended to a lustrous highlighted satin finish; underside fully protected by a heavy duty Sound Guard undercoating; 3-1/2" drain opening; template and countertop mounting clips are included.
Chicago Faucets model #201-AGN2AE3ABCP sink faucet for hot and cold water, concealed deck mount with 8" fixed centers, chrome plated; rigid/swing gooseneck spout, 5-1/4" center-to-center; 2.2 GPM pressure compensating Softflo aerator; 2-3/8" metal, vandal-proof, lever handles with sixteen point, tapered broach and secured blue and red index buttons; Quaturn™ rebuildable compression cartridge, opens and closes 90°, closes with water pressure, features square, tapered stem; ½" NPSM supply inlets and coupling nut for 3/8" or ½" flexible riser; ECAST® construction with less than 0.25% lead content by weighted average; ADA compliant, Certified to NSF/ANSI 61.
Elkay model #LK35 Standard Cup Strainer, fits 3-1/2" opening (4-1/2" top diameter), stainless steel conical strainer basket with flex stem and rubber stopper, C.P. brass, 1-1/2" O.D. tailpiece.
Chicago #STC-11-11-AB Heavy Duty lead-free, loose key stops and supplies with flexible riser and flange.
Zurn #Z-1180 or Josam series 61030 fixture trap type solids interceptor in lieu of trap, top access, gasketed cover, removable galvanized steel basket and stainless steel screen. See specification section 2.16 for additional information. Coordinate with casework manufacturer and Architect for installation.

P-11 Art Classroom Sink –Handicap: Elkay model #ULUHAD1415-55 "Lustertone" Classic Stainless Steel 16-1/2"x16-1/2"x5-3/8" deep single bowl undermount ADA sink, single 14"x14" bowl, 18-gauge type 304 stainless steel, under- counter mounted sink; highest quality; seamlessly drawn from nickel bearing stainless steel; bowl depth = 5-3/8"; 1-3/4" radius coved corners; exposed surfaces hand blended to a lustrous

highlighted satin finish; underside fully protected by a heavy duty Sound Guard undercoating; 3-1/2" rear center drain opening.
Chicago Faucets model #201-AGN2AE3ABCP sink faucet for hot and cold water, concealed deck mount with 8" fixed centers, chrome plated; rigid/swing gooseneck spout, 5-1/4" center-to-center; 2.2 GPM pressure compensating Softflo aerator; 2-3/8" metal, vandal-proof, lever handles with sixteen point, tapered broach and secured blue and red index buttons; Quaturn™ rebuildable compression cartridge, opens and closes 90°, closes with water pressure, features square, tapered stem; ½" NPSM supply inlets and coupling nut for 3/8" or ½" flexible riser; ECAST® construction with less than 0.25% lead content by weighted average; ADA compliant, Certified to NSF/ANSI 61.
Elkay model #LK35 Standard Cup Strainer, fits 3-1/2" opening (4-1/2" top diameter), stainless steel conical strainer basket with flex stem and rubber stopper, C.P. brass, 1-1/2" O.D. tailpiece.
Chicago #STC-11-11-AB Heavy Duty lead-free, loose key stops and supplies with flexible riser and flange.
Zurn #Z-1180 or Josam series 61030 fixture trap type solids interceptor in lieu of trap, top access, gasketed cover, removable galvanized steel basket and stainless steel screen. See specification section 2.16 for additional information. Coordinate with casework manufacturer and Architect for installation.

P-12 Countertop Sink – Exam Room - Handicap: Elkay model #LRADQ1919-65-3 "Lustertone" 19-1/2"x19" nominal, single 16"x13-1/2" bowl, 18-gauge type 304 stainless steel, self-rimming countertop sink; highest quality; seamlessly drawn from nickel bearing stainless steel; bowl depth = 6-1/2"; 1-3/4" radius coved corners; exposed surfaces hand blended to a lustrous highlighted satin finish; bowl and faucet deck are recessed 3/16" below outside edge of sink; underside fully protected by a heavy duty Sound Guard undercoating; 3-1/2" drain opening; faucet holes on 8" centers; 3 faucet holes; Quick-Clip.
Chicago Faucets model #201-A3I7ABCP deck mounted 8" fixed centers concealed hot and cold water sink faucet, 9-1/2" L type swing spout, 2.2 GPM aerator, 4" vandal proof wrist-blade handles, Quaturn compression operating cartridge, ½" NPSM supply inlets and coupling nut for 3/8" or ½" flexible riser, ECAST design for reduced lead content.
Elkay model #LK35 Standard Cup Strainer, fits 3-1/2" opening (4-1/2" top diameter), stainless steel conical strainer basket with flex stem and rubber stopper, C.P. brass, 1-1/2" O.D. tailpiece.
Chicago #STC-11-11-AB Heavy Duty lead-free, loose key stops and supplies with flexible riser and flange. 1-1/2" x 1-1/2" polished chrome plated cast brass adjustable "P" trap, cleanout plug, extension to wall with escutcheon.

P-13 Countertop Sink with bubbler – Handicap: Elkay model #DRKADQ2517C-55 "Lustertone" 25"Lx17"W nominal, single 16"x13-1/2" bowl, #18-gauge type 304 (18-8) nickel bearing stainless steel, self-rimming countertop sink; highest quality; seamlessly drawn from nickel bearing stainless steel; bowl depth = 5-1/2"; 3" vertical and 2-1/4" horizontal radius coved corners; exposed surfaces are polished to a highlighted Celebrity bright finish; bowl and faucet deck are recessed 3/16" below outside edge of sink; underside fully protected by a heavy duty Sound Guard undercoating; off-centered 3-1/2" drain opening; faucet holes on 8" centers; 3 faucet holes and 1 bubbler hole on opposite end.
Elkay model # LK2439 Faucet, two handle Contemporary Hi-Arc concealed undermount faucet with 45° restricted swing spout and aerator, outlet height = 10", reach = 6.5", no hose spray.
Elkay model # LK1141A no-lead Flexi-Guard Bubbler, push-button bubbler, self -closing, with built-in adjustable volume control; heavy chrome plated body with ½" thread connection.

Elkay model #LK35 Standard Cup Strainer, fits 3-1/2" opening (4-1/2" top diameter), stainless steel conical strainer basket with flex stem and rubber stopper, C.P. brass, 1-1/2" O.D. tailpiece.
Provide point-of-use mixing valve for this fixture.
Provide McGuire or Chicago (#STC-11-11-AB) heavy duty, lead free, polished chrome-plated cast brass quarter-turn ball valve with convertible loose key handle, flexible risers, escutcheons. 1-1/2" x 1-1/2" polished chrome plated cast brass adjustable "P" trap, cleanout plug, extension to wall with escutcheon. Provide offset drain to rear of counter. Install with rim in countertop at 34".
The drawings indicate the orientation of the bubbler (either mounted on the left or right side of the fixture) and most are not specifically called out.

P-14 Countertop Lavatory –Handicap: American-Standard #0476.028 "Aqualyn", 20-3/8" x17-3/8" nominal, 16" wide x 10" front to back x 5-5/8" deep bowl, vitreous china, self-rimming countertop, front overflow, faucet holes on 4" centers, faucet ledge.
Chicago Faucets model #3400-E39VPABCP deck mounted hot and cold water manual metering mixing sink faucet, 4" fixed centers, polished chrome plated, 4-3/4" center to center integral cast brass spout, 0.35 GPM vandal proof non-aerating spray, #MVP metering adjustable cycle time closure cartridge, ½" NPSM supply inlet and coupling nut for 3/8" or ½" flexible riser. This product meets ADA ANSI/ICC A117 requirements and is tested and certified to industry standards: ASME A112.18.1M, Certified to NSF/ANSI 61.
Provide point-of-use mixing valve for this fixture.
Chicago #STC-11-11-AB Heavy Duty lead-free, loose key stops and supplies with flexible riser and flange. 1-1/4" x 1-1/2" polished chrome plated cast brass adjustable "P" trap, cleanout plug, extension to wall with escutcheon.

P-15 Wall Hung Lavatory - Toddler –Handicap: American-Standard #0955.000 "Murro", 22" deep x21-1/4" wide, vitreous china, wall hung, rear overflow, center faucet hole only, recessed self-draining deck, for concealed arm support.
Chicago Faucets model #3400-E39VPABCP deck mounted hot and cold water manual metering mixing sink faucet, 4" fixed centers, polished chrome plated, 4-3/4" center to center integral cast brass spout, 0.35 GPM vandal proof non-aerating spray, #MVP metering adjustable cycle time closure cartridge, ½" NPSM supply inlet and coupling nut for 3/8" or ½" flexible riser. This product meets ADA ANSI/ICC A117 requirements and is tested and certified to industry standards: ASME A112.18.1M, Certified to NSF/ANSI 61.
Chicago #STC-11-11-AB Heavy Duty lead-free, loose key stops and supplies with flexible riser and flange. 1-1/4" x 1-1/2" polished chrome plated cast brass adjustable "P" trap, cleanout plug, extension to wall with escutcheon.
Concealed arm carrier support with foot support to suit construction. Install with rim at 30" maximum above finished floor.
Provide point-of-use mixing valve for this fixture.
Insulate cold water, hot water, and waste beneath lavatory. Refer to paragraph 2.2.E for additional information.

P-16 Countertop Sink –Handicap: Elkay model #LRADQ1918-65-3 "Lustertone" 19"x18"x6-1/2" deep nominal, single 16"x11-1/2" bowl, 18-gauge type 304 stainless steel, self-rimming countertop sink; highest quality; seamlessly drawn from nickel bearing stainless steel; bowl depth = 6-1/2"; 1-3/4" radius coved corners; exposed surfaces hand blended to a lustrous highlighted satin finish; bowl and faucet deck are recessed 3/16" below outside edge of sink; underside fully protected by a heavy duty Sound Guard undercoating; 3-1/2" drain opening; faucet holes on 8" centers; 3 faucet holes; Quick Clip.

Chicago model #201-RSGN8AE35VPXKABCP two handle deck mounted sink faucet with restricted swing spout, ceramic cartridges, 1.5 gpm pressure compensating Softflo vandal-resistant aerator, 8" fixed centers, 8" reach, 2-3/8" vandal proof lever handles, ceramic ¼ turn operating cartridge, ADA compliant.
Elkay model #LK35 Standard Cup Strainer, fits 3-1/2" opening (4-1/2" top diameter), stainless steel conical strainer basket with flex stem and rubber stopper, C.P. brass, 1-1/2" O.D. tailpiece.
Chicago #STC-11-11-AB Heavy Duty lead-free, loose key stops and supplies with flexible riser and flange. 1-1/4" x 1-1/2" polished chrome plated cast brass adjustable "P" trap, cleanout plug, extension to wall with escutcheon.

P-17 Shower Base and Valve – Non-Handicap: Tile shower stall by G.C. Florestone Terrazzo Model #200 Recess Shower Receptor, 36"x36". Shoulder will be not less than 2-1/2" inside. Flange, cast integral, will be galvanized-bonderized steel and extend not less than 1" above shoulder on three (3) sides for installation. Drain body will be brass, cast integral, and will provide for a non-caulked connection not less than 1" deep to a 2" pipe. Receptor will be manufacturer of tan and white marble chips cast in white Portland cement to produce a compressive strength of not less than 3,000 PSI, 7 days after casting. Terrazzo surface will be ground, polished, and the entire unit sealed to resist stains and moisture after any air holes and/or pits are grouted. Receptor will be reinforced with 16 gauge wire. Removeable type stainless steel strainer plate will be supplied.
Moen Commercial model #8375EP15 Single Handle Pressure Balancing Shower Valve with Integral Stops; chrome plated metal construction, pressure balancing cycle valve design, ½" CC connections with ¼ turn stops (included), vandal resistant screws. Operation shall be lever style handle with temperature indicators on the escutcheon, handle operates counterclockwise through a 270° arc with off at 6 o'clock and maximum hot at the 9 o'clock position. Shut-off in a clockwise direction. Adjustable temperature limit stop to restrict the handle travel in the hot direction. Moen #1222 cartridge design with nonmetallic/nonferrous and stainless steel materials.
Moen Commercial model #8290 Vandal Proof Showerhead; fixed mount vandal proof showerhead, metallic spray face and shell, brass swivel ball assembly, adjustable spray angle, designed to deliver 1.5 GPM at 60 PSI.
Provide floor drain in center of shower stall.

P-18 Shower Valve - Handicap: Tile shower stall and base by G.C.
Moen Commercial model #8346EP15 Single-Handle Pressure Balancing Shower Valve with Hand-Held Shower System; chrome plated metal construction, pressure balancing cycle valve design with ¼ turn stops. System contains hand-held shower with 36" slide bar, drop ell, vacuum breaker, 69" metal hose and hardware. Operation shall be lever style handle with temperature indicators on the escutcheon, handle operates counterclockwise through a 270° arc with off at 6 o'clock and maximum hot at the 9 o'clock position. Shut-off in a clockwise direction. Adjustable temperature limit stop to restrict the handle travel in the hot direction. Moen #1222 cartridge design with nonmetallic/nonferrous and stainless steel materials. 1.5 GPM Hand-Held Shower Head. Provide collapsible water dam with end-caps along front edge of shower stall similar to K.R. Specialties, Stay Dry Systems or Freedom Showers Collapsible Water Retainers. Provide floor drain in center of shower stall.

P-19 Wall Hung Two-User Lavatory - Handicap: The modular multiple lavatory system shall be Bradley Image Lavatory System™ model #MG-2/IRP/LSD/TMA/CHAR or approved equal by Sloan Valve Company, Intersan or Willoughby Industries, Inc.. Multiple lavatory systems shall provide two (2) hand washing stations, with the centerline of each stations located on 30" centers, perpendicular to the

mounting wall. Each hand washing station mounted at standard height shall comply with ANSI and ADA accessibility standards.

1. Bowl material for each station shall be a cast polymer resin complying with ANSI Z124.3 and ANSI Z124.6. Bowl finish shall be decorative stone.
2. Bowl Color: Empire Gray (other optional colors available) – Final Color Selection by Architect.
3. Lavatory stations shall be secured to a heavy gauge stainless steel frame.
4. All supply and waste connections shall be concealed within the frame.
5. Base shall support all hand washing stations to ANSI Z124.3 load ratings. Each hand washing station shall have an aerator served by an independent solenoid valve and actuated by an infrared sensing module with conical transmitting beams not exceeding the bowl perimeter. Each sensor shall have a 2-3 second turn-off delay; and automatic shutoff after 30-45 seconds of continuous operation.
6. Contoured access panel shall be 300 series stainless steel.
7. Lavatory system shall include plug-in transformer, all waste and supply connections to wall, and thermostatic mixing valve with stops, strainer and check valves.
8. There shall be a liquid soap dispenser included with the lavatory.

McGuire heavy duty polished chrome-plated cast brass angle valve kits, loose key, flexible risers, escutcheons. 1-1/2" x 1-1/2" polished chrome plated cast brass adjustable "P" trap, cleanout plug, extension to wall with escutcheon.

P-20 Rear Counter Mounted Eyewash, Barrier Free: Guardian Equipment model #GB1849LH Barrier-Free Eyewash, Deck Mounted, AutoFlow™ 90° Swing-Down. Eyewash outlet assembly is lowered and extended to permit access by wheelchair user. ADA compliance is dependent on 27" knee clearance under counter and 34" maximum counter height. Spray heads swing down from storage to operational position, activating water flow.

Spray Head Assembly: Two GS-Plus™ spray heads. Each head has a "flip top" dust cover, internal flow control and filter to remove impurities from the water flow.

Valve: 1/2" IPS plug-type valve with PTFE coated O-ring seals. Swinging head assembly down from storage to operational position opens orifice and activates water flow. Unit remains in operation until spray head assembly is returned to storage position.

Strainer: Unit is furnished with in-line strainer to protect valve and spray heads from debris in water line.

Mounting: Unit mounts on countertop behind sink. Furnished with mounting hardware for securing unit to counter.

Construction: Polished chrome plated brass.

Supply: 1/2" NPT female inlet.

Sign: ANSI-compliant identification sign.

Quality Assurance: Unit is completely assembled and water tested prior to shipment.

P-21 Bi-Level Water Cooler - Handicap: Halsey Taylor model #OVLSERGRN-VRWF bi-level barrier free water cooler, GreenSpec; shall deliver 8.0 GPH of 50ºF water at 90ºF ambient and 80ºF water inlet. Fountain shall include energy savings, filtered, vandal-resistant bubbler, mechanical front pushbar activation, contour-formed basin to eliminate splashing and standing water, and rounded corners and edges. Bubbler shall be chrome plated, two-stream, mount-building type. Cooling unit shall have a high efficiency positive start compressor using R134A, with pressurized counterflow cooling evaporator/chiller. The water cooler shall have a 1/5 HP compressor rated for 370 Watts at 115V-1Ø power, 4.0 full load amps. A wall mounting frame (in-wall frame/plate) is furnished with the water cooler for easy installation. The manufacturer shall certify the unit to meet the requirements of ANSI/NSF 61 & 372 (lead free) and meets Federal and State low-lead requirements.

Provide angle stop and "P" trap with cleanout for the fountain.

P-22 Bi-Level Water Cooler with Bottle Filler and Filter - Handicap: Halsey Taylor model #HTHBWF-OVLSER-I complete bi-level barrier free water cooler with HydroBoost® bottle filling station; shall deliver 8.0 GPH of 50ºF water at 90ºF ambient and 80ºF water inlet. Unit shall include bi-level oval fountains with integral bottle filling station constructed of stainless steel and ABS plastic. Bottle filler shall include electronic sensor for no-touch activation with automatic 20-second shut-off timer. It shall provide 1.5 GPM flow rate with laminar flow to minimize splashing. It shall include anti-microbial protected plastic components to prevent mold and mildew. Fountains shall include front pushbar activation and shall have oval contour-formed basins to eliminate splashing and standing water, and rounded corners and edges. Bubblers shall be chrome plated, two-stream, mount-building type with integral good guard and anti-squirt feature. Unit shall include WaterSentry Plus filter, certified to NSF/ANSI 41 & 53 for lead reduction, with visual monitor to indicate when replacement is necessary. Cooling unit shall have a high efficiency positive start compressor using R134A, with pressurized counterflow cooling evaporator/chiller. The water cooler shall have a 1/5 HP compressor rated for 370 Watts at 115V-1Ø power, 4.0 full load amps. A wall mounting frame is furnished with the water cooler for easy installation. The manufacturer shall certify the unit to meet the requirements of ANSI/NSF 61, Section 9 and the Safe Drinking Water Act. Unit complies with ARI Standard 1010.
Provide angle stop and "P" trap with cleanout for the fountain.

P-23 Mop Receptor: Fiat model #MSBID-3624 molded stone mop service basin, 36"x24"x10"D, 1" wide shoulders; factory installed drain body shall be stainless steel and designed to provide for a lead caulk or QDC-3 joint to a 3" drain pipe.
Chicago model #445-897S-XKRCCP service sink faucet with integral check and stops, cast brass spout with VB and pail hook, 8" centers .
Fiat Mop Hanger #889-CC; 24" long by 3" wide, stainless steel attached with three (3) rubber tool grips.
Fiat Hose and Hose Bracket #832-AA; 30" long flexible, heavy duty, 5/8" rubber hose, cloth reinforced, with ¾" brass coupling at one end. Bracket is 5" long by 3" wide. 18 gauge #302 stainless steel with rubber grip.

P-24 Washer Supply/Drain: Symmons model #W-602-X Laundry-Mate supply and drain unit with ½" supplies and 2" drain with integral stops and recessed wall box with wall plate.

P-25 Deck Mounted Eyewash: Guardian Equipment model #G1805 (or G1805LH depending on mounting) deck mounted AutoFlow™ 90° Swivel, Right-Hand (or left hand) mounting.

Spray Head Assembly: Two GS-Plus™ spray heads. Each head has a "flip top" dust cover, internal flow control and filter to remove impurities from the water flow.

Valve: 1/2" IPS plug-type valve with PTFE coated O-ring seals.
Swinging head assembly from storage to operational position opens orifice and activates water flow. Unit remains in operation until head assembly is returned to storage position.

Strainer: Unit is furnished with in-line strainer to protect valve and spray heads from debris in water line.

Mounting: Unit may be mounted on right side (G1805) or left side (G1805LH) of sink. Furnished with mounting shank, positioning lugs, locknut and washer for securing unit to counter.

Construction: Polished chrome plated brass.

Supply: 1/2" NPT female inlet.

Sign: ANSI-compliant identification sign.

Quality Assurance: Unit is completely assembled and water tested prior to shipment.

P-26 Wall Mounted Eyewash: Guardian Equipment model #GBF1721 Barrier-Free WideArea™, Eye/Face Wash, Wall Mounted, Stainless Steel Bowl and Skirt.

ADA Compliance: When installed at recommended mounting height, unit complies with ADA requirements for accessibility by handicapped persons (maximum height and reach, minimum knee clearance and distance from obstructions).

Spray Head Assembly: Four GS-Plus™ spray heads. Each head has a "flip top" dust cover, internal flow control and filter to remove impurities from the water flow.

Valve: 1/2" IPS brass stay-open ball valve. Valve is US-made with chrome plated brass ball and PTFE seals.

Bowl: 11-1/8" diameter stainless steel with wrap-around skirt. **Mounting:** Welded stainless steel wall bracket.

Supply: 1/2" NPT female inlet.

Waste: 1-1/2" OD chrome plated brass tailpiece.

Sign: ANSI-compliant identification sign.
Quality Assurance: Unit is completely assembled and water tested prior to shipment

P-27 Whirlpool: Provide Whitehall Mobile Whirlpool model #S-110-M with a 110-gallon capacity, 56"L x 24"W x 25"D, or approved equal. Whirlpool shall be fabricated from heavy gauge, type 304 stainless steel. Construction shall be seamless welded and exposed surfaces shall be polished to satin finish. Bottom of tank shall be a seamless, rounded coved design to minimize bacteria build up. Whirlpool shall have heavy duty swivel casters with locking device on rear pair of casters. Provide a turbine assembly with raising and lowering device which functions both as agitator and emptying device, permits adjustment of desired height, direction of water agitation, and can be locked into place. Turbine assembly shall be UL listed 1/2 HP jet pump motor with automatic thermal overload protector and lifetime-sealed bearings. Provide a thermometer with a stem retainer to prevent rattling when whirlpool is in operation. Provide Whitehall Manufacturing Whirlpool Mixing Valve model #MXT15-OTG-SMC. Mixing Valve Assembly shall be factory assembled and tested. The Thermostatic Mixing Valve shall comply with ASSE and CSA standards. Valve shall contain a copper encapsulated, paraffin-based Thermal Actuator. Valve shall be a chrome plated, solid DZR brass body with a capacity of 15 GPM at 45 PSI differential and a maximum operating pressure of 125 PSIG. Supply pressure variation shall be up to 20%. Valve shall have a maximum outlet temperature of 110°F. Assembly shall include an outlet temperature gauge, lockable inlet and outlet ball valves and a vacuum breaker. Valve shall comply with ASSE 1069, ASSE 1070 and CSA B125.3 standards. Provide surface mounted cabinet for the valve.

2.3 PLUMBING FIXTURES – OUTDOOR RESTROOMS AND STORAGE BUILDING

A. Provide plumbing fixtures as specified herein. Fixture trim, traps, faucet, escutcheons and waste pipes exposed to view in finished spaces shall be I.P.S. brass with polished

chromium plating over nickel finish. Fixtures shall have manufacturer's label or trademark indication first quality.

B. Fixtures with wall outlet flanges shall be set proper distance from floor or wall to make first-class joint with closet setting compound or gasket.

C. Mounting heights shall be as shown on architectural details.

D. Each individual fixture shall be provided with supply stops for each water service. Supply stops and supply risers shall be lead-free to meet NSF-61G.

E. Exposed piping below handicap lavatories and sinks shall be insulated with PVC coated insulation similar to Truebro LavGuard 2, McGuire Mfg. Co. Inc., Plumberex Specialty Products Pro-Extreme, or approved equal. The product shall be rigid high-impact, stain-resistant PVC, 1/8" constant wall thickness with internal ribs, have UV protection, and have an E-Z Tear-To-Fit trim feature. The color shall be china white and shall be Compatibility #100 series to fit all 1-1/4" or 1-1/2" cast brass or tubular P-trap assemblies and 3/8" or ½" angle stop assemblies.

F. Fixture Schedule: Unless otherwise specified, fixtures shall be as follows (Note: Manufacturers and Model numbers are provided to set standard of fixture) :

1. Stainless Steel Fixtures including Water Closets, Urinals and Lavatories with integral flush valves and faucets: Acorn Engineering Company, Metcraft Industries, Willoughby Industries Inc. or equal.
2. Mop Receptor: Crane Plumbing/Fiat Products, Stern-Williams Co. Inc., Zurn ZPPG, E.L. Mustee & Sons, Florestone Products Co. or equal.
3. Mop Receptor Faucets: Moen Commercial, Crane Plumbing/Fiat Products, Stern-Williams, American Standard, Chicago Faucets, Speakman Co. or equal.

OSP-1 Water Closet (Non-Handicap - Public): Furnish and install Acorn Engineering Company Dura-Ware model #2105-W-1-1.6GPF-FVCH-ADA Siphon Jet Toilet. Fixture shall be fabricated from 16 gauge, type 304 stainless steel. Construction shall be seamless welded and exposed surfaces shall have a satin finish with an integral contoured toilet seat. Toilet shall be concealed siphon jet type with an elongated bowl and a self-draining flushing rim. Toilet shall meet ANSI 112.19.2M requirements, using a minimum average water consumption of 1.6 gallons per flush. Toilet trap shall have a minimum 3-1/2" seal that shall pass a 2-1/8" diameter ball and be fully enclosed. Toilet waste outlet shall be gasketed waste. Connecting hardware provided by installer. Fixture specified shall include flush valve with wall supply (i.e. the flush valve shall be concealed behind the wall in the accessible plumbing chase).
Zurn Industries, Jay R. Smith, Josam or equal hub and spigot combined waste fitting and chair carrier supports, with adjustable extensions, rear foot support and face plate with foot support & feet bolted to floor, with seat mounting height to be 15" above finished floor.

OSP-2 Water Closet (Handicap - Public): Furnish and install Acorn Engineering Company Dura-Ware model #2105-W-1-1.6GPF-FVCH-ADA Siphon Jet Toilet. Fixture shall be fabricated from 16 gauge, type 304 stainless steel. Construction shall be seamless welded and exposed surfaces shall have a satin finish with an integral contoured toilet seat. Toilet shall be concealed siphon jet type with an elongated bowl and a self-draining flushing rim. Toilet shall meet ANSI 112.19.2M requirements, using a minimum average water consumption of 1.6 gallons per flush. Toilet trap shall have a minimum 3-1/2" seal that shall pass a 2-1/8" diameter ball and be fully enclosed. Toilet

waste outlet shall be gasketed waste. Connecting hardware provided by installer. Fixture specified shall include flush valve with wall supply (i.e. the flush valve shall be concealed behind the wall in the accessible plumbing chase).
Zurn Industries, Jay R. Smith, Josam or equal hub and spigot combined waste fitting and chair carrier supports, with adjustable extensions, rear foot support and face plate with foot support & feet bolted to floor, with seat mounting height to be 18" above finished floor.

OSP-3 Urinal (Non-Handicap - Public): Furnish and install Acorn Engineering Company Dura-Ware model #2158-w-1-FVCH Stainless Steel Urinal. Urinal mounted at 17" rim height to comply with ANSI, ADA and UFAS accessibility requirements. Interior to have a contoured surface to facilitate cleaning. Fixture shall be fabricated of 18 gauge with 16 gauge bowl type 304 stainless steel with exposed surfaces polished to a satin finish. Fixture specified shall include flush valve with wall supply (i.e. the flush valve shall be concealed behind the wall in the accessible plumbing chase) - (0.5 GPF).
Zurn Industries, Jay R. Smith, Josam or equal hub and spigot combined waste fitting and chair carrier supports, with adjustable extensions, rear foot support and face plate with foot support & feet bolted to floor, with rim mounting height to be 24" above finished floor.

OSP-4 Urinal (Handicap - Public): Furnish and install Acorn Engineering Company Dura-Ware model #2158-w-1-FVCH Stainless Steel Urinal. Urinal mounted at 17" rim height to comply with ANSI, ADA and UFAS accessibility requirements. Interior to have a contoured surface to facilitate cleaning. Fixture shall be fabricated of 18 gauge with 16 gauge bowl type 304 stainless steel with exposed surfaces polished to a satin finish. Fixture specified shall include flush valve with wall supply (i.e. the flush valve shall be concealed behind the wall in the accessible plumbing chase) - (0.5 GPF).
Zurn Industries, Jay R. Smith, Josam or equal hub and spigot combined waste fitting and chair carrier supports, with adjustable extensions, rear foot support and face plate with foot support & feet bolted to floor, with rim mounting height to be 17" above finished floor.

OSP-5 Wall Hung Lavatory (Handicap - Public): Furnish and install Acorn Engineering Company Dura-Ware model #1953-1-DMS-4-H24-GE-OF-LC 18" wide Lavatory. Fixture shall be fabricated from heavy gauge, type 304 stainless steel. Construction shall be seamless welded with a satin finish exterior. Lavatory deck shall have an integral air-circulating, self-draining soap dish. Lavatory angle braces and fasteners shall be furnished by manufacturer. Installation shall be made in accordance with manufacturer's recommendation and details. Units to conform with ANSI, UFAS and ADA requirements for accessibility. Fixture shall be provided with deck mounted spout, air control hot and cold water valve, 4" centerset faucet holes, grid strainer with close elbow (1-1/4"), and lavatory overflow.
McGuire heavy duty polished chrome-plated cast brass angle valve kits, loose key, flexible risers, escutcheons. 1-1/4" x 1-1/2" polished chrome plated cast brass adjustable "P" trap, cleanout plug, extension to wall with escutcheon. Grid drain.
Concealed arm carrier support with foot support to suit construction. Install with rim at 34" maximum above finished floor.
Insulate cold water, hot water, and waste beneath lavatory.

OSP-6 Mop Receptor: Fiat model #MSBID-3624 molded stone mop service basin, 36"x24"x10"D, 1" wide shoulders; factory installed drain body shall be stainless steel and designed to provide for a lead caulk or QDC-3 joint to a 3" drain pipe. Chicago model #445-897S-XKRCCP service sink faucet with integral check and stops, cast brass spout with VB and pail hook, 8" centers .

Fiat Mop Hanger #889-CC; 24" long by 3" wide, stainless steel attached with three (3) rubber tool grips.
Fiat Hose and Hose Bracket #832-AA; 30" long flexible, heavy duty, 5/8" rubber hose, cloth reinforced, with ¾" brass coupling at one end. Bracket is 5" long by 3" wide. 18 gauge #302 stainless steel with rubber grip.

2.4 KITCHEN EQUIPMENT

A. Kitchen equipment shall be set in place by the Kitchen Equipment Subcontractor.

B. The Plumbing Subcontractor shall provide hot and cold water, natural gas, drainage, waste and vent to each of these fixtures as required and make final connections to same.

C. The Plumbing Subcontractor shall furnish and install shut-off valves at each fixture and, where required, shall provide unions to permit the removal of fixtures for repairs. All hot and cold water piping, valves, waste and vent piping to Kitchen Equipment exposed to normal view, including piping under exposed counters, shall be chrome-plated brass pipe or chrome-plated copper tubing after fabrication.

D. The Kitchen Equipment layout plans show the approximate size, number, and locations of connections for each item of Kitchen Equipment. The Plumbing Subcontractor is advised that the size, number, and arrangement of connections may vary with different manufacturers. This Contractor shall make the connections no smaller than those provided at the fixture and shall vary the arrangement to suit the equipment furnished. The Kitchen Equipment Subcontractor shall furnish certified roughing-in drawings to the Plumbing Subcontractor before proceeding with the work. Verify and coordinate all floor drain and floor sink locations with the kitchen equipment contractor before they are set.

E. The following items and those indicated on the Drawings shall be furnished and installed by the Kitchen Equipment Contractor, but the Plumbing Subcontractor shall make all connections, hot and cold water, gas, waste (direct or indirect), and vent piping, thereto and provide necessary traps, shut-offs, thereof:

3-Compartment Pot Sinks	Floor Troughs	Ice Cuber with Bin
Hand Sinks	Convection Steamer	Cold Food Counters
Prep Tables w/ Sinks	Double Convection Ovens	2-Burner Range
Hot Food Counters/Wells	Soiled Dishtables w/ Sinks	Clothes Dryer
30 & 40 Gallon Tilting Skillets	Hose Reel/Control Panel	Cooler Coils
4-Burner Ranges with Ovens	(2) Dishmachines	Freezer Coils
Pre-Rinse Hose Assemblies	Disposers & Controls	Tilting Kettle
40 & 60 Gallon Tilting Kettles	Back Work Counters w/ Sink and/or Hand Sink	
Double Deck Pizza Ovens	Convection Steamer	Fryer Assembly
6-Burner Ranges with Convection Ovens		Roll-In Combi Ovens
Eye Wash Stations	Utility Distribution System	Coffee Brewer
Air Screen Merchandiser	Espresso Machine	

G. The Kitchen Equipment Subcontractor shall furnish all faucets, strainers, lever handle wastes and waste outlets required on equipment; all furnished equipment shall be installed by the Plumbing Subcontractor. All other specialty items such as tailpieces, traps, valves, and shut-offs, shall be furnished and installed by the Plumbing Subcontractor.

H. The Plumbing Subcontractor shall furnish and installed the mop sink in Janitor B188 and B198 (Kitchen Equipment Items #18 & #184). The floor mounted mop sink shall be Eagle

Group model #F2820, Advance Tabco #9-OP-48, or equal, constructed of type 304 stainless steel, with 8" deep drawn coved corner sink with drain and flat strainer plate. Provide service faucet model #312690 with 8" centers, ½" NPT female inlets and vacuum breaker. Also, provide 3-pole mop holder model #312688 and hose & bracket model #312689. Equal manufacturers for the mop sinks are Advance, Aero or Griffin.

I. The dishmachines shall have a backflow preventer installed on the incoming hot water supply piping. Also, there shall be non-testable dual check backflow preventers with vacuum breaker installed under the 3-compartment pot sinks on both the cold and hot water taps for connection by the soap/sanitizing subcontractor. This is shown on the drawings.

J. Several pieces of cooking equipment require water filtration systems and are shown on the drawings. These are furnished by the Kitchen Equipment Contractor, but the Plumbing Subcontractor shall install and pipe them. They are typically located on the wall or metal panel behind the equipment.

K. The Kitchen Equipment Subcontractor shall furnish all flexible gas fittings for the cooking equipment and restraints to the Plumbing Subcontractor. The Plumbing Subcontractor shall install all equipment that requires plumbing and make final connections.

L. The Kitchen Equipment Subcontractor shall furnish mechanical gas valves, full size of gas headers, interlocked to the dry chemical suppression systems. The Plumbing Subcontractor shall install the gas solenoid valves in the gas headers to the kitchen equipment. The Electrical Subcontractor shall wire the valve into the fire suppression system for the kitchen hood. This is typical for two systems/kitchens.

M. The Plumbing Subcontractor shall furnish and installed a mechanical gas solenoid valve with manual reset, full size of gas header in an accessible location, preferably exposed below the ceiling. CO Detection System wired to the Gas Solenoid System is required for kitchen hood in lieu of in-line solenoid valve wired to fan switch since possibly some of the gas appliances have gas pilots (none currently do, though). Furnish and install gas detector panel and gas solenoid valve as noted below (typical for two systems):

1. Honeywell E^{3}Point Toxic and Combustible Gas Detector, Standalone Platform (single or dual-gas monitoring) model #E3SARHSCO base unit with remote sensor capability, surface-mount or equal is a combination sensor and energy saving unit. Concentration of a targeted gas is monitored and ventilation equipment cycled when selected threshold levels are exceeded. Because ventilation equipment runs only when necessary, energy costs for heating and operating fans are greatly reduced. Detector shall monitor carbon monoxide (CO). Detector includes an easy to read digital display, a test feature to aid in installation, and an internal audible alarm. Stand Alone Detectors can be used to monitor up to two remote transmitters. See drawings for additional information and wiring. See plans for location of panel and solenoid valve. Gas Detector Systems shall be Brasch, Toxalert, Vulcain, American Gas Safety or approved equal.
   Provide remote sensors so that if there is one sensor at the panel, then there is one remote sensor for each type of gas to be detected.

2. Provide Heiser model #835 Manual Reset Relay or approved equal wired between gas solenoid valve and the gas detection panel. Alternate Fire System Electric Gas Valve Reset is by Brooks Equipment Co., Inc.

3. Gas Solenoid Valve shall be Asco model #8210G100 or approved. Valve shall have a brass body, NBR seals, PA disc-holder, stainless steel core tube and springs. Valve shall be UL Listed and be sized for a 2" pipe. Gas Solenoid Valve shall be Asco, Danfoss, Honeywell or approved equal.

4. In addition, provide relay enclosures for electrical shunt trip breakers for power panels to kitchens. These need to be the same manufacturer as the CO detection system panel for ease of integration. This system include Emergency Power Off buttons.

N. An alternate system for the CO & Flammable Gas Detection System is as follows:

1. CONTROL UNIT (LA Series): At each Cooking Station or as shown on Drawings, provide an ISIMET - LA Series Control Panel Model KLA-2215-R-P-C with IRE/S relay and enclosure to control the shunt trip circuit breakers. Panel shall be brushed stainless steel with concealed wall box provided with panel service switch, low voltage transformer and fuse block. Panel shall comply with UL508-A, Standards for Industrial Control Panels. Panel should include a clear flip up protective cover for panic button. The mounting height for the control panel shall be 60" from the finished floor.

   a. Panel shall have integral printed circuit board with logic device to provide a 120-vac output circuit to activate the Fuel Gas Solenoid and a 24-vac output circuit to activate utilities as shown on drawings. Activation of output circuits shall be enabled only by switch ON and then keying.

b. The Panel shall be equipped with a service switch for the output circuits and a momentary enabling key switch. Deactivation of output circuits shall not require engagement of enabling key. Panel shall be provided with N/O momentary panic button assembly to deactivate output circuits in case of emergency. Reset after panic shall occur by re-keying.

c. Provide panel with additional terminals for integration of ISIMET Remote Panic Button Assembly, Fuel Gas Sensor, CO Sensor and opto-isolated input terminal for integration with facility's alarm system. A fire alarm signal shall deactivate all utilities controlled by the LA Series Control Panel.

d. Provide panel with dry contact terminal and 24-vac terminal for output integration. ISIMET "Panic" shall provide a notification signal to a secondary monitoring system. Reset of Controller shall withdraw notification signal.

1. CARBON MONOXIDE (CO) SENSOR: Carbon Monoxide Sensor shall be Honeywell model E3SA sensor with E3SCO cartridge. Locate as shown on Drawings and integrate assembly with Kitchen Hood Controller.

2. REMOTE CARBON MONOXIDE (CO) SENSOR: Remote Carbon Monoxide Sensor shall be Honeywell model E3SRMCO. Locate as shown on Drawings and integrate assembly with Kitchen Hood Controller.

   a. Mounting Note: CO Sensor should be wall mounted at a minimum height of five feet above the floor and at least ten feet away from fuel gas burning equipment. This will allow a visual notification of detection and will prevent false positive readings from the sensor.

3. FUEL GAS SENSOR: Fuel Gas Sensor shall be ISIMET Model FGS-2212 to detect raw fuel gas within the kitchen area. Assembly shall consist of wall box and stainless steel

panel with sensor and indicator lamp. Locate as shown on drawings and integrate assembly with Kitchen Hood Controller.

a. Mounting note: Gas sensors for Natural Gas (Methane) should be mounted about one foot below the ceiling.

4. SOLENOID VALVE: Furnish and install ISIMET Series 300 normally closed natural gas specific zero pressure differential solenoid. Solenoid coil shall be 120-vac. Provide a ball valve up-stream from solenoid. Thoroughly flush piping system prior to placing into service. Final connection to coil from control unit by Electrical Contractor. Solenoid shall close upon loss of operating power and require re-keying for reactivation of service. Solenoids are sized as indicated on Drawings.

5. INTEGRATION AND CONFIGURATION

a. INTEGRATION WITH OTHER BUILDING SYSTEMS: CAUTION – Operation of emergency devices, including emergency showers and eyewashes, shall not be integrated with this system for either activation or deactivation.

b. ENERGY MANAGEMENT CONTROL SYSTEM (EMS): Where shown on Drawings, provide low voltage integration wiring to connection point of the system as directed by the system installer. Make connection of wiring and configure Controller to activate with available control voltage.

c. BUILDING ALARM SYSTEM: Where shown on Drawings, provide low voltage integration wiring from the Controller to connection point of Building Alarm System. Configure Controller to comply with Alarm System monitoring requirements. From Building Alarm System, provide low voltage wiring to receive output signal from that system for shutdown of Controller in case of fire alarm. Final connection by others. Note that the CO Detection Systems are completely independent of the building fire alarm system due to false alarms when there are power outages.

d. ANSUL FIRE SUPPRESSION SYSTEM: Where shown on Drawings, provide low voltage integration wiring from the ANSUL System to connection point of LA Controller. Final connection by others.

e. SYSTEM CONFIGURATION: Controller shall be factory configured to the specified configurations and shall be capable of field adjustments to meet specific project modification requirements.

6. INSTALLATION: Install in accordance with manufacturer's recommendations and instructions. Verify manufacturer's mounting heights to comply with ADA or other standards. Furnish and install all devices as shown on Drawings and as specified herein. Where device is to be installed by other trades, furnish and then turn over to appropriate trade for installation.

a. ELECTRICAL: All work specified in this section shall be performed according to electrical specifications and by that contractor. Make final connections to monitoring and remote panic assembly panels as indicated on Drawings and specified herein. Furnish and install low voltage control wiring from LA Series Controller to connection point of Energy Management Control System, Building Alarm and ANSUL System. Final connection by others.

b. CONDUIT: Unless otherwise specified for wiring systems, provide conduits for control and integration wiring from point of connection to each device to accessible point above ceiling. Provide separate conduit for each device that is controlled and integrated with Controller. Conduits for monitoring carbon monoxide detectors and methane gas detectors shall be separate from line voltage, control wiring and integrated systems wiring. Where system components are mounted along side the Controller within a common wall, install conduit for low voltage control wiring between the devices.

c. WIRING:
   i. Power to Control Unit: Provide dedicated electrical service to LA Series controller. Minimum 15 amp circuit.

   ii. Low Voltage Control Wiring: Provide 24 VAC control wiring from LA Series Controller to each controlled utility or device. Make connections at controlled device and terminate at output terminal on Controller. Minimum wiring, 18 AWG, plenum rated cable. Provide cable with required conductors plus two spares.

   iii. Integrated Systems: Provide low voltage wiring for integration to other systems as shown on Drawings. Verify voltage and wire sizes to comply with requirements of each system.

d. WIRING: Do not install wiring or cable for integrated systems, carbon monoxide detectors, methane detectors, or other interface wiring within conduit for either 24-vac control, 120-vac line voltage or three phase wiring. Each wiring system should be housed in independent conduit and not bundled with wiring for other systems.

7. The Plumbing Subcontractor shall provide additional relay enclosure (IRE/S) to allow the CO detection panel and the electrical panel to be configured in factory for shunt trip. This include Emergency Power Off buttons in both kitchens. The Electrical Subcontractor shall provide power circuits to both the Isimet panel and the relay enclosure and wire the 120V output to the shunt trip breaker.

2.5 LABORATORY EQUIPMENT

A. All mechanical service fixtures, fittings, and related items shall be furnished under the scope of work of this section, whether itemized or not and shall be of best quality. Specialized laboratory fixtures shall be used on science furniture and fixtures, shall be of red brass with a copper content of 81%. All water valves shall be manufactured using NSF 61 Lead-Free Brass alloys. Fixtures used in connection with furniture other than science furniture shall be good quality domestic fixture of modern design. All fixtures shall be in chromium plated finish over nickel and copper, unless specifically specified to be chemical-resistant metallic bronze finish. All sinks have overflow drain, so pipe accordingly.

B. Laboratory water fixtures shall be ½" I.P.S., unless otherwise specified, and shall have lever handles or ADA compliant wrist blade handles as specified. Water valves shall use interchangeable cartridge designs with all wearable parts self-contained. Gooseneck spouts shall be extra heavy seamless brass tubing with vacuum breakers as manufactured by Chicago Faucet, T & S Brass, Zurn ZPPG, WaterSaver Faucet Company, Moen Commercial or equal. Student Table, Demonstration Table and Prep Room Sinks shall have faucets similar to the models called out in section 2.5.J.

a. Sinks with two faucets shall be one water single faucet and one water single faucet with aspirator on the nozzle.

C. Removable serrated hose ends shall be provided on all water fixtures in accordance with the equipment list. Where indicated, serration shall be so designed as to hold hose securely. These shall be furnished in addition to the aerators for Owner's optional use.

D. Spring flow aerators are to be furnished on all water fixtures.

E. Laboratory Gas valves shall be AGA certified, Massachusetts Plumbing Board approved ball valve type with integral serrated nozzle and internal check valve. 3/8" ips quarter-turn design with an ADA compliant lever handle. Valve to be rated for 125psi max working pressure. All single gas turrets shall be similar to Chicago Faucet model #LGB1-31C-55 or equal Straight Pattern Ball Valve. These shall have straight serrated nozzles with check valve, metal level handles, index button for natural gas service, straight wall flange and shanks, solid brass valve construction and shall be fully assembled and tested. Equivalent manufacturers are T & S Brass, WaterSaver Faucet Company, or equal.

F. Tank nipples shall be furnished where required to anchor fittings to laboratory furniture and shall provide a tapered pipe thread running into a thread to allow use of lock nut and still provide leakproof joints.

G. Colored index buttons shall be provided to designate type of service on all mechanical service fixtures and both color and lettering shall be provided in button which shall be located in top of handles of fixtures. Color designations shall be as follows:

Lab Hot Water – Red Button with White "H"
Lab Cold Water – Blue Button with White "C'
Lab Gas – Green Button with White "G"

All indexes shall be of the colored plastic material and indented letters shall be filled with enamel in contrasting color.

H. Crump cup strainers of stainless steel shall be provided at stainless steel sinks. Provide tailpieces for stainless steel sinks.

I. Vacuum breakers are required where serrated hose tips are furnished, shall be chrome plated brass, and shall be either Chicago Faucet, Opmax or Watts Regulator Company LF-9 backflow preventer as required by area plumbing code. Vacuum breakers shall be installed between the control valve and the outlet of the fixture and, when area code requires vacuum breaker to be installed in an elevated position, piping necessary to connect valve, vacuum breaker, and hose shall be by this Contractor. Where vacuum breakers are required by area code, those mechanical service fixtures not requiring a hose connection shall not have vacuum breakers, but shall be provided with devices acceptable to the code authorities that will prevent under any circumstances the connection of a hose.

J. Laboratory Plumbing Fixtures as scheduled required the following faucets or gas turrets and are as follows (note that model numbers provided are for reference and shall be used as a standard only). Also, note that the single air and gas turrets in the students tables are not listed and are specified above/:

1. L-1: Student Table Sink – One (1) Cold Water Only Faucet Chicago Faucets model #LWS3-C11-A or equal and one (1) Cold Water Only Deck Mounted Faucet Chicago Faucets model #LWS3-C31-A with aspirator.
2. L-2: Student Table Sink (Handicap) - One (1) Cold Water Only Faucet Chicago Faucets model #LWS3-C11-A or equal
3. L-3: Demonstration Table Sink – One (1) Cold Water Only Faucet Chicago Faucets model #LWS3-C11-A or equal
4. L-4: Emergency Shower/Eyewash/Facewash – One (1) Chicago Faucets model #8420-NF wall mounted combination eye/face wash and safety drench shower, wheelchair accessible combination eye/face wash and safety drench shower with integral pull handle.
5. L-4A: Emergency Shower/Eyewash/Facewash – One (1) Chicago Faucets model #8405-NF floor mounted combination eye/face wash and drench shower, wheelchair accessible combination eye/face wash and safety drench shower with stainless steel pullrod by Plumbing Subcontractor.
6. L-5: Hand Wash and Prep Room Sink - One (1) Mixing Faucet Chicago Faucets model #930-369XKCP.
7. L-6: Pass-Thru Fume Hood - Integral faucet and control

K. Science Room Fixture L-4 shall have the following features:

1. Eye/Face Wash
2. 1" NPT Male Thread Inlet (Supply Connections)
3. 1-1/2" NPT Male Thread Outlet (Drain Connection)
4. Anti-corrosive polyamide 11 plastic coating in high-visibility yellow color
5. Wall Recessed Mounting
6. Eyewash assembly in ABS plastic
7. Eyewash bowl in Stainless Steel
2. Two high-flow aerated water spray at low pressure with automatic opening anti-dust cover
3. Brass Fittings with Galvanized Pipe Construction
4. Pull Handle for activation
5. Shower head in Stainless Steel
6. High-visibility photoluminescence safety sign with green background and white text for easy identification
7. Maintenance card for recording periodic testing
8. Certified to the ANSI Z358.1 Standard for Emergency Eyewash and Shower Equipment
9. Equal manufacturers to Chicago Faucets are Bradley, Guardian Equipment & Encon.

L. Science Room & Garage Fixture L-4A shall have the following features:

1. Combination Eye/Face Wash and Drench Shower
2. 1-1/4" NPT Female Thread Inlet
3. 1-1/4" NPT Female Thread Outlet
4. Anti-corrosive polyamide 11 plastic coating in high-visibility yellow color
5. Floor Mounted
6. Eyewash assembly in ABS plastic
7. Eyewash bowl in ABS Plastic
8. Two high-flow aerated water spray at low pressure with automatic opening anti-dust cover
9. Brass Fittings with Galvanized Pipe Construction
10. Push Handle for activation
11. Pull Rod for activation

12. Shower head in ABS Plastic
13. High-visibility photoluminescence safety sign with green background and white text for easy identification
14. Maintenance card for recording periodic testing
15. Wheel Chair Accessible
16. Certified to the ANSI Z358.1 Standard for Emergency Eyewash and Shower Equipment

M. Single Zone Valve Box Assemblies for Emergency Gas Shut-off Valves at Science Classrooms: Similar to Isimet LSP – Laboratory Service Panel for Natural Gas System

1. CONTROL PANEL: At each science classroom as shown on Drawings, provide an ISIMET – LSP2211-3 –T Laboratory Service Panel. Panel shall have brushed stainless steel door panel and trim with gray powder coated enclosure provided with low voltage transformer and fuse block. Enclosure shall be NEMA 1 rated. Panel shall be labeled “NATURAL GAS SERVICE PANEL”. Panel shall comply with UL508-A, Standards for Industrial Control Panels.

   a. Panel shall have integral printed circuit board with logic device to provide 24-vac output circuit to activate integral 24-vac natural gas solenoid. Activation of output circuit shall be enabled only by switch ON and then keying.

   b. The Panel shall be equipped with a service switch and a momentary enabling key switch. Deactivation of output circuit shall not require engagement of enabling key. Panel shall be provided with N/O momentary panic button assembly to deactivate output circuit in case of emergency. Reset after panic shall occur by re-keying. Green LED shall indicate operation ON. Red LED shall indicate that shut-down has occurred due to pressing the panic button.

   c. Provide panel with dry contact terminals for output integration. ISIMET “Panic” shall provide a notification signal to a secondary alarm monitoring system. Reset of Service Panel shall withdraw notification signal.

2. SOLENOID: Service Panel shall be furnished with ISIMET Series 303 normally closed natural gas specific zero differential solenoid. Solenoid coil shall be 24-vac. Solenoid shall be UL listed. Service Panel shall be provided with a ball valve up-stream from solenoid. Thoroughly clean piping system prior to placing into service.

3. WIRING: Do not install wiring or cable for integrated systems, remote panic assemblies, fuel gas sensors or other interface wiring within conduit for either 24-vac control or 120-vac line voltage. Each wiring system should be housed in independent conduit and not bundled with wiring for other systems.

   a. Line and 24-vac control wiring furnished and installed by Electrical Subcontractor.

4. Emergency Gas Shut-Off Panel shall be Isimet, American Gas Safety, Mapa Products, Asco, or approved equal.

N. Alternate Single Zone Valve Box Assemblies for Emergency Gas Shut-off Valves at Science Classrooms:

1. MERLIN UTILITY CONTROLLER: At each science classroom and elsewhere as shown on Drawings, provide a Utility Controller with fascia panel mounted switches to activate remote solenoids and relays to control natural gas, domestic water and

electrical convenience outlets or other indicated services or devices. Utility Controller shall comply with Underwriter's Laboratory UL61010-1 3rd Edition Standards. Controller shall have integrated printed circuit board and Microprocessor with adaptable programming features. Controller shall utilize and operate a pressure transducer to perform a pressure drop test on the natural gas line before allowing gas to be supplied. Controller shall continuously check incoming gas supply pressure throughout operation. Controller shall provide line voltage signals for output circuits. Controller shall provide inputs for remote EPO's and Gas Sensors. The Controller shall be equipped with an Authority Key Lock that restricts activation of output signals to the instructor or educator. Controller shall be provided with a fascia mounted EPO button. Output signals will require Key Lock authority for re-set.

2. PRESSURE TRANSDUCER: Each Controller shall be provided with a UL approved pressure transducer to be installed on the natural gas pipe, either via the solenoid valve or via a reducing fitting located as close to the solenoid valve as is permissible on the downstream side.

3. SOLENOID VALVE: At each science classroom and where shown on Drawings, provide UL approved solenoids for Gas services. All solenoids shall be normally closed and fail closed on loss of power. Number of solenoids, intended use and pipe sizes are as noted in Equipment Schedule or Drawings.

4. REMOTE PANIC BUTTON: Where shown on Drawings and where classroom size and configuration restricts clear path from work areas to Utility Controller, provide a wall mounted Remote Panic Button. Assembly shall be located as shown on Drawings and as stipulated in Equipment Schedule. Integrate assembly with low voltage input on Controller.

5. FUEL GAS SENSOR: Where shown on Drawings and in Equipment Schedule, furnish and install a AGS Merlin Fuel Gas Sensor in order to detect raw fuel gas within the classroom. Integrate Fuel Gas Sensor with the Controller.

O. The Plumbing Contractor shall provide an additional electrical relay enclosure for the science labs connected to the natural gas shut-off system. The manufacturers shall be the same for each enclosure. The intent is that if the gas is shut off in an emergency either at the gas panel or the remote shut-off button, then the electrical system will also be shut off as well. The electrical subcontractor shall wire the electrical relay enclosure.

2.6 PIPE MATERIALS

A. All soil, waste, vent and storm drain lines in accessible areas 2 in. and larger shall be cast-iron "no-hub," ASA group 022 pipe and fittings joined with "Clamp-All," or equal; on pipe sizes 3 in. and larger, use four (4) band clamps, two (2) band clamps will only be allowed on 2 in. pipe. All buried soil, waste, vent, and storm lines shall be service weight cast-iron pipe with all fittings carefully fitted and caulked together with oakum and lead, sealed gas and watertight. Minimum size of piping below ground shall be 2 in. Where it is impractical to install cast-iron pipe, as in tight partition work or where the sizes of lines are smaller than 2 in., Type "L" copper tubing shall be used conforming to ASTM Specification with sweat type fitting using lead free solder and non-corrosive flux, "Non-Korrode," or approved equal, conforming to ASTM Specification B-32 alloy 50A. In lieu of oakum and lead joints, "push on type" resilient gasket fittings may be used on buried pipe only. Provide extra heavy cast-iron for urinal connections.

1. Furnish and install hubless soil pipe couplings designated Heavy Weight (HW), made of extra wide, heavy duty corrugated type 304 stainless steel with axially slotted heavy duty, worm drive clamps tightened to 80 in lbs. of torque. Flanged gaskets to be made of neoprene rubber, meeting the requirements of ASTM C 564, with sealing rings under each stainless steel clamp. Manufacturers shall be Mission Heavy Weight, Husky 4000, Clamp-All 125, or equal.

B. All vent lines 2 in. and smaller shall be Type "L" copper, or DWV, except minimum size below ground shall be 2 in. Minimum vent terminal through roof shall be 4 in. except otherwise noted. Vent flashing at the roof shall be by the Roofing Subcontractor.

C. All hot water, cold water, tempered water, laboratory water, hot water recirculating piping and emergency shower piping within the building shall be hard copper Type "L" seamless drawn tubing assembled with sweat fittings. All solder used shall be lead free, cadmium free, "Silverbrite - 100," or approved equal, complying with the latest issue of ANSI A-5.8 publication. All exposed runs to all toilet fixtures and sinks shall be chrome plated. As an alternate in the school building, the Plumbing Contractor can use polypropylene random copolymer (PP-RCT) for piping mains. This shall not be used in the Storage/Toilet Building since it is unheated in the winter.

1. Mechanical grooved pipe couplings, fittings, Mechanical T's, and other products are acceptable to be used on piping systems and mechanical equipment connections 2"diameter and larger (in lieu of welded/flanged and threaded methods) in systems specified. Operating conditions not to exceed -30°F to 250°F temperature range according to the gasket lining selected and working pressures as shown in the coupling manufacturer's current product specifications.
   a) Copper Piping Systems: Grooved piping products for use with ASTM B88 hard Type L copper tubing shall be copper tubing sized. (Flaring of pipe ends to IPS dimensions is not allowed.) Fittings shall be ASTM B75 or B152 wrought copper or ASTM B584-87 bronze sand casting. Couplings shall be ASTM A395 and A536 ductile iron, with angle pattern bolt pads or tongue and groove design for rigidity upon visual confirmation of metal-to-metal bolt pad contact with no torque requirement. Coupling housings coated with copper colored alkyd enamel. Gaskets shall be Style "EHP" EPDM grade to suit the intended service. Gaskets used on potable water systems shall be EPDM, UL classified in accordance with ANSI / NSF61 for both hot (180F) and cold (86F) potable water service.

2. Press Fitting: Copper press fittings shall conform to the material and sizing requirements of ASME B16.18 or ASME B16.22. O-Rings for copper press fittings shall be EPDM.
   a. Manufacturers of Copper Press Fittings:
      Viega, 17545 Daleview Dr., Lakewood, OH 44107, (877) 620-0016;
      Rigid Tool Company, 400 Clark Street, Elyria, OH 44035, (800) 519-3456;
      Elkhart Products Corporation "Xpress Press-Connect Fittings", 1255 Oak Street, Elkhart, Indiana 46515, (800) 284-4851
      Nibco Press System, 1516 Middlebury Street, Elkhart, IN 46516-4740, (800)234-0227

3. Vic-Press 304™ Fittings: In lieu of alternate piping methods, Vic-Press 304™ may be used on piping systems 1/2" through 2" in size. Pipe shall be ASTM A312 .Schedule 10 type 304/304L stainless steel.. Fittings and couplings shall be precision cold drawn austenitic stainless steel, complete with synthetic rubber O-ring. O-ring grade to suit the intended service. O-rings used on potable water systems shall be EPDM, UL classified in accordance with ANSI / NSF61 for potable water service.

a) Manufacturers of Vic-Press 304™ Fittings: Victaulic Company of America

4. Solder Standard: Solder metal shall conform to the requirements of ASTM B32. Soldering fluxes shall conform to ASTM B813. Solder and fluxes used in drinking water systems shall have a maximum of 0.20-percent lead (Pb) content.

5. Polypropylene: Pipe and fittings shall be Niron Clima by Nupi Americas or equal, manufactured from a PP-RCT resin meeting the short-term properties and long-term strength requirements of ASTM F2389. The piping shall be extruded with a middle layer that has glass fiber content to restrict thermal expansion.
   a. Fittings may be either socket fusion through nominal 5 inch, electrofusion through 8 inch or butt fusion style in nominal 2 inch through 24 inch.

D. Cold water pipe below ground: Type K soft copper tubing with flared fittings or polypropylene (PP-RCT).

E. Indirect waste piping less than 1-1/4" in size shall be Type "L" hard drawn copper tubing with wrought copper sweat fittings joined with approved 95/5 lead free tin antimony solder.

F. Indirect waste piping 1-1/4" and larger in size shall be Type DWV hard drawn seamless copper tubing with wrought copper drainage fittings joined with approved 95/5 lead free tin antimony solder.

G. All natural gas piping inside the building shall be Schedule 40 black steel pipe with malleable pattern fittings, installed in strict compliance with the Massachusetts Fuel Gas Code, (248 CMR 5.00). All piping 2 in. and below shall be assembled with screwed malleable iron fittings; 2-1/2 in. and above shall be welded. Provide necessary ball type gas shut-off valves or square head cocks and drips as required. All joints shall be made up with "Rectoseal" and tested.

1. All welding shall be done in accordance with the welding procedures of the National Certified Pipe Welding Bureau, or any other approved procedure, conforming to the requirements of the ASA Code for Pressure Piping. No welder shall be employed on the work who has not been fully qualified under the above specified procedure and so certified as a member of the local chapter of the National Certified Pipe Welding Bureau or similar locally recognized testing authority.

2. All natural gas piping, including gas shut-off valves and final connections to kitchen equipment, shall be the responsibility of the Plumbing Subcontractor.

3. The Plumbing Subcontractor shall apply for the new natural gas service and the Owner shall pay for all fees and charges required. On-site service entrance piping shall be by Eversource Gas Company, including all gas pressure regulators and gas meter.

4. All gas piping and final connections to gas-fired boiler's gas trains and gas trains regulators vent piping shall be the responsibility of the Plumbing Subcontractor.

   a. All main gas pressure regulators shall be independently vented to a safe outdoor location. Vent lines from regulators shall not be connected into a common line with the bleed line from gas operated diaphragm valves or from pressure relief valves. Vent lines shall be of steel or wrought iron pipe with means provided at termination points to prevent stoppage of the lines by foreign material, water or

insects. Coordinate with HVAC Subcontractor and Domestic Hot Water Boiler manufacturer for gas train venting requirements. These are not shown on the drawings, but are required to be installed by this contractor per code. Note that ventless gas regulators may be utilized on the gas trains.

5. Science room gas piping from outlet of emergency gas shut-off valves to gas turrets can be either as specified above or by using corrugated, semi-rigid stainless steel tubing with brass mechanical attachment fittings terminating in male pipe fittings as manufactured by TracPipe, Gastite, Titeflex Corporation, Metal-Fab Inc. or equal.

   a. Tubing is available is sizes 3/8", ½", 3/4", 1", 1-1/4", 1-1/2" and 2".
   b. The 3000 series stainless steel tubing is jacketed with yellow polyethylene sleeving which provides ease of running through joists, studs, and other building components. The jacket is marked at one foot intervals with the amount of tubing left on the reel, for quick measurement. The yellow color is the international designation for fuel gas.
   c. Straight male pipe fittings are standard and are available in sizes shown above to fit all tubing. Additional fittings include termination mount and flange-mount straight and 90° elbow fittings for termination of gas lines near movable appliances. Tee fittings are available for additional branch lines into tubing runs; reducer tees are available in popular sizes and pipe outlet tees terminate in pipe threads on the outlet leg for size changes utilizing available black iron reducer fittings.
   d. Accessories are available for expansion of the flexible piping material and additions to existing fuel gas piping systems. These accessories include: manifold-four port, pressure regulators, protection devices, and shut-off valves.

6. MegaPress Fittings: ½-inch through 2-inch shall conform to ASME B31.1, ASME B31.3, or ASME B31.9 MegaPress fittings with zinc and nickel coating for use with IPS carbon steel pipe conforming to ASTM A53, ASTM A106, ASTM A135, or ASTM A795. MegaPress fittings shall have an HNBR sealing element, 420 stainless steel grip ring, separator ring, and an un-pressed fitting leak identification feature. Sealing elements shall be verified for the intended use.

H. Compressed air piping – above grade: type 'L', hard drawn copper with silver brazed copper fittings. Provide brazed to thread fittings for connection of gas (air) turrets.

I. Perforated PVC Piping for Radon Mitigation System shall be Schedule 40 PVC conforming to ASTM D-1785. Piping shall be manufactured from a PVC compound with a cell class 12454-B as defined in ASTM D-1784. In addition to factory perforations, piping shall have 5/8" holes drilled at 4 feet on center facing down for condensate drainage.

J. PVC Piping for Radon Mitigation System Above Grade shall be Schedule 40 PVC conforming to ASTM D-1785. Piping shall be manufactured from a PVC compound with a cell class 12454-B as defined in ASTM D-1784.

K. Stainless Steel Piping for Radon Mitigation System Outside shall be similar to Blucher-Josam Stainless Steel Drainage Waste Systems o approved equal. Stainless steel shall be high grade austenitic type/grade 304

L. Acid Resistant Pipe and Fittings:

1. The corrosive waste drainage system, conforming to ASTM F1412, shall be Orion Blueline flame-retardant polypropylene type II copolymer pipe and fittings. The pipe

and fittings shall be joined using the Orion mechanical joint coupling. The pipe shall be supplied in factory grooved 10-ft length. Fittings are to meet or exceed Schedule 40 dimensions. Each Orion coupling shall have 300 series stainless steel outer band and 5/16" bolts, nuts and washers plated to meet a 100-hour salt spray test per ASTM B117. The polypropylene material shall conform to ASTM D4101.

2. As an alternate joining method, the Plumbing Subcontractor may consider using a socket fusion system as follows: The corrosive waste drainage system, conforming to ASTM F1412, shall be Orion's Blueline flame retardant pipe and fittings. Pipe and fittings shall be joined using the Orion socket fusion system conforming to ASTM D2657. The pipe shall be supplied in 10-ft lengths. The fittings shall meet or exceed Schedule 40 dimensions. The polypropylene material shall conform to ASTM D4101.

3. Piping shall be supported from clevis or loop type pipe hangers, to allow free movement of pipe for expansion and contraction, not greater than 4 ft. on centers.

4. Fixture traps shall be type UTP, P-trap with full drop union. Below ground traps shall be type RBP P-trap.

5. All floor drains serving the Science Labs are located under emergency showers/eyewash stations and/or under ice makers. The discharge from these fixtures does not need to be treated through the pH Neutralizing System and shall discharge to the sanitary sewer system (note: discharge at emergency fixtures will be highly diluted). Therefore acid resistant floor drains are not required at thee fixtures.

6. Orion corrosion resistant finished floor cleanouts shall be Type FCO, round or square as required for finish floor. Floor cleanouts shall be manufactured from fire retardant polypropylene material conforming to ASTM D 4101, ferrule supplied with countersunk plug and adjustable top with round or square nickel bronze cover, with AWCO (Acid Waste Cleanout) cast in cover.

    a. Alternate floor cleanouts: Zurn model #Z9A-CO1-F Adjustable Floor Cleanout – Polypropylene body with gas and watertight tapered plug and round scoriated stainless steel top with "AWCO" cast on cover, 3" or 4" as shown.

7. Acid resistant piping passing through fire walls shall have approved sleeves and fire stops.

8. Below ground piping shall be Schedule 40 polypropylene with heat fusion joints or electro-fusion Rionfuse® joists are also acceptable. Installation of above materials shall be in strict compliance with the State Plumbing Code and with manufacturer's installation recommendations and procedures.

9. Acid resisting piping and fittings shall be by Zurn ZPPG, Orion Fittings, Inc., Enfield Co., R&G Sloane Mfg. Co. (George Fischer), Fuseal, or approved equal acid drainage waste systems.

10. Pipe Supports: All piping installed under this Section of the Specifications shall be independently supported from the building structure and not from the piping, ductwork, or conduit of other trades. All supplementary steel required to meet the requirements specified herein shall be furnished and installed by the Plumbing Subcontractor and shall be subject to the approval of the Architect-Engineer.

11. An alternate Corrosive Waste Drainage System by Zurn Industries Inc. to be considered shall be as follows:

    a. Pipe shall be manufactured to Schedule 40 polypropylene pipe dimensions and tolerances per ASTM F-1412. Pipe to be supplied in 10 foot lengths and manufactured with a chemically resistant and fire retardant polypropylene material conforming to ASTM-D4101.

    b. Fittings shall be manufactured to Schedule 40 polypropylene pipe dimensions of a chemically resistance and fire retardant polypropylene material conforming to ASTM-D4101. Fittings to conform to applicable tolerances in ASTM-F1412.

    c. Pipe and fittings are joined by either heat fusion or by using mechanical joints. Zurn patented fittings accept either joining method.

        i) At Lab Benches: Pipe and fittings shall be joined by use of the Zurn mechanical seal that has a chemical resistance equal to the pipe and fittings. The mechanical joint system shall incorporate a positive mechanical system (groove) for axial restraint.

        ii) Above Grade: Pipe and fittings shall be joined by the use of the Zurn Fusion Lock™ joining machine. Each fitting socket shall have a molded Fusion Lock™ heavy gauge wire seal that can be rotated in the socket to desired position.

12. Another alternate Corrosive Waste Drainage System by Charlotte Pipe and Foundry Company to be considered shall be as follows:

    a. Special drainage systems for corrosive or acid waste shall be manufactured from CPVC Type IV, Grade I compounds with a minimum cell classification of 23447. Pipe and Fittings shall conform to ASTM F 2618. Pipe shall be Schedule 40 dimensions. One-Step Solvent Cement shall be specially formulated for chemical waste applications and conform to ASTM F 493. All pipe, fittings and cement shall be supplied as a system by a single manufacturer and shall be certified by NSF International for use in corrosive waste drain systems and shall bear the mark "NSF-cw". Special Drain system is to be the ChemDrain® system as manufactured by Charlotte Pipe and Foundry Co. Installation to be in accordance with manufacturer's instructions and all applicable code requirements. Buried pipe shall be installed in accordance with ASTM D 2321 and ASTM F 1668. The special drainage system is intended for the listed chemicals for use in non-pressure chemical waste applications with a maximum working temperature of 220° F.

M. pH Neutralization System: Refer to Section 2.42 for system description and component specifications.

2.7 VALVES

A. All valves in contact with potable water systems must be lead-free or meet the requirements of NSF61G. The model numbers given may not indicate this, but any submitted valve will be reviewed based on meeting the Lead Free law and NSF 61G.

B. Gate Valves:

1. Where indicated on the Drawings, all gate valves 4in. and larger shall be Class 125 iron body, bronze mounted and bonnet conforming to ASTM A 126, Class B cast-iron, flanged ends, with Teflon packing, two-piece packing gland assembly, Stockham Figure G-612, or approved equal.

2. Valves 3 in. and smaller, where indicated on the Drawings, shall be Class 125, body and bonnets shall be of ASTM B 62 cast bronze composition, solid disc, copper-silicon alloy stem, brass packing gland, Teflon packing, and malleable handwheel, solder end, Stockham Figure B-110, or approved equal.

3. Valves shall be as manufactured by Stockham, Jenkins, Hammond, or approved equal.

C. Butterfly Valves:

1. On grooved installations, shutoff valves may be Victaulic butterfly valve model 608N, Anvil International n style 6721, or approved equal for sizes 2-1/2” through 6”. Valves shall be cast bronze body, grooved ends with Grade CHP flouroelastomer-coated ductile iron disc. Seat rated -30F to 250F and UL classified IAW ANSI/NSF 61 for both hot (180F) and cold (86F) potable water service.

D. Ball Valves:

1. On water lines inside the building, ball valves 3 in. and smaller shall be as manufactured by Nibco “Lead-Free Brass Ball Valves" model #T-FP-600A-LF-LL two-piece body, full port, blowout-proof stem, PTFE seats, stainless steel ball, locking lever handle, threaded end. For solder end valve, provide Nibco “Lead-Free Brass Ball Valves" model #S-FP-600AD-LF with drain. Provide 1-1/4 in. extended stems for piping 1/2 in. to 1 in. size; 1-1/4 in. extended stems for piping 1-1/4 in. to 2-1/2 in. size. Valves shall be provided with stainless steel ball, reinforced Teflon seats and seals, bronze body, 400 PSI WOG, positive l00 percent shutoff. Ball valves shall be full port style and all shall be lead free.

2. Drain valves at all low points shall be "Apollo" 78-100 or 78-200 Series, 1/2 in. or 3/4 in. solder by 3/4 in. hose end with attached dust cover cap and chain.

3. Valves on gas lines shall be UL listed, 250 PSI natural gas rated, "Apollo" Model 80-100-YRPV Series with tee or lever handle, as approved by the National Fuel Gas Code. Where indicated on the Drawings, for Classroom zone shutoffs, ball valves shall be enclosed in a recessed valve box, as hereinafter specified.

4. Ball valves shall be of one (1) manufacturer, Conbraco Industries, Inc., "Apollo," Watts Regulator, Nibco/Scott, or approved equal.

E. Balancing Valves:

1. Where indicated on the Drawings, furnish and install Y-pattern multi-turn globe style valves. Bronze or metal copper alloy body, calibrated with differential pressure connection points. Digital hand-wheel with concealed memory stop to provide full valve closure and re-opening to set position.

2. Balancing valves shall be as manufactured by Victaulic, Nibco, Armstrong, Anvil International Gruvlok GBV or approved equal.

3. Alternate balancing valve: Furnish and install Flow Design Inc. ICSS Inline AutoFlow Controller for drinking water applications featuring:

    a. Flow limiting cartridge is machined stainless steel for greater control accuracy and dependability. Factory adjustable.
    a. All wetted parts are stainless steel meeting NSF/ANSI Standard 372 for minimal lead content.
    b. Compact inline design is less than half the height of typical controllers, allowing the ICSS to fit easily into tight installation.
    c. Tested and approved for “commercial hot water applications”.

4. Alternate balancing valve: Furnish and install Circuit Solver (¾” – 2”), size as indicated on plans. Valve shall be Circuit Solver as manufactured by Therm-Omega-Tech, Inc or equivalent.

    a. Circuit Solver shall regulate the flow of recirculated domestic hot water based on water temperature entering valve, regardless of system operating pressure.
    b. When fully closed Circuit Solver shall bypass a minimum flow of hot water to maintain dynamic control of the recirculating loop.
    c. Circuit Solver valve is factory set for project conditions.
    d. Circuit Solver body shall be constructed of stainless steel. Internal components type 303 stainless steel; rated for 200 PSIG working pressure and 300˚F working temperature, NSF-61 Certified and the Thermal Actuator shall be spring loaded and self-cleaning.
    d. Circuit Solver to be installed by qualified tradesmen. Installed in each domestic hot water return piping branch beyond last hot water device in that (individual) branch. Provide suitable line size isolation valves, unions and strainer as indicated in piping detail shown on drawings. Provide suitable access panel as required in non-accessible ceiling and wall installations.
    e. Contact factory representative, Urell Incorporated at 617-923-9500 if additional information is required.

F. Check Valves:

1. Check valves shall be furnished and installed where indicated on the Drawings. Checks up to 3 in. shall be Class 125, solder ends, body and caps shall be ASTM B 62 cast bronze composition, swing type disc, Stockham Figure B-309.

2. Check valves 4 in. and larger shall be iron body, bronze mounted with body and cap conforming to ASTM A 126 Class B cast-iron, flanged, swing type disc, Stockham Figure G-931.

3. Check valves shall be as manufactured by Stockham, Jenkins, Milwaukee, or approved equal. All check valves shall be lead free.

G. Pressure Reducing Valves:

1. Provide adjustable pressure reducing valves manifold set to maintain a maximum water service discharge pressure of 80 psig at the domestic water service entrance. Valve shall be cast iron body with bronze trim, flange connections, compression diaphragm, and stainless steel springs. Downstream pressure shall not vary more than one pound for every ten pounds of variation in incoming water supply pressure.

2. Provide globe type bypass valve. Install shutoff valve on each side of reducing valve and full-sized bypass with shutoff valve. Install strainer on inlet side of pressure reducing valve. Install pressure gauge on inlet and outlet of valve.

3. Furnish and install, where indicated on the Drawings, Ametek/U.S. Gauge Co.'s Figure P500, 2 in. diameter, 0 lb. to 120 lbs. pressure gauges, complete with petcocks and brass connections.

4. On main water service entrance, the pressure reducing valves will be piping in a manifold configuration for high and low flow situations. The high capacity water pressure reducing valve shall be similar to a 3" Watts model #LF223 and the smaller capacity pressure reducing valve shall be similar to a 1-1/4" Watts model #LFU5B. See detail on drawings.

5. Pressure reducing valves shall be as manufactured by Watts Regulator Co., Wilkins, A.W. Cash Valve Mfg. Co., Mueller Co., or approved equal.

H. Plug Valves: Furnish and install cast-iron plug valves on all natural gas piping 2 in. and larger, with flanged ends, Model 133 as manufactured by Serek Audco, with 100 percent free area, rated at 125 PSI working pressure, or approved equal.

I. Strainers: Strainers shall be iron body 'Y' type with bronze strainers, 250 psig steam and 400 W.O.G. Provide ball valve with hose bib for blow down similar to Watts # B-6000-CC.

J. Expansion Tanks: Expansion tanks shall be Taco #PAX series for domestic hot water application. The domestic hot water system expansion tanks shall be sized by the Plumbing Subcontractor/Manufacturer for review by the Architect/Engineer. The expansion tank, although precharged to 40 PSI, should be recharged to the CW inlet water pressure to the domestic hot water system or just under it. Verify expansion tank size with manufacturer before releasing (i.e. have the manufacturer run an expansion tank sizing program).Note: expansion tank size on the drawings was engineered and is sized as required. Also note that there are three (3) water heater systems that require expansion tanks.

1. Expansion tank shall be as manufactured by Taco, Watts Water Technologies, Flexcon Industries or approved equal.

K. Backwater Valve: 2" coated cast iron backwater valve, offset type, bronze fixed swing-check assembly, bolted gasketed cover and no-hub connection similar to Josam model #67402, Jay R. Smith, Mifab, Zurn, Wade or equal. Furnish as shown on drawings for HVAC condensate drains.

1. Backwater valves are also required for the storm drain system serving different roof elevations if the piping connects above grade. See plans.

L. Pipe Alignment Guides: Pipe alignment guides shall be concentric type Keflex Series P, or approved equal by Metraflex or Asco.

N. Ice Maker Supply, IMB-1: Furnish and install Sioux Chief model #.696-VC2 Ox Box Ice Maker outlet box recessed into the wall. Provide ½" supply line inlet connection (sweat) with 3/8" compression cold outlet. The valve shall be equipped with quarter-turn operation, chrome plated valve. If necessary, provide water hammer arrestor in box.

Alternate manufacturers are Oatey and Viega. Note: These are shown for ice maker connections and refrigerator ice maker connections, but not for all refrigerators.

2.8 BACKFLOW PREVENTERS

A. Furnish and install the following backflow preventers, reduced pressure or double check valve assemblies as manufactured by Watts Regulator, Apollo or Wilkins.

1. A Reduced Pressure Zone Assembly shall be installed at each potential health hazard location to prevent backflow due to backsiphonage and/or backpressure. The assembly shall consist of an internal pressure differential relief valve located in a zone between two positive seating check modules with captured springs and silicone seat discs. Seats and seat discs shall be replaceable in both check modules and the relief valve. There shall be no threads or screws in the waterway exposed to line fluids. Service of all internal components shall be through a single access cover secured with stainless steel bolts. Body and shutoffs shall be constructed using Lead Free* cast copper silicon alloy materials. Lead Free* reduced pressure zone assembly shall comply with state codes and standards, where applicable, requiring reduced lead content. The assembly shall also include two resilient seated isolation valves, four resilient seated test cocks and an air gap drain fitting. The assembly shall meet the requirements of: USC; ASSE Std. 1013; AWWA Std. C511; CSA B64.4. Shall be a Watts Series LF009.

2. Alternate MFR specification: The Apollo® Model RP4A and RPLF4A Lead Free* Reduced Pressure Backflow Preventer A Series provide maximum protection of the potable water supply due to back-siphonage or backpressure from substances that are hazardous to the potable water supply. The top accessed modular check valve cartridges provide captured springs, replaceable seats, and reversible silicone seat discs. This Made in America assembly features ball valve shutoffs with stainless steel handles and nuts as standard and carries the five-year Apollo® factory warranty.

B. Backflow preventers shall be installed at the following locations:

1. On cold water feed to hot water hydronic systems: No. LF909QT-SHW 1 in. complete with bronze strainer; quarter-turn, full port resilient sealed bronze ball valve shut-offs; bronze body construction; ball valve test cocks; captured spring assemblies; modular design; replaceable seats; stainless steel check modules for hot water temperatures (up to 210°F); and drain piping with air gap to receptor.

2. Furnish and install 6 in. Reduced Pressure Principle Backflow Preventer, Apollo® Model #RPLF 4A Lead Free* at the domestic water service entrance. In addition, furnish and install a 3” bypass backflow preventer similar to above. The assembly shall be manufactured in America and carry a 5-year Apollo® factory warranty. The TriForceTM center-stem guided check valves shall feature reversible silicone rubber seat discs. The check valves shall be held in place by SS snap-in retainers. Access to the check valves and relief valve internals shall be by an Apollo® quick-connect SS coupling. The bodies shall be domestic SS in 4” size. The Lead Free* Apollo® domestic ball valve test cocks shall have SS handles. The assembly shall prevent contamination of the potable water supply due to back-siphonage or backpressure from substances that are health or non-health hazards. The pressure drop across the assembly shall be documented by an independent laboratory.

3. For site irrigation system in the main school, furnish and install a backflow preventer on the cold water supply as follows:

a. Cold Water – 2" Model LF009QTS.

4. For Science Rooms: Furnish and install backflow preventer on the cold water supply as follows:

   a. Cold Water – 3" Model LF909QTS.

5. For Soap Dispensers in Janitors Closets, where shown: Furnish and install backflow preventer on the cold water supply to soap dispenser (four (4) locations shown) only as follows:

   a. Cold Water – 1/2" Watts Model #LF009-QTS, Apollo model #4ALF200, or approved equal.

6. For 3-bay sinks in kitchen: Furnish and install backflow preventer on the cold and hot water tee fittings off of the piping serving the faucets. Note that the faucets do not need this protection similar to:

   a. Cold Water – 1/2" Watts Model #9D Dual Check Valve with Atmospheric Vent shall be installed at referenced cross-connections. Valve shall feature stainless steel and rubber internals protected by an integral strainer. Primary check shall be rubber to rubber seated, backed by the secondary check with rubber to metal seating. The device shall be ASSE approved under Std. 1012.

7. For dish-machines in kitchen: Furnish and install backflow preventer on the hot water supplies to the unit similar to:

   a. Hot Water – 3/4" Watts Model #LF009-QTS, Apollo model #4ALF200, or approved equal. Hot water temperature is ~120°F.

8. For Outdoor Toilet & Storage Building, Furnish and install backflow preventer on the cold water feed to the site drinking water stations around the field to the unit similar to:

   a. Cold Water – 1-1/2" Watts Model #LF009-QTS, Apollo model #4ALF200, or approved equal.

9. For Outdoor Toilet & Storage Building, Furnish and install backflow preventer on the cold water service entrance similar to:

   a. Cold Water – 3" Watts Model #LF009-QTS, Apollo model #4ALF200, or approved equal.

C. This Subcontractor shall provide a spare parts repair kit for each 009 or 909 reduced pressure backflow preventer, to consist of a repair kit for the first check, second check, and relief valve.

D. Units shall be Watts Regulator Co., Apollo, Wilkins, Febco, Division of CMB, Inc., Hersey Products, Inc., Conbraco or approved equal.

E. The Plumbing Subcontractor shall file and prepare all Applications for Backflow Preventers Testing approval with the Department of Environmental Protection 310 CMR 22.22 and pay all fees and charges.

F. All backflow preventers shall be installed and tested in accordance with Regulation 310 CMR 22.22.

G. All certificates of approval and test results shall be sent to the Architect-Engineer.

2.9 TRAPS

A. Provide separate traps with integral cleanouts on fixtures and equipment requiring connections to sanitary system. Exceptions are fixtures with integral traps. Traps exposed to view, including connecting drain lines, shall be chrome plated. No trap shall be less than 1-1/2 inch and shall be sized as required by Code.

B. Traps shall be service weight cast-iron where buried in floors or serving floor drains with trap primer connections where noted on the Drawings. Where traps are not connected directly under the drain they serve in the floor, they shall be fitted with top cleanouts and extensions to the floor with access covers and plates.

C. Furnish and install traps as required for all items of equipment furnished under other Sections of these Specifications, and/or by the Owner.

2.10 INSULATION

A. All hot water, hot water recirculating, and cold water piping shall be insulated with Manville FLAME-SAFE fiberglass pipe insulation, Owens-Corning Fiberglass 25, Knauf or approved equal. The insulation shall have an average thermal conductivity not to exceed .25 BTU in. per sq. ft. per F. per hour at a mean temperature of 75 degrees F. Thickness of the insulation shall be 1/2 in. for cold water piping up to and including 2 in., 1 in. thick for cold water piping 2-1/2 in. and above, and 1 in. for hot water and hot water recirculating piping. Jacket shall be FLAME-SAFE AP. The insulation shall be applied over clean dry pipe with all joints butted firmly together. Longitudinal jacket laps and the butt strips shall be smoothly secured with Benjamin Foster 85-20 adhesive. Lab cold water shall be insulated as indicated above. For lab hot water piping insulation thickness, refer to section 2.27.A.

B. All concealed and exposed roof drains and rainwater leaders/storm drain and emergency overflow storm drain piping, verticals, mains, fittings, and offsets above ground shall be insulated with 1” thick insulation, same as specified for hot and cold water piping.

C. All fittings and valves shall be insulated with the proper factory pre-cut fiberglass insulation and covered using the factory, pre-molded, one-piece PVC fitting covers secured with flexible off-white 10 mil polyvinyl chloride film bonded with a specially formulated adhesive that can be installed indoors and out with a strong permanent bond conforming to MIL Spec. No. 7798-A.

D. All exposed supply and waste piping to handicapped lavatories or sinks shall be insulated with Truebro Model 101W or 102W "Handi-Lav-Guard" trap and hot water insulation kits with accessory no. 105. Equal manufacturers are McGuire Mfg. Co. Inc., Plumberex Specialty Products Pro-Extreme, or approved equal. Refer to paragraph 2.2.E for additional information.

E. All exposed insulated piping, in public areas and storage areas, 10 ft. 0 in. up from finish floor shall be provided with an additional jacket made of high impact polyvinyl chloride 10

mil thickness, applied over herein before specified insulation, using vapor barrier mastic-adhesive.

F. All buried trap primer, hot and cold water piping shall be insulated with 1/2 in. foamed plastic insulation equal to K-Flex Insul-Tube® Flexible Closed Cell Pipe Insulation. Environmentally-friendly, CFC-free flexible elastomeric thermal insulation is non-porous, non-fibrous and resists mold growth. Used for reducing heat gain and preventing condensation or frost formation on cold water plumbing systems. EPA registered antimicrobial agent provides additional protection against mold, fungal and bacterial growth. Tough skin exterior withstands tearing and severe environmental conditions. UV resistant.

G. Tempered water piping for emergency showers and emergency eye/face washes shall not be insulated since the required water temperature will be between 60˚F & 70˚F.

H. Insulation shall be Manville, Owens-Corning, CertainTeed Corp., Armstrong, or approved equal.

2.11 PIPE SLEEVES, HANGERS AND SUPPORTS

A. Pipe sleeves, pipe hangers, pipe anchors, auxiliary steel, fire treated wood blocking and fixture supports shall be furnished and set by this Contractor, and he shall be responsible for the proper and permanent location. This Contractor shall be responsible for all core drilling.

B. Pipe sleeves shall be installed and properly secured at all points where pipes pass though masonry, concrete or wood. Pipe sleeves shall be of sufficient diameter to provide approximately ¼" clearance around insulation. Pipe sleeves through masonry partitions and floors shall be Schedule 40 galvanized steel pipe. Wall sleeves shall have chromium plated escutcheons with set screws or clips for firmly holding in place. Sleeves through wall shall end flush with surface of walls. Sleeves in floors shall extend 1" above the floor and after installation of piping shall be packed and made water tight. Provide core drilling. Core openings shall have Link-Seal fire rated penetration closures. Sleeves in exterior walls shall have water stop plates, shall end flush with the surface of the walls and shall have Link-Seal penetration closures.

C. Where pipes penetrate fire rated floors and partitions, the openings shall be firestopped per Section 07 84 00 Firestopping, by the Plumbing Subcontractor. Note that cores of 4" diameter and below are by the Plumbing Subcontractor and cores over 4" diameter are by the General Contractor.

D. All piping shall be rigidly supported from the building structure by means of approved hangers and supports. This Contractor shall furnish and install all required auxiliary steel required for hanging of piping

E. All horizontal piping shall be hung with approved adjustable malleable iron pipe hangers. Cast iron soil pipe shall be supported at 5' intervals except where 10' lengths of piping are used, then 10' intervals are acceptable. Supports shall be placed directly beneath horizontal fittings that connect to the stack. Copper tubing 1-1/2" and larger shall be supported at 10' intervals. Copper tubing 1-1/4" and smaller shall be supported at 6' intervals. Steel piping shall be supported at 6' intervals for piping1/2" and smaller, at 8' intervals for ¾" and 1" piping and at 10' intervals for piping 1-1/4" and larger.

F. Vertical cast iron piping shall be supported at base, at each story height and at 10' intervals. Vertical steel piping and copper tubing shall be supported at each story height and at no more than 10' intervals.

G. Hangers for piping sizes 4" and smaller shall be Carpenter & Paterson, No. 1A band type, Anvil International, Grinnell Company, Calco Steel Products Company or equal, black steel with hanger rods with machine threads; for uninsulated copper tubing, the hangers shall be copper plated. Hangers for piping larger than 4" shall be the adjustable clevis hanger type, malleable iron and extension rod. Chain, strap, perforated bar or wire hangers will not be approved. Approved gang hangers may be used in lieu of separate hangers on pipes running parallel to each other and close together. Where used for uninsulated copper tubing, all hangers shall be copper plated. Insulation shields shall be provided on all horizontal insulated piping at each hanger or supported location. Insulation shields shall be galvanized steel, 180 degrees arc and centered in the hanger or support. On diameters 4" and smaller, shield shall be 12" long, 18 gauge steel. On diameters 5" and 6", shield shall be 18" long, 16 gauge steel. On diameters 8" and 10", shield shall be 24" long, 14 gauge steel. On diameters greater than 10", shield shall 24" long 12 gauge steel. This Contractor shall furnish and install steel insulation shields at each hanger location on piping to be installed. Structure attachments shall be as manufactured by Carpenter & Patterson, Anvil International, or approved equal and shall be suitable to carry the weight. Pipe alignment guides shall be split-sleeve type as manufactured by Broat Manufacturing, Inc. and suitable for copper tubing.

H. All fixtures and equipment shall be supported and fastened in a satisfactory manner and in accordance with fixture manufacturer's recommendations.

I. Where chair carriers are required, they shall be completely concealed in the building construction and shall rigidly support the fixture from the floor. Chair carrier shall support fixtures is such a manner that no part of the fixture will be supported by the wall or partition. Chair carriers shall be furnished complete with necessary bolt, nuts and washers as well as connecting nipples of the proper length with gaskets for the fixture connection. All available or optional anchor foot assemblies shall be utilized. Carriers must fit in available space and shall be of the special narrow type or compact style where necessary. Chair carriers for water closets and urinals shall include flushometer supply pipe support.

J. Wherever fire treated wood blocking is required to insure adequate support of fixtures and related piping, it shall be provided by this Contractor.

2.12 CLEANOUTS

A. Cleanouts shall be provided in soil and waste pipes and the radon system at changes in direction, where shown on Drawings, and at other points required by Code so that lines will be readily accessible for cleaning or rodding out; provide a minimum of 24 inch clearance for rodding. Cleanouts shall be same size as pipe in which they are installed but not larger than four inches.

B. Cleanouts shall be installed so that cleanout opens in direction of flow of drainage line served or at right angles thereto. Cleanout plug shall be kept free of dirt and construction materials and shall not be covered with cement, plaster or other permanent finishing materials.

C. Floor cleanouts shall have cast iron body and frame with square adjustable scoriated secured nickel bronze top. Unit shall be vertically adjustable for a minimum of two inches.

When waterproofing membrane is used, provide clamping collar. Cleanouts shall consist of "Y" fittings and 1/8 inch bends with brass or bronze screw plugs. Cleanouts in tile floors shall have square top covers recessed for tile insertion; in carpeted areas, provide carpet cleanout markers. Floor cleanout shall be Zurn 1400 Series Level-trol Supreme cleanouts and Type ZN-1400-Z in terrazzo floors, Type ZN-1400-TX in tiled floors, Type ZN-1400-CM in carpeted floors, and Type ZN-1400 in all other locations. Cleanouts shall be set flush and level with top of finished floor surface except in carpeted areas where they shall be flush with concrete.

D. Provide cleanouts a base of vertical stacks with cleanout plug located approximately 30 inches above floor. Extend cleanouts to wall with access covers. Cleanout shall consist of sanitary tees. Furnish nickel-bronze square frame and cover with minimum opening 6 x 6 inches at each wall cleanout.

E. In horizontal runs above grade, cleanouts shall consist of cast brass screw plug in fitting or in caulked cast iron ferrule.

F. Wall cleanouts shall be brass, recessed head plugs with Zurn ZN1441 with round cover.

G. Provide floor and/or wall cleanouts of the type specified above; cleanouts shall be Zurn, Jay R. Smith, Josam, Mifab, Watts Drainage or equal.

2.13 ACCESS PANELS

A. Furnish access panels for access to all parts of the plumbing systems that require accessibility for the proper operation and maintenance of the system. Refer to specification section 08 31 00 for products. Access panels to be installed by building contractor depending on where it is to be installed (i.e. gypsum board, tiling, masonry, etc.).

B. Size shall be sufficient for the purpose, but no less than 12 inches by 12 inches. Particular attention shall be exercised in the selection of doors for masonry walls in order that frame sizes used will match the courses of brick or block. In restrooms, the access panels are called out as 12”x12” stainless steel for accessing valves, trap primer valves and water hammer arrestors.

2.14 JOINTING COMPOUNDS

A. Provide pipe dope, Teflon tape, wax rings, neoprene gaskets and other jointing compounds as required by best standard practice and only on service as recommended by the manufacturer. Work shall conform to manufacturer’s recommendations with regard to use of putties, jointing compounds or both in installing plumbing fixtures and trim.

2.15 FLOOR DRAINS

A. Provide floor drains of the type specified hereinafter; drains shall be Zurn, Jay R. Smith, Josam, Mifab, Watts Drainage or equal. Provide suitable clamping device and extensions if required, where installed in connection with waterproofing membrane. Refer to plans for quantities of floor drains.

B. FD-1: Zurn ZB415-5B-P (Josam Model 3000*-A-2-50) round top or equal, coated cast iron floor drain, two-piece body with double drainage flange, invertable non-puncturing flashing collar, weepholes, polished bronze strainer head, (Nikaloy round SUPER-FLO

grate), ½" trap primer connection, bottom outlet size varies (see plans); tile flange if required by floor type.

C. FD-2: Zurn ZN1902-K-2-32 (Josam Model 49024AS-3) or equal sanitary floor sink; square cast iron 10" deep with acid resisting interior, double drainage flange with weepholes, bottom outlet size varies, aluminum internal dome strainer, Nikaloy sanitary sloped rim, and Nikaloy anti-tilting (SUPER-FLO) ½ (one-half) grate.

D. FD-3: Zurn ZB415-7B w/ZB329-9 (Josam Model 30004-7E3) round top or equal, cast iron floor drain, two-piece body with double drainage flange, invertable non-puncturing flashing collar, weepholes, adjustable polished bronze strainer head, 7" round grate with 9"x3-1/2" oval receptor funnel, 4" bottom outlet.(; tile flange if required by floor type.)

E. FD-4: Zurn ZN1900-K-3 (Josam Model 49024AS-4) or equal sanitary floor sink; square cast iron 6-(1/4)" deep with acid resisting interior, double drainage flange with weepholes, bottom outlet size varies, aluminum internal dome strainer, Nikaloy sanitary sloped rim, and Nikaloy anti-tilting (SUPER-FLO) 3/4 (three quarter) grate.

F. FD-5: Zurn model #Z507-P-Y 7" medium duty floor drain, round top, Dura-Coated cast iron body with bottom outlet, seepage pan and combination membrane flashing clamp and frame for medium-duty cast iron deep flange slotted grate, trap primer connection, sediment bucket.

G. FD-6: Garage Trench Drain, 110'-0" long (QTY. = 1); Zurn model #Z886-HDS: Channels are 80" long, 6-3/4" wide reveal and have a 4" throat. Modular channel sections are made of 0% water absorbent High Density Polyethylene (HDPE). Channels have a positive mechanical connection between channel sections that will not separate during the installation and mechanically lock into the concrete surround every 10". Channels weigh less than 2.31 lbs per linear foot, have a smooth, 1-1/2" radiused self-cleaning bottom with a Manning's coefficient of .009 and .75% or neutral 0% built in slope. Channels have rebar clips standard to secure trench in its final location. Channels provided with standard SBG grates that lock down to frame. Zurn 5-3/8" wide reveal Stainless Steel cast Bar Grate conforming to ASTM specification A351, Grade CF8 (type 304), cast grate is rated class E per the DIN EN1433 top load classification. Supplied in 20" nominal lengths with ½" wide slots, and ¾" bearing depth. Grate has an open area of 27.7 sq. in per ft. The .105" thick Heavy-Duty Stainless Steel Frame Assembly conforms to ASTM specification A-240 (type 304) with 10 – 4" long concrete anchors per 80". Grate lockdown bars are to be integral to the frame. All welds must be performed by a certified welder per ASTM standard AWS D1.6. Frames produced in the U.S.A.
Provide Zurn model #P6-RFSC 40"x5-3/8" stainless steel reinforced slotted grate weighing 5.2 lbs per linear foot. The grate has an open area of 12.0 square inches per linear foot. Grate conforms to DIN rating of C, ANSI rating of Heavy-Duty, ADA compliant and H-20 load rating. Stainless steel grate conforms to ASTM A351 Type 304 cat body and A-240 Type 304 for grate skin.

H. FD-7: Outdoor Storage Rm Trench Drain, 80" long (6'-8"L) (QTY. = 1); See specification for FD-6 trench drain and match.

2.16 SOLIDS INTERCEPTOR

A. Josam Series 61000 Nikaloy Solids Interceptor, bottom access, fixture trap type, with 1 ½" slip joint inlet, 1 ½" threaded side outlet, gasketed cover and removable perforated stainless steel basket. Equal manufacturers are Zurn model #Z1180, J.R. Smith Manufacturing Company, Rockford Sanitary Systems and Mifab.

B. Locate as shown on drawings on Art Room Sinks for fixtures P-10 & P-11.

2.17 SEMI-AUTOMATIC GREASE INTERCEPTOR

A. Furnish and install GI-1 & GI-2, in kitchen serving various kitchen fixtures as required by code, similar to Zurn model #Z1172-10000-RE (Josam, Jay R. Smith, Rockford or approved equal)) rated at 100 GPM flow, 200 lb. grease capacity with 4 in. inlet and outlet, with recessing receiver enclosed type for recessed installation to lower inlet and outlet inverts. Grease Interceptor shall come complete with internal air relief by-pass, bronze cleanout plug, visible double wall trap seal with removable pressure equalizing flow diffusing baffle, flow control fitting, steel frame with non-skid cover and adjustable interceptor carrier brackets. If other manufacturer is used, this Subcontractor shall be responsible to adjust and allow for difference in rough-in requirements.

1. Each flow control fitting must be accessible, therefore provide floor access cover for servicing above this fitting if not located under recessed receiving enclosure.

B. Furnish and install GI-3, in kitchen serving various kitchen fixtures as required by code, similar to Zurn model #Z1170-800-RE (Josam, Jay R. Smith, Rockford or approved equal)) rated at 50 GPM flow, 100 lb. grease capacity with 4 in. inlet and outlet, with recessing receiver enclosed type for recessed installation to lower inlet and outlet inverts. Grease Interceptor shall come complete with internal air relief by-pass, bronze cleanout plug, visible double wall trap seal with removable pressure equalizing flow diffusing baffle, flow control fitting, steel frame with non-skid cover and adjustable interceptor carrier brackets. If other manufacturer is used, this Subcontractor shall be responsible to adjust and allow for difference in rough-in requirements.

1. Each flow control fitting must be accessible, therefore provide floor access cover for servicing above this fitting if not located under recessed receiving enclosure.

C. Grease trap shall have acid resistant coated interior and white coated exterior steel, with cleanout plug and by-pass, internal air relief, visible double wall trap, removable baffle, gasketed cover bearing PDI seal of approval, sediment tray, gasketed non-skid secure cover, with lifting ring.

D. Provide interior grease interceptor of the type specified above; interceptor shall be Zurn, Jay R. Smith, Josam, Mifab, Wade, Rockford Sanitary Systems or equal.

2.18 WATER HAMMER ARRESTORS

A. Maintenance free water hammer arrestors shall be furnished and installed at all locations in the water systems where quick acting valves are installed as well as wherever water hammer may occur. Examples of such locations are as follows:

1. Flushometer valves.
2. Self-closing and metering faucets.
3. All laundry equipment.
4. Dishwashers.

B. Water hammer arrestors shall be as manufactured by Zurn , Josam Manufacturing Company, J.R. Smith Manufacturing Company, Wade, Mifab Systems or Precision Plumbing Products, Inc. Type 304 stainless steel with nesting type bellows. Arrestors shall be installed at each and every multiple of fixtures or items as listed above, water

hammer arrestors may serve groups of fixtures. Sizing and placement shall be in accordance with PDI Standard PDI-WH-201 and Certified to NSF 61G and/or California AB1953 lead-free standard. Provide access panels.

C. Water hammer arrestors shall be as follows (model numbers based on Zurn):

	Type	Fixture Unit Rating	Model
1.	SA “A”	1-11	Jay R. Smith 5005, PPP SC500A, Zurn Z1700-100
2.	SA “B”	12-32	Jay R. Smith 5010, PPP SC750B, Zurn Z1700-200
3.	SA “C”	33-60	Jay R. Smith 5020, PPP SC1000C, Zurn Z1700-300
4.	SA “D”	61-113	Jay R. Smith 5030, PPP SC1250D, Zurn Z1700-400

2.19 THERMOMETERS AND PRESSURE GUAGES

A. Straight Thermometers:

1. Where indicated on the Drawings, furnish and install 7 in. long die-cast aluminum case, "Adjustable Angle" red appearing mercury tubing thermometers, H.O. Trerice Co., Cat. A001 complete with separable stainless steel Type 304 socket, 30 degrees to 240 degrees F. range, and lagging extensions when installed in insulated pipe.

2. Thermometers to be adjusted to a position for maximum readability from normal operator's position.

3. Thermometers shall be H.O. Trerice Co., Weksler Instruments Corp., Weiss Instruments, or approved equal.

B. Dial Thermometers:

1. Dial thermometers, where indicated on the Drawings, shall be of the Bi-Metal actuated design with over-temperature and low temperature protection, with aluminum, hermetically sealed case, non-removable gasketed ring, 5 in. dished dial size, stainless steel stem with stainless steel thread connection, accuracy 1 percent at mid range, 2 percent at side ends, fixed 1/2 in. NPT with 3/4 in. NPT lead free or stainless steel well, dial shall have adjustability to be rotated 360 degrees and the stem turned 180 degrees for readability, range 0 degrees to 240 degrees F. and with 4 in. stem lengths.

2. All thermometers shall be installed at an angle easily readable from the floor. All thermometers shall have brass separable sockets with casings.

C. Pressure Gauges: Pressure gauges shall be as manufactured by Trerice, or approved equal, Series 600, 4-1/2 in. diameter, range 0 to 200 PSI, aluminum case, white face with black figures, with petcocks. Any component of the pressure gauge that comes in contact with potable water shall be lead free or stainless steel.

1. Pressure Gauges shall be H.O. Trerice Co., Weksler Instruments Corp., Weiss Instruments, or approved equal.

2.20 HOT WATER CIRCULATING PUMPS

A. Furnish and install all stainless steel construction circulation pumps, as follow:

1. Pump No. (RP-1 & RP-1A) 120 degrees – Building HWR:

Furnish and install, in Boiler/Mechanical Room, where indicated on the Drawings, Grundfos Model #Magna3 40-120 F N stainless steel circulating pump, 448 Watts maximum, 1 phase, 115 volt motor with built-in overheat protection, to deliver 23.0 GPM at 25 ft. head.

2. Pump No. (RP-2) 70 degrees – Tempered Water Piping for Emergency Showers @ Auto/Diesel Shop:

   Furnish and install, in Mechanical/Boiler Room, where indicated on the Drawings, Grundfos Model #Magna3 32-60 F N stainless steel cartridge circulating pump, 106 Watts maximum, 1 phase, 115 volt motor with built-in overhead protection, to deliver 2.5 GPM at 8 ft. head.

3. Pump No. (RP-3) 110 degrees –Science Labs HWR:

   Furnish and install, in Acid Neutralizer Room, where indicated on the Drawings, Grundfos Model #Magna3 32-60 F N stainless steel cartridge circulating pump, 106 Watts maximum, 1 phase, 115 volt motor with built-in overhead protection, to deliver 3.0 GPM at 14 ft. head.

4. Pump No. (RP-4) 70 degrees – Tempered Water Piping for Emergency Showers @ Science Labs:

   Furnish and install, in Acid Neutralizer Room, where indicated on the Drawings, Grundfos Magna3 32-100 F N stainless steel cartridge circulating pump, 178 Watts maximum, 1 phase, 115 volt motor with built-in overhead protection, to deliver 9.0 GPM at 20 ft. head.

B. The above specified pumps are the Grundfos Magna3. Any substitution shall be equivalent to this pump. The Magna3 is of the canned rotor type, i.e. pump and motor form an integral unit without shaft seal and with only two gaskets for sealing. The bearings are lubricated by the pumped liquid.

   1. The pump is characterized by the following:

      a. Controller integrated in the control box.
      b. Control panel with TFT display on the control box.
      c. Control box prepared for optional CIM modules (these are required).
      d. Built-in differential-pressure and temperature sensor.
      e. Cast-iron pump housing.
      f. Carbo-fiber reinforced composite rotor can.
      g. Stainless steel bearing plate and rotor cladding.
      h. Aluminum alloy stator housing.
      i. Air-cooled power electronics.

   2. Characteristic features of the pump are:

      a. AUTOADAPT.
      b. FLOWADAPT and FLOWLIMIT
      c. Proportional-pressure control.
      d. Constant-pressure control.
      e. Constant-temperature control.
      f. Constant-curve duty.

g. Max. or min. curve duty.
h. Automatic Night Setback.
i. No external motor protection required.

3. Communication – The Magna3 enables communication via the following:

a. Wireless Grundfos GO remote.
b. Fieldbus communication via CIM modules.
c. Digital inputs.
d. Relay outputs.
e. Analog input.

4. Motor and electronic controller: The Magna3 incorporates a 4-pole synchronous, permanent-magnet motor (PM motor). This motor type is characterized by higher efficiency than a conventional asynchronous squirrel-cage motor. The pump speed is controlled by an integrated frequency converter.

C. The pumps shall be controlled by immersion aquastats installed in 1-1/4 in. oversize tee and pipe, as detailed. Aquastat shall be provided and installed by the Plumbing Subcontractor and wired by the Electrical Subcontractor.

1. Circulator Aquastat shall be Honeywell model #L4006B1163 or approved equal, 100 - 240°F temperature range, 5 - 30°F adjustable temperature differential. Aquastat shall have totally enclosed Micro Switch & snap-acting switches that operate on temperature rise to setpoint, visible control point scale and external adjustment screw horizontal or vertical insertion of the sensing element, direct or well immersion of the sensing element.

D. Install one (1) Grundfos model #TP 40-240 in-line pumps for each boiler. These pumps are furnished with the boilers and are sized to deliver 112 GPM at 32 ft. head. The pumps are for the domestic hot water boilers, one per boiler, installed per manufacturer's instructions. These are 1 HP pumps with a rated voltage of 208V-3phase.

E. Circulating pump shall be Taco, Armstrong Pumps Inc., Bell and Gossett, Grundfos Pumps Corp., or approved equal.

F. Circulating pumps must be balanced to ensure proper flow. Pump performance should be documented at the close-out of the project.

2.21 THERMOSTATIC MIXING VALVE ASSEMBLIES

A. Furnish and install mixing valves where indicated or required as manufactured by Powers Controls. Acceptable mixing valves shall be manufactured by Powers, Leonard Valve Company, Symmons, Armstrong Rada, Lawler or approved equal and shall match the performance characteristics for each mixing valve.

B. MV-1: Furnish and install in the boiler/Mechanical Room one (1) Powers #LFIS200C00LP+ Lead-Free digital water temperature control and monitoring system shall feature full-color touchscreen interface which is configurable on location and does not require factory pre-programming. System shall control water temperature to +/- 2°F in accordance with ASSE 1017 and during periods of low/zero demand and feature a user-programmable high temperature alarm. Unit shall feature Feed Forward or Predictive Control which anticipates changes in system demand and adjusts valve pre-emptively to

maintain mixed set point. Controller shall be password protected and feature a user-adjustable outlet temperature range of 80 - 180°F and an approach temperature of 2°F. System shall digitally monitor inlet pressure and temperature, mixed outlet temperature, mixed outlet set point, pressure and flow/BTUs (optional), as well as return temperature without the use of an external module. System shall control an engineer specified recirculation pump based on user-set return temperature limits. Controller shall integrate with building automation systems through Bacnet and Modbus protocols and feature local and remote temperature alarms. System will also feature a user-set and controlled, high-temperature sanitization mode for use as part of user's safe and properly designed thermal bacteria eradication protocol. In the event of a power failure or loss of cold water, system will close the hot water supply. System shall be listed/approved to ASSE 1017, cUPC, NSF , CSA 24/UL873 and BTL (Bacnet Testing Laboratories) and should be mounted on a heavy-duty welded strut with corrosion resistance coating and factory tested as a complete unit. The tempering valve shall be rated for a minimum 0.5 GPM flow, maximum 405 GPM at 10 PSIG pressure drop.

C. MV-2: Furnish and install in the boiler/Mechanical Room for the Garage and Early Educational Emergency Shower & Eye/Face Wash Units one (1) Powers ETV400ADNOOO emergency tempering master mixing valve, rough brass with union angle strainer checkstops, outlet type T/P color-coded gauge pre-piped, factory tested and assembled in a recesses stainless steel cabinet with locking door. Capacity of 3-102gpm at 45 psid.

D. MV-3: Furnish and install in the Acid Neutralizing Room one (1) Powers #LFMM432 Master mixing valve shall feature paraffin-based, thermal actuation technology for precise temperature control. Valve shall be listed to ASSE 1017 and certified to CSA B125 and have an approach temperature of 5°F. Valve shall have an outlet temperature range from 90 – 160°F with a lockable temperature-setting feature. Body shall be constructed using Lead Free* brass material which shall comply with state codes and standards, where applicable, requiring reduced lead content. Valve shall also be manufactured of corrosion resistant materials and feature a single-seat design for positive shutoff. Valves shall come standard with union check stops. Minimum flows to ASSE 1017 shall be LFMM432 4.0 gpm

E. MV-4: Furnish and install for the Science Room Emergency Shower & Eye/Face Wash Units one (1) Powers ETV400ADNOOO emergency tempering master mixing valve, rough brass with union angle strainer checkstops, outlet type T/P color-coded gauge pre-piped, factory tested and assembled in a recesses stainless steel cabinet with locking door. Capacity of 3-102gpm at 45 psid.

F. MV-5, 6, 7 & 8: Furnish and install for multiple bathroom lavatories one (1) Powers LFLM496-1 Thermostatic tempering valve shall be constructed using Lead Free* cast copper silicon alloy material which shall comply with state codes and standards, where applicable requiring reduced lead content. The valve shall feature advanced paraffin-based actuation technology and union connections for ease of maintenance. All internal components shall be corrosion-resistant. Valve shall feature integral checks to prevent cross-flow and inlet screens to filter out debris. The valve shall be ASSE 1069, ASSE 1070, ASSE 1017 and IAPMO cUPC listed. Capacity of the valve shall be 12.0 gpm at 45psi differential. Valve shall perform to a minimum flow of 0.5 gpm to ASSE 1070. Control temperature shall be adjustable between 80°F - 120°F. The valve shall feature a vandal-resistant lockable handle to prevent tampering. The valve shall be a Powers' HydroGuard® Model LFLM496 (3/4").

G. MV-9: NOT USED

H. MV-10: Furnish and install for individual Emergency Eye or Eye/Face Wash Units (single) one (1) Powers ES150-2-2 Thermostatic mixing valve for supplying tepid water to emergency fixtures shall feature cold-water bypass system to ensure flow in the event of valve failure or loss of hot water supply. The valve shall be listed to ASSE 1071, provide precise water temperature control over a wide range of flow conditions, and effectively shut down on loss of cold water. The valve shall feature powerful paraffin-based actuation technology and checkstops to prevent cross flow. The valve shall be factory set to 85˚F with a lockable means of securing the temperature. The valve shall be rated for 3 GPM for the eye/face wash. Note: adjust outlet water temperature to 65˚F.

I. For single-user wall hung lavatories or individual fixtures where noted and individual kitchen hand sinks not already receiving tempered water, provide point-of-use thermostatic mixing valve similar to Powers LFG480-11 3/8" hot water tempering mixing valve with adjustable temperature setting set for 110°F for each lavatory & sink. Maximum valve setting shall not exceed 112°F. Capacity of the valve must be 3 gpm @ 45psi differential or 4 gpm @ 45psi differential. Thermostatic lavatory tempering valve shall be constructed using Lead Free* brass material which shall comply with state codes and standards, where applicable requiring reduced lead content. Control temperature must be adjustable between 80 - 120° F with a locking nut to prevent unauthorized or accidental adjustment. The valve shall contain integral checks to prevent cross flow and inlet screens to filter debris.

2.22 AUTOMATIC TRAP PRIMER VALVE

A. Furnish and install automatic trap primers where indicated or required as manufactured by Precision Plumbing Products, Model P-1 or P-2, as noted on the Drawings, with vacuum breaker and adjustment set screw.

1. These are adjustable to the static line pressure by use of the adjusting screw. System operating range is 20 PSI minimum to 80 PSI maximum.
2. The valve requires a 10 PSI pressure drop across the valve to activate and will deliver a metered amount of water to the floor drain. The trap primer is to be connected to a cold water supply only.
3. Constructed of 360 brass, EPDM E70 O-rings, Dow #7 Silicone, #60 stainless steel mesh screen, stainless steel adjustment screw.
4. Model P1-500 will prime 1-4 floor drains using PPP model #DU-U Distribution Unit.
5. Model P2-500 will prime 1-2 floor drains using PPP model #DU-U Distribution Unit.

B. Provide distribution unit(s) as required to supply multiple floor drains as manufactured by Precision Plumbing Products.

C. Provide air gap fitting below the trap primer valve and before the distribution unit, similar to Precision Plumbing Products, Model #AG-500.

D. Provide automatic trap primer valves of the type specified above; trap primers shall be Precision Plumbing Products (PPP Inc.), Mifab, Sioux Chief Mfg. Co. or approved equal.

2.23 ELECTRONIC TRAP PRIMER VALVE

A. Furnish and install electronic trap primers where indicated or required as manufactured by Precision Plumbing Products, Model PT-6, as noted on the Drawings, with vacuum breaker and adjustment set screw. The unit shall have the following features:

1. Atmospheric vacuum breaker.
2. Pre-set 24 hour adjustable timer.
3. Manual over ride switch.
4. 120v or 220v solenoid valve.
5. 3/wire single point connection.
6. 3/4” FNPT connection.
7. Calibrated manifold for equal water distribution.
8. 5/8” or 1/2” outlet compression fittings.
9. Six opening manifold.

B. The Prime-Time Priming Assembly will supply a minimum of 2 oz. of potable water at 20 P.S.I.G. at a preset factory setting of 6 seconds every 24 hours. The entire unit is pre-assembled in a steel cabinet ready to be flush wall mounted.

C. Provide air gap fitting in the vertical piping within the trap primer valve cabinet before the distribution manifold, similar to Precision Plumbing Products, Model #AG-500.

D. Provide electronic trap primer valves of the type specified above; trap primers shall be Precision Plumbing Products (PPP Inc.), Mifab, Sioux Chief Mfg. Co. or approved equal.

2.24 SCIENCE ROOMS GAS-FIRED WATER HEATER (GWH-1)

A. The natural gas water heater shall be A.O. Smith Cyclone Xi model #BTH 120, Bock Optitherm, Lockinvar Shield, State or approved equal, with up to 96% thermal efficiency, a storage capacity of 60 gallons, an input rating of 120,000 BTU’s per hour, a recovery rating of 138 gallons per hour (gph) at 100°F rise and a maximum hydrostatic working pressure of 160 PSI. Water heater shall:

1. Have a seamless glass lined steel tank construction with glass lining applied to all water-side surfaces after the tank has been assembled and welded.
2. Meet the thermal efficiency and standby loss requirements of the US Department of Energy and current edition of ASHRAE/IESNA 90.1.
3. Have foam insulation and an ASME rated T&P relief valve.
4. Have a down-fired power burner designed for precise mixing of air and gas for optimum efficiency, requiring no special calibration on start-up.
5. Be approved for 0” clearance to combustibles.

B. Heater shall be supplied with maintenance free powered anode.

C. The control shall be an integral solid-state temperature and ignition control device with integral diagnostics, graphic user interface, fault history display, and shall have digital temperature read-out.

D. The BTH-120 model is design-certified by Underwriter’s Laboratories (UL), Inc., according to ANSI Z21.10.3 – CSA 4.2 standards governing storage-type water heaters. It also meets the thermal efficiency and standby loss requirements of the U.S. Department of Energy and current edition ASHRAE/IESNA 90.1. Complies with SCAQMD Rule 1146.2 and other quality management districts with similar requirements for low NOx emissions.

E. For Standard Power Venting: Water heater shall be suitable for standard power venting using a 4” diameter PVC pipe for a total distance of 70 equivalent feet of vent piping.

F. Operation of water heater(s) in a closed system where thermal expansion has not been compensated for (with a properly sized thermal expansion tank) will void the warranty.

G. Water heater should incorporate ICOMM™ system for remote monitoring, leak detection and fault alert.

H. Acid Neutralization Kit

1. Furnish and install A.O. Smith #9007607005 Neutralizer Kit for the water heater. Provide stock for three limestone chip replacements for each unit.
2. If manufacturer cannot provide acid neutralizing kit, provide after-market kit rated for condensate flue similar to JJM Boiler Works model #JM2. Provide signage indicating serving and neutralizing chip frequency.

2.25 HOT WATER BOILER (BLR-1, 2 & 3)

A. The WATER HEATER shall be a LOCHINVAR ARMOR Model AWN1250NPM having a modulating input rating of 1,250,000 Btu/Hr, a recovery capacity of 1485 gallons per hour at a 100^{o}F rise and shall be operated on Natural Gas. The WATER HEATER shall be capable of full modulation firing down to 20% of rated input with a turn down ratio of 5:1.

B. The WATER HEATER shall bear the ASME "H" stamp and shall be National Board listed. There shall be no banding material, bolts, gaskets or "O" rings in the header configuration. The stainless steel combustion chamber shall be designed to drain condensation to the bottom of the heat exchanger assembly. A built-in trap shall allow condensation to drain from the heat exchanger assembly. The complete heat exchanger assembly shall carry a five (5) year limited warranty.

C. The WATER HEATER shall be ANSI Z21.10.3 certified. The WATER HEATER shall comply with the energy efficiency requirements of the latest edition of the ASHRAE 90.1 Standard. The WATER HEATER shall be AHRI certified to 98% thermal efficiency. The WATER HEATER shall be certified for indoor installation.

D. The WATER HEATER shall be constructed with a heavy gauge steel jacket assembly, primed and pre-painted on both sides. The combustion chamber shall be sealed and completely enclosed, independent of the outer jacket assembly, so that integrity of the outer jacket does not affect a proper seal. A burner/flame observation port shall be provided. The burner shall be a premix design and constructed of high temperature stainless steel with a woven metal fiber outer covering to provide modulating firing rates. The WATER HEATER shall be supplied with a gas valve designed with negative pressure regulation and be equipped with a variable speed blower system, to precisely control the fuel/air mixture to provide modulating WATER HEATER firing rates for maximum efficiency. The WATER HEATER shall operate in a safe condition at a derated output with gas supply pressures as low as 4 inches of water column.

E. The WATER HEATER shall utilize a 24 VAC control circuit and components. The control system shall have an electronic display for water heater set-up, water heater status, and water heater diagnostics. All components shall be easily accessed and serviceable from the front of the jacket. The WATER HEATER shall be equipped with; a high limit temperature control certified to UL353, ASME certified pressure relief valve, outlet water temperature sensor, inlet water temperature sensor, a UL 353 certified flue temperature sensor, low water flow protection, built-in freeze protection. The manufacturer shall verify proper operation of the burner, all controls and the heat exchanger by connection to water and venting for a factory fire test prior to shipping.

F. The WATER HEATER shall feature the “Smart System” control with a Multi-Colored Graphic LCD touch screen display, password security, pump delay with freeze protection, pump exercise, and USB PC port connection. The WATER HEATER shall feature night setback for the domestic hot water tank and shall be capable of controlling a building recirculation pump while utilizing the night setback schedule for the building recirculation pump. The WATER HEATER shall have the capability to accept a 0-10 VDC input connection for BMS control of modulation or setpoint and enable/disable of the water heater, and a 0-10 VDC output of water heater modulation rate. The WATER HEATER shall have a built-in cascading sequencer with modulation logic options of “lead lag” or “efficiency optimized”. The BOILER shall be capable of remote communication via optional CON-X-US™ Remote Connectivity which is capable of sending test message or email alerts to notify the caretaker of a boiler alarm and remote programming of onboard boiler control. Both modulation logic options should be capable of rotation while maintaining modulation of up to eight water heaters without utilization of an external controller. Supply voltage shall be 120 volt / 60 hertz / single phase.

G. The WATER HEATER shall be equipped with two terminal strips for electrical connection. A low voltage connection board with data points for safety and operating controls, i.e., Auxiliary Relay, Auxiliary Proving Switch, Alarm Contacts, Runtime Contacts, Manual Reset Low Water Cutoff, Flow Switches, High and Low Gas Pressure Switches, Tank Thermostat, Tank Sensor, Building Management System Signal, Modbus Control Contacts and Cascade Control Circuit. A high voltage terminal strip shall be provided for supply voltage. The high voltage terminal strip plus integral relays are provided for independent control of the Domestic Hot Water Pump and Building Recirculation Pump.

H. The WATER HEATER shall be installed and vented with a Vertical Vent and Sidewall Air system with a vertical roof top termination of the vent with the combustion air being drawn horizontally from a sidewall. The flue shall be CPVC, Polypropylene or Stainless Steel sealed vent material terminating at the roof top with the manufacturers specified vent termination. A separate pipe shall supply combustion air directly to the WATER HEATER from the outside in a different pressure zone than that of the exhaust vent. The air inlet pipe may be PVC, CPVC, Polypropylene or Stainless Steel sealed pipe. The WATER HEATER’s total combined air intake length shall not exceed 150 equivalent feet. The WATER HEATER’s total combined exhaust venting length shall not exceed 100 equivalent feet. *Foam Core pipe is not an approved material for exhaust piping.*

I. The WATER HEATER shall have an independent laboratory rating for Oxides of Nitrogen (NO_x) of 20 ppm or less, corrected to 3% O_2.

J. The WATER HEATER shall operate at altitudes up to 4,500 feet above sea level without additional parts or adjustments.

K. The WATER HEATER’s firing control system shall be M9 Direct Spark Ignition with Electronic Supervision

L. The WATER HEATER shall be constructed in accordance with MA Massachusetts Code.

M. Domestic Boilers/Hot Water Generators shall be Lockinvar, Heat Transfer Products, Burnham, Thermal Solutions, Laars Heating Systems Company or approved equal.

2.26 STORAGE TANK (HWS-1, 2 & 3)

A. The STORAGE TANK shall be a Lochinvar Lock-Temp "Energy Saver" tank, Model RGA0650 with vertical construction having a storage capacity of 650 gallons. The tank shall be

constructed with an inner chamber baffle designed to receive all circulation to and from the water heater to eliminate turbulence in the tank. The baffled tank shall supply 80% of tank capacity without a drop in outlet temperature, regardless of rate of draw.

B. The STORAGE TANK shall be constructed in accordance with ASME Boiler and Pressure Vessel Code requirements, (if ASME – "HLW" stamped and registered with the National Board of Boiler and Pressure Vessel Inspectors). The tank shall be furnished with the following connections: two 3" NPT dielectric circulating connections, one 2" NPT dielectric hot water outlet, one 1-1/4" NPT relief valve connection, one 3/4" NPT aquastat opening and one 1" NPT drain connection.

C. The STORAGE TANK shall have a working pressure of 150 PSI. The interior of the STORAGE TANK shall be glass lined and fired to 1600° F to ensure a molecular fusing of glass and steel, furnished with magnesium anodes and carry a five (5) year limited warranty.

D. The STORAGE TANK shall be constructed with a heavy gauge galvanized steel jacket assembly, primed and pre-painted on both sides with a minimum dry film thickness of 0.70 mills. The STORAGE TANK shall be completely encased in a minimum of 2" thick, high density polyurethane foam insulation to meet the energy efficiency requirements of the latest edition of the ASHRAE 90.1 Standard.

E. Provide vacuum breaker and temperature/pressure relief valve conforming to Massachusetts Plumbing Code.

F. Provide a diaphragm type expansion tank rated for domestic water use and sized for the expansion volume and pressure of the hot water system. Also, provide a diaphragm type expansion tank for the boiler system.

G. Domestic Hot Water Storage Tanks shall be Lochinvar, Heat Transfer Products, Burnham, Thermal Solutions, Laars Heating Systems Company or approved equal.

2.27 ELECTRIC WATER HEATER – OUTDOOR TOILET & STORAGE BUILDING

A. Water heater shall be model #EL80-6, manufactured by RHEEM/RUUD, having electrical input of 6 kW and a recovery rate of 27 GPH at a 90°F temperature rise. Water heater shall have a storage capacity of 80 gallons. Water heater shall have the UL seal of certification and be factory equipped with an AGA/ASME rated temperature and pressure relief valve. Tank interior shall be coated with a high temperature porcelain enamel and furnished with an R-Tech resistored magnesium anode rod rigidly supported. Water heater shall meet of exceed the energy factor requirements of ASHRAE Standard 90.1b-1992. Tank shall have a working pressure rating of 150 psi, and shall be completely assembled. Water heater shall be equipped with copper, low watt density, resistored, "screw-in" type elements. Tank shall be insulated with 2-1/2" rigid polyurethane foam insulation. Water heater shall be equipped with surface mounted thermostats each with an integral, manual reset, high limit control. Water heater shall be covered by a three year limited warranty against tank leaks.

1. Domestic Hot Water Storage Tanks shall be Rheem/Ruud, Lochinvar, Heat Transfer Products or A.O. Smith.

B. Provide automatic shutoff device for excessive tank temperature. Initial tank water temperature shall be set to 125°F.

C. Heaters shall be provided with a manufacturer's warranty of at least 3 years based on commercial use.

D. Provide vacuum breaker and temperature/pressure relief valve conforming to Massachusetts Plumbing Code.

E. Where a backflow has been installed on the main water service into the building and /or the service into the water heater, provide a diaphragm type expansion tank rated for domestic water use (potable systems) and sized for the expansion volume and pressure of the hot water system.

2.28 MINI-TANK ELECTRIC WATER HEATER – REMOTE SINKS

A. Furnish and install, where shown on the drawings, mini-tank electric water heaters in the base cabinet serving the individual sink or multiple sinks. The water heater shall be Bosch, Stiebel Eltron, Ariston, or approved equal.

B. The Bosch Tronic 3000T point-of-use electric mini-tanks are available in three sizes which can be wall-hung (bracket included) or floor-mounted. Simply tap into the cold water line and install the water heater directly at the sink to provide hot water. They may also be installed in-line with a larger hot water source to eliminate the wait for hot water. The water heater features are:

1. Supplies up to 2 sinks at a time (ES8 model)
2. Provides hot water quickly at point-of-use
3. Compact, lightweight, space saving
4. Units can be wall / floor mounted (bracket included) with multi-directional mounting available (ES8 model only)
5. Temperature / pressure relief valve included on ES8
6. Temperature / pressure relief valve installed on ES4 and ES2.5
7. Glass-lined tank for long service life
8. Models ES2.5 and ES4 have a simple 120VAC plug-in connection (1440 Watts)
9. Model ES8 has a hard wired connection (1440 Watts)

C. EWH-1: For multiple sinks, provide Bosch model #ES8 or approved equal.

D. EWH-2: For single sinks, provide Bosch model #ES4 or approved equal.

2.29 PIPE IDENTIFICATION AND VALVE TAGS

A. All piping, except that piping which is within inaccessible chases, shall be identified with semi-rigid plastic identification markers equal to Seton or approved equal Setmark pipe markers or Marking Services Inc. Direction of flow arrows are to be included on each marker. Each marker background shall be appropriately color coded with clearly printed legend to identify the contents of the pipe in conformance with the "Scheme for the Identification of Piping Systems" (ASME 13.1-2007). Setmark snap-around markers shall be used above six inch overall diameters up to six inches and strap-around markers shall be used above six inch overall diameters. Markers shall be located adjacent to each valve, at each branch, at each cap for future, at each riser take off, at each passage through wall, at each pipe passage through floors, at each pipe passage to underground and on vertical and horizontal piping at 20 foot intervals maximum. All non-portable water lines and outlets shall be identified in accordance with the requirements of the Massachusetts Uniform State Plumbing Code.

B. All valves shall be designated by distinguishing numbers and letters carefully coordinated with a valve chart. Valve tags shall be 19 gauge polished brass, 1-1/2 inch diameter with stamped black filled letters similar to Seton S type 250-BL or approved equal. Lettering shall be 1/4 inch high for type service and 1/2 inch for valve number. Tag shall be attached to valves with approved brass "S" hooks, or brass jack chin. Whenever a valve is above a hung ceiling, the valve tag shall be located immediately above the hung ceiling. Check valves do not need to have an ID.

C. Furnish a minimum of two typed valve lists to be framed under glass or plexi-glass. Each chart shall be enclosed in an approved .015 inch thick plastic closure for permanent protection. Valve numbers shall correspond to those indicated on the Record Drawings and on the printed valves lists. The printed list shall include the valve number, location and purpose of each valve. It shall state other necessary information such as the required opening or closing of another valve is to be opened of closed. Printed framed valve lists shall be displayed in each Mechanical Room or in location designated by the Owner.

D. Equipment nameplates shall be 3/4 inch by 2-1/2 inch long .02 inch aluminum with a black enamel background with engraved natural aluminum letters similar to Seton Style 2065-20. Nameplate shall have pressure sensitive taped backing. Alternate MFR is Marking Services Inc. model MS-215.

E. Provide a brass will plaque, minimum .020 inch thickness, secured to the exterior wall just above the grade line for all buried serviced entrances or exits. Samples of such are: Water Service Below; Sanity Sewer Below; Kitchen Waste Below; Storm Drain Below; etc.

F. Label all flue and combustion air piping with stick-on labels (EXHAUST / INTAKE).

2.30 HOSE BIBBS, SILL COCKS AND ROOF HYDRANTS

A. Interior hose bibbs (H.B.'s) shall be Woodford Model B24, Josam, Zurn, Mifab, Wade or equal; chrome plated, anti-siphon, vacuum breaker protected wall faucet, hose connection, enclosed in a flush mounted wall box. Provide at each bathroom group and in Boiler Room. Note that for non-public areas, Woodford Model 24 exposed hose bib can be used.

B. Freeze-proof sill cocks (FPSC's) shall be Woodford model B65, Josam, Zurn, Mifab, or Wade,or equal; non-freeze type, recessed box with chrome plated face, vacuum breaker, hose connection, integral stop and loose T key.

1. Note that there are several locations of freeze-proof sillcocks around the building near grade and serving the roof level.

C. Roof hydrants shall be Woodford model RHY2-MS, Josam, Zurn, Mifab, or Wade,or equal and shall have the following features:

1. Rod guide eliminates side pull on rod, reduces wear on packing, packing nut and stem.
2. Adjustable link for easy adjustment and positive lever lock position.
3. One piece variable flow plunger with large cushion type seal for longer life is not easily damaged and assures shut-off even when foreign particles are present,
4. All hydrant repairs can be made from top of unit without removing hydrant.
5. Hose connection backflow preventer: Model #50HF with ¾" hose connection, ASSE 1052 Listed, field testable dual check holds against 125 PSI backflow pressure.

6. 1” NPT female inlet connection
7. 1-1/4” US made galvanized pipe casing.
8. 1/8” NPT drain hole (must be piped to a drain location)
9. Mounting System – must be ordered separately for hydrant support.

2.31 ROOF DRAINS

A. Roof drains shall be as specified hereinafter, Zurn, Jay R. Smith, Josam, Mifab, Froet or Wade. Drains shall be cast iron with clamping device for making watertight connection. Free openings through strainer shall be twice area of drain outlet. Provide 4 lb. lead flashing 12” in diameter greater than outside diameter of drain collar.

B. RD-1: Zurn ZC163-SC-W4 or equal, combination 15” diameter roof drain and overflow drain, Dura-coated cast iron bodies with combination membrane flashing clamp/gravel guards, double Top-Set deck plate, low silhouette cast iron domes; no-hub outlets; 4” internal water dam on overflow drain; provide(underdeck clamp and/or) extension as required by the application.

C. Emergency Roof Drain Downspout Nozzle Outlet: Zurn #Z199-DC, MIFAB® Series R1960-F, or approved equal fabricated type 304 stainless steel downspout nozzle with hinged perforated birdseed cover in flush model. Provide stainless steel screws, tamperproof, with pan heads with anchors to affix to building. Note: the screen should be removable and easily reinstalled or not installed at all.

D. At every roof drain, provide a Roof Drain Marker to identify the location of the roof drain if it is buried. The Roof Drain Marker shall by similar to the following:

1. Basis-of-Design Product: Provide roof drain markers manufactured by Roof Drain Marker Co., LLC., West Bridgewater, MA; (877) 571-6644; email: lmay@roofdrainmarker.com; www.roofdrainmarker.com.

2. Roof Drain Marker: Drain dome-mounted vertical fiberglass flag marker secured in aluminum socket in turn secured with pre-punched aluminum bracket configured for through-bolting to roof drain dome.
   Flag Marker: Pultruded fiber-reinforced polymer rod, 1/2 inch (12 mm) diameter by 48 inch (1219 mm) long, with reflective dual-colored reversible ends enabling marking of selected drains.
   Flexural Strength, minimum, ASTM D 790, 700,000 psi
   Impact Strength, minimum, ASTM D 256: 40 ft-lb/in.
   Marker Base: 1 by 1 by 4 inch (25 by 25 by 102 mm) extruded aluminum bar, ASTM B 209 (ASTM B 209M), with milled flag receiver, threaded flag set screw retainer, and threaded base.
   Flag Bracket: 1 by 11 by 0.063 inch (25 by 25 by 1.60 mm) aluminum plate bracket, ASTM B 221 (ASTM B 221M).
   Fasteners: Alloy Group 2 (A4) stainless-steel bolts, ASTM F 593 (ASTM F 738M), and nuts, ASTM F 594 (ASTM F 836M).

2.32 EXPANSION COMPENSATORS

A. Flexible expansion loops of the size and type noted on the drawings shall be "Metraloop" by Metraflex or approved equal, constructed of materials compatible for the service(s) intended and as shown, with axial movements of 4". Flexible loops shall impart minimal thrust loads on the piping, and be guided and anchored in accordance with manufacturer’s recommendations. Flexible loops shall consist of two flexible sections,

and a 180 return bend with a drain/air release fitting. Flexible loops for potable water systems shall be approved by the Massachusetts Plumbing Board.

B. The alternate methods to using the specified flexible expansion loops are standard expansion loops (as shown on the drawings if there is room) and/or expansion compensators with female copper sweat ends and stainless steel bellows and pipe/shell.

D. There are several building expansion joints on this project. Anytime the piping crosses a building expansion joint, braided stainless steel piping should be utilized on either side of the joint so the piping can move with the building independently from the fixed piping system. These are indicated on the drawings. Note that standard expansion loops will not work at these locations.

2.33 GAS FIRED WATER HEATER AND BOILER FLUE VENT AND COMBUSTION AIR PIPING

A. Furnish and install, where shown on the Drawings, domestic hot water heater flue and combustion air venting in accordance with the boiler manufacturer's published installation instructions.

B. The water heater shall be installed and vented with a Direct Vent system with vertical roof termination of both the flue vent and combustion air. The flue shall be schedule 40 CPVC, Polypropylene or Stainless Steel sealed vent material terminating at the roof with the manufacturers specified vent cap. A separate pipe shall supply combustion air directly to the boiler from the outside. The air inlet pipe shall be Schedule 40 solid PVC, CPVC, Polypropylene or Stainless Steel sealed pipe. Foam Core pipe is not an approved material for exhaust or intake piping. Refer to boiler manufacturer’s installation instructions for allowed materials and installation guidelines.

C. Provide all components required for complete system. Venting systems including, but not limited to, pipe sections, tees and elbows, drains, cleanouts, supports, variable lengths, termination caps and screens.

D. Flue vent low point drains shall be piped to an acid neutralizing tank furnished by boiler manufacturer. Pipe and install in accordance with manufacturers recommendations.

2.34 HEATING BOILER FLUE PIPING – By HVAC Contractor

2.35 WATER SUB-METERS

A. Furnish and install water sub-meters on the domestic water system at the boiler water feed and serving the domestic water system to meet LEED criteria for metering. The water sub-meters shall be as follows:

1. For the 1” boiler water feed, provide BadgerMeter Recordall Cold Water Bronze Disc Meter model #25-RTR rated for 0.5 GPM – 25 GPM with 5/8” x 3/4” piping connections. The water meter complies with ANSI/AWWA standard C700 and consists of three basic components: meter housing, measuring chamber and permanently sealed register. The water meter is bronze with externally threaded spuds. The meter uses a direct magnetic drive, through the use of high-strength magnets, providing positive reliable and dependable register coupling for straight-reading, remote or automatic reading options. The water meter will provide a digital pulse output to the EMS system for monitoring.
2. For the 3” cold water feed to the domestic hot water system, provide BadgerMeter Recordall Cold Water Bronze Disc Meter model #35-RTR rated for 0.75 GPM – 35

GPM with 3/4" piping connections. The water meter complies with ANSI/AWWA standard C700 and consists of three basic components: meter housing, measuring chamber and permanently sealed register. The water meter is bronze with externally threaded spuds. The meter uses a direct magnetic drive, through the use of high-strength magnets, providing positive reliable and dependable register coupling for straight-reading, remote or automatic reading options. The water meter will provide a digital pulse output to the EMS system for monitoring.

3. Alternate water meter manufacturers are Neptune, Sensus, H2O Degree or approved equal.

2.36 NATURAL GAS SUB-METERING

A. Provide gas sub-meter for the domestic water boiler similar to the following:

1. Provide Elster American Meter model #AC-630 Diaphragm Meter or approved equal; die-cast aluminum case; oil-impregnated self-lubricating bushings; molded convoluted diaphragms for smooth operation & long life; rigid reinforced flag rods for positive alignment and sustained accuracy; graphite-filled phenolic valves to minimize wear; long life low friction grommet seals; single coat polyester primer with high solids polyurethane top coat; security seals that indicate tampering.
2. Provide optional remote volume pulser.

B. Provide gas sub-meter for the heating boilers similar to the following:

1. Provide Romet "Imperial" Rotary Gas Meter model #RM-5000 or approved equal; positive displacement type meter that use the classic "roots" principle of measurement; cast aluminum body and covers; extruded aluminum impellers; high grade alloyed steel impeller shafts; synthetic elastomer o-ring/gaskets; high carbon steel bearings; steel allot timing gears and reduction gears. Maximum Flow Rate = 5,000 CFH. Maximum pressure drop = 0.96" w.c. Start Flow = 4.0 CFH. Weight = 32 LBS.
2. Description: Two counter-rotating impellers spin inside the pressurized precision machined measuring chamber. The rotation is transmitted via a magnetic couple to the mechanical index. An odometer style index totalizes the raw "uncorrected" volume. The uncorrected volume can be transmitted via an integrated Low Frequency Pulser to a remote mounted Index, PLC, or Energy Management System.

C. Alternate gas sub-meters shall be Onicon Inc. #F-5300 Series Thermal Mass Flow Meter with #D-100 Flow Display with Network Interface. Provide Onicon Inc. #N-100 Network Interface Module.

2.37 MOTORS, STARTERS, AND WIRING

A. Provide motors and controls, and furnish starters, for plumbing equipment. Provide control and other related wiring, including interlocks. Power wiring to panelboards, disconnect switches, starters and motors shall be provided by Division 26000. Starters that are not integral to equipment shall be installed and wired under Division 26000 and furnished under this Section.

A. All motors and starters shall comply with specifications included in Division 260000.

2.38 COMPOUND TYPE COLD WATER METER – DOMESTIC WATER SERVICE @ SCHOOL

A. These specifications are in compliance with the latest revision of AWWA Standard C702 with certain exceptions as noted below. All specifications meet or exceed the latest revision on AWWA C702.

B. Compound meters shall consist of a combination of an AWWA Class II turbine meter for measuring high rates of flow and a nutating disc type positive displacement meter for measuring low rates of flow enclosed in a single maincase. An automatic valve shall direct flows through the disc meter at low flow rates and through the turbine meter at high flow rates. At high flow rates, the automatic valve shall also serve to restrict the flow through the disc meter to minimize wear.

C. The capacity of the meter in terms of normal operating range, maximum loss of head, and maximum continuous flow shall be as shown below:

Size	Normal Operating Range (gpm)	Max. Head Loss at Cont Flow (psi)	Max. Continuous Flow (gpm)	Max. Capacity Flow (gpm)	Min. Test Flow (gpm)
3"	1/2 – 450	6	350	450	1/4

D. The size of the meters shall be determined by the nominal size (in inches) of the opening in the inlet and outlet flanges. Overall lengths of the meters shall be as follows:

Size	Laying Length	Max. Height from Center with Local Register
3"	17"	7-3/4"

E. Casing bolts shall be made of type 316 stainless steel.

F. Maincases shall be flanged. The 3" size shall have optional oval flanges or round flanges per Table 4, AWWA C702.

G. The maincase and cover shall be sand cast of water works bronze containing not less than 75% copper. The size, model, manufacturer's trademark, and arrows indicating direction of flow shall be cast in raised characters on both sides of the maincase. The size and arrows indicating direction of flow shall be cast in raised characters on the housing cover. A 1-1/2" test plug shall be located on the maincase cover for the purpose of field testing the meter. The maincase shall have a single drain plug located on either side of the maincase or near the outlet end of the meter casing.

H. A single magnetic-drive register shall record the flow of the turbine and disc meters and a single number wheel stack shall sum the registration of the meter. Registers shall be permanently sealed, electronic encoder register (EER) indicating in cubic feet (Refer to section 2.21.D for EER specification). Registers shall be permanently roll sealed, straight reading, indicating in gallons, cubic feet, or cubic meters. Registers shall include a center-sweep test hand, meter size and a glass lens.

I. Register boxes and covers shall be of bronze or thermoplastic composition. The name of the manufacturer, manufacturer trademark and the meter serial number shall be clearly identifiable and located on the register box cover.

J. The register box shall be secured to meter bayonet with a seal wire tamper resistant screw.

K. The meter serial number shall be imprinted on the meter flange or cover as well as the register box cover.

L. The compound measuring assembly shall be a self-contained unit, attached to the cover for easy field removal. The turbine rotor spindle shall be stainless steel with a ceramic bearing and endstone.

1. The nutating disc chamber shall be a self-contained unit mounted on the cover and easily removable from the cover. It shall conform to AWWA Standard C-700 for the following size: 2" - 5/8" disc.

M. One vertical 1-1/2" NPT tapped boss shall be provided on the housing near the outlet for use during field performance testing purposes or as a tap for pressure recording.

N. The automatic valve shall be of the weight type and uses gravity for operation. All valve parts shall be made of water works bronze, stainless steel, or a suitable polymer with a replaceable semi-hard rubber seal. Only the cover must be removed to gain access to the valve for inspection or service.

O. A strainer shall be provided for the disc meter. It shall be easily removable and have an effective straining area of at least double the disc meter inlet.

P. Registration accuracy over the normal operating range shall be 98.5% to 101.5%. Registration at the crossover shall not be less than 95%. Registration at the low flow rate shall not be less than 95%.

Q. All meters shall be equipped with a digital encoder register per AWWA C707, shall meet all AWWA C702 performance standards, and shall include all required hardware for installation. The digital encoder will allow connectivity to a close proximity read system, a radio frequency read system and a telephone in-bound system.

R. Acceptable meters shall be the Badger Recordall Compound or approved equal.

S. Water meters for site irrigation system and for outdoor toilet and storage building shall be similar, but not the same size. See plans or coordinate with the Worcester DPW for water meter sizes.

2.39 TIMECLOCKS

A. Furnish and install, where indicated on the Drawings (i.e. for the RP-1 & 1A, RP-2, RP-3 & RP-4 pumps), multi-purpose digital timeclocks as manufactured by Tork, Model DZS-100, or approved equal.

B. Unit shall consist of:

1. On/off time with override.
2. Unit controllers shall have capability to program on one (1) minute intervals.
3. Unit can program in AM/PM or 24 hour format.
4. LED display.
5. 365-day capability.
6. 120 Volt control.
7. Solenoid valve.

2.40 EXTERIOR CONCRETE GREASE INTERCEPTOR – FURNISHED AND INSTALLED BY SITE CONTRACTOR, BUT PIPING TO & FROM & PIPING INSIDE TANK BY PLUMBER

2.41 HOT AND COLD WATE HOSE STATION AND MIXING UNIT, HS-1

A. Furnish and install Armstrong model #3033 Hot and Cold Water Hose Station and Mixing Unit Assembly, standard materials, or approved equal, where shown on the drawings. It shall have a model 320 ¾" inlets/outlet thermostatic mixing valve (TMV) of disposable cartridge construction. TMV features unique full range temperature control from full cold to field adjustable maximum temperature limit stop in a single handle turn. TMV can be set and locked to a single temperature and will hold outlet temperature ±2°F in the event of inlet pressure and/or temperature fluctuation/change. Thermal shutdown capability protects operator in the event of an inlet supply failure. This model includes integral tandem valve comprising of two (2) full port ball valves cross-linked by a stainless steel bridge piece and lever for simultaneous on/off control of both inlet supplies. Outlet thermometer of stainless steel construction and shatter-proof Lexan lens. Unit is mounted on a heavy-duty stainless steel single-piece hose rack that is suitable for wall or column installation. Supplied with 25 feet white 300 PSI/200°F rated washdown hose with "live" swivel adaptors. Rubber cushioned 10 GPM rated water saver spray nozzle and nozzle hook supplied as standard. Unit is supplied fully assembled and pressure tested with strain relief and ¾" coupling for hose attachment. Inlet check valves are required.

B. Acceptable manufacturers are Armstrong, SuperKlean Washdown Products, Strahman Valves Inc., or approved equal.

2.42 TWO STAGE pH NEUTRALIZATION SYSTEM

A. The laboratory waste pH neutralization system shall be supplied as a complete, integrated process system by a single supplier. The system shall be as manufactured by Concorp, Inc. of Acton, Massachusetts. The system shall be Concorp Model PHS/2-500-SP, or approved equal.

B. The laboratory waste pH neutralization system shall be a modified two-stage with two continuous, stirred tank reaction chambers in series, with an effluent pH monitor. Each treatment stage shall have bi-directional proportional pH control and have equal treatment capacity in order to provide full redundancy. The wastewater from the laboratory drain system shall flow by gravity to the system. The wastewater shall flow into the first treatment tank. After mixing and treatment, the wastewater shall flow into the second tank for additional treatment as necessary. The wastewater shall then be periodically pumped or gravity discharged through an effluent monitoring assembly. The pH of the final treated effluent wastewater shall be monitored independently and shall be recorded on a circular chart recorder. The effluent monitoring assembly shall have a sampling port assembly. The wastewater shall then be discharged to the sewer. The pH neutralization system shall have provisions for temporary wastewater collection in the event the wastewater is out-of-spec. The system shall be supplied with the ability to switch between semi-batch treatment and continuous gravity discharge. The system shall be controlled by a central system control panel using Concorp proprietary control system and process technology.

C. Equipment Specifications - pH Neutralization System

1. System Tank

Quantity:	one (1)
Type:	rectangular two-chamber baffled tank with internal baffles and effluent baffle

Model:	Concorp Model PPNT-R-2/500
Volume:	1650 gallons, overall 500 gal each reaction chamber
Size:	42” x 54” x 84” deep (nominal internal) 58” x 88” x 84” h (nominal overall)
Material:	polypropylene
Baffles:	internal 1/2” thick PP baffles/partitions
Wall Thickness:	1/2" minimum
Bottom Thickness:	1/2" minimum
Fittings:	Inlet: 4" Outlet: 4” PP Vent: 4" Overflow: 4" PP
Cover:	1/2" min. thickness with stiffeners and/or supports. Cover shall be removable, have an access port and fitted for all necessary sensors and equipment.

2. Mixers for Neutralization Tanks

Quantity:	two (2)
Type:	top entry, fixed mount, continuous-duty
Model:	Lightnin, Neptune, Dynamix, Concorp
Motor:	1/3 HP minimum, 1750 rpm, TEFC, 115 VAC, 1 phase, 60 Hz. NEMA "56C" flange mounting, high efficiency
Drive:	Gear reduction to 350 rpm
Mount:	Beam Mount, gasketed
Pumping Capacity:	2-3 tank volume turns per minute
Mixer Shaft:	3/4" dia. x 60” long min.
Mixer Impeller:	11.5” diameter min.

All wetted parts shall be type 316 stainless steel or polypropylene. The mixer shall be a vertical on-center mount for each reaction chamber. A positive seal shall be provided for the mixer shaft as it enters the tank. A steel beam mounting shall support mixer. Beam shall be blast cleaned with two coats of epoxy paint and mounted using 316 SS fasteners.

3. Chemical Storage

Quantity:	two (2)
Type:	cylindrical, flat-bottom, closed top DOT approved containers
Covers:	molded high-density polyethylene
Volume:	15 gallons, nominal
Diameter:	21" Height: 39" Wall Thickness: 3/16"
Material:	High-density polyethylene

Tanks shall have fittings for connection to the tubing to chemical metering pumps and low-level controls. A fitting shall be provided for the convenient filling and re-closing of the tanks. Low level control switches shall be provided for each chemical storage tank, which shall be wired to the system control panel. The float switches shall be constructed from polypropylene wetted parts.

4. Chemical Reagent Containment and Metering Pump Mounting Enclosure

Quantity:	one (1)
Type:	Rectangular Secondary Containment Custom Fabricated Enclosed PP unit, with two self-closing doors
Material:	1/2" thickness polypropylene

Quantity:	two (2)

Containment:	acid and caustic drum secondary containment
Size:	110% secondary chemical containment

Unit shall provide secondary containment of the chemical reagents. A polypropylene mounting shelf and enclosure shall be provided for mounting the chemical feed pumps. Unit shall be constructed of polypropylene and shall have solid top, bottom, sides and rear panels. The front of the unit shall have two polypropylene self-closing doors with clear plexiglass windows. Chemical containment pallets or over pack drums shall be provided for secondary containment of the chemical reagent feed drums. Unit shall have two separate compartments for chemical storage with 110% containment of the chemical reagent tanks.

The chemical feed discharge lines shall have complete secondary sleeves, which are hard-piped for each chemical feed line, using sweeps for all bends and turns. The discharge lines shall be seamless PE tubing with PVC secondary containment piping. The chemical feed piping shall be installed from the chemical reagent station to chemical injection containment boxes located on the top of the neutralization tanks.

5. Chemical Metering Pumps

Quantity:	four (4)
Capacity:	4 gallons per hour minimum
Model:	Prominent
Turndown Ratio:	1200:1 (minimum)
Control:	direct proportional control
Display:	Alphanumeric Fluorescent, LED, or LCD

The metering pumps shall be electronically controlled, solenoid-actuated, diaphragm-type pumps with ball-check valves. All wetted materials shall be of PVC, polypropylene, EPDM or Teflon. The exterior housings shall be NEMA 4 rated waterproof and dust-proof and constructed of fiberglass-reinforced plastic. The pumps shall have provisions for complete manual control and direct external control. These pumps shall be matched to the control instruments to insure complete control-loop compatibility and shall be wired so that the pH controller directly adjusts the metering pump flow rate. The pumps shall be mounted in the chemical storage and containment cabinet. Foot valves and injection valves must be provided with the metering pumps. Pumps shall be provided with over-pressure relief and anti-siphon capabilities.

6. pH Electrodes and Mounting Assemblies

Quantity:	three (3) T1, T2, outlet
Type:	industrial pH sensor, compatible with transmitter with ATC
Mount:	top entry

The pH electrodes shall be Concorp double-junction, permanent-reference glass sensors. The measurement range shall be from pH 0.0 to pH 14.0. The sensors shall be directly connected to the pH transmitters. Automatic temperature compensation and sensor diagnostics features shall be provided. The sensors shall be an immersion type sensor and have encapsulated sensor terminations. All electrodes shall be supplied with all necessary mounting and installation hardware. The pH sensors shall be mounted using a union type assembly. All sensors shall be top mounted via an airtight seal and assembly.

7. pH Transmitters

Quantity:	three (3) T1, T2, outlet
Model:	Signet, Aquametrix, ProMinent, or Concorp
Power:	24v dc
Input:	direct pH sensor input, 15' cable min.
Output:	analog output (4 - 20 mA)

The pH sensors shall be directly wired to the pH transmitters. Porous junctions shall be of PTFE or porous glass and annular in configuration. The measurement range shall be from pH 0.0 to pH 14.0. The transmitter electronics shall be protected from radio frequency interference (RFI) . The transmitter shall be a two-wire type and the output shall be a 4-20 mA current loop. Transmitter electronics shall be adjustable for current loop calibration purposes and shall utilize push-button configuration and sensor calibration. Automatic temperature compensation and sensor diagnostics shall be provided.

The sensors shall be an immersion type sensor and have encapsulated sensor terminations. All electrodes shall be supplied with all necessary mounting and installation hardware.

8. System Controller

Quantity:	one (1)
Model:	Programmable Controller, Operator Interface Alllen Bradley PLC and OIT
Input:	12 discrete inputs (minimum) 4 analog inputs (minimum) 10 discrete outputs (minimum
Control Action:	bi-directional proportional pH control with integrated tank level and discharge control
Display:	multi-line operator interface

Controls shall be programmed for full proportional control for each neutralization stage, flow monitoring and totalizing capacity, out-of-spec wastewater collection and recycle, effluent discharge control and effluent pH alarms. Programming shall include parameters based on expected titration curves. Program memory shall be protected by storage in non-volatile memory and/or battery back-up. Controls shall directly control metering pump flow rates. Controller shall be networkable for communications. Operator interface shall have graphic display with keypad. Unit shall be networked with controls to provide operator input and control.

9. Recorder

Quantity:	one (1)
Type:	one circular chart recorder for outlet recording microprocessor based circular chart recorder
Model:	Partlow,Honeywell, Concorp DR5000
Display:	Alphanumeric Fluorescent, LED, or LCD
Chart:	10" diameter paper chart

The recorder shall use 10" diameter circular charts. The recorder shall be set for a chart rotation time of 7 days. The recorder shall accept a 4-20 mA direct current signal for pH recording. Charts and supplies shall be provided in sufficient quantity to last for at least three months (at 24 hours of operation per day). Paper used shall provide a permanent inked record for regulatory purposes and shall not be temperature or pressure-sensitive.

10. Instrument Panel
    The panel enclosure shall be NEMA 4X rated (water-tight and dust-proof). External connectors and cable outlets shall be water-resistant. All instruments shall be identified by black and white engraved, laminated nameplates. Lettering shall be 3/8" high, minimum.

    The instrument panel shall be arranged to give an orderly presentation of the instrumentation. The enclosure shall have a hinged panel that provides ready access to all instruments and accessories for servicing. All items shall be so wired and mounted that, in general, any one item can be removed without interruption of the other items. No zero-based analog signals shall be used between instruments.

    Audible and visual alarms and prompts shall be supplied as part of the panel system to provide indication of the following conditions:

High Effluent pH	Low Acid in Storage Tank
Low Effluent pH	Low Alkali in Storage Tank
Mixer 1 On	Mixer 2 On
Transfer Pump On	Tank High Water

    All instruments shall be mounted semi-flush on the front of the panel in a manner such that all basic controls and adjustments are accessible without unlatching or opening the panel itself. A main power disconnect conforming to OSHA standards for lock-out/tag-out shall be included for the control panel for servicing of the panel and system.

    Control panel shall have provision for a set of remote alarm dry contacts for alarm connection to the building management system.

11. Outlet pH Monitoring Assembly

Quantity:	one (1)
Configuration:	Custom inlet tee to accept pH sensor
Size:	4” pipe
Material:	Polypropylene

    Unit shall maintain liquid immersion of pH sensor. An effluent sample tap assembly shall be provided. Unit shall be constructed from 4" flame-retardant polypropylene piping.

12. Discharge Pump

Quantity:	two (2)
Type:	immersion/submersible centrifugal pump
Flow / Head:	30 gpm @ 15 ft TDH
Motor:	1/3 HP, 115 VAC, 60 Hz, single phase
Material:	Stainless steel wetted parts
Discharge Pipe:	2” polypropylene

    Pump shall be mounted with sub-plate assembly to facilitate service and maintenance. Pump shall also be provided as a prepackaged unit. Pump shall be provided with outlet ball valve and ball check valve.

13. Tank Level Control

Quantity:	three (3)
Primary Level Sensor:	tethered float control with encapsulated switch

High Level Sensor:	magnetic float switch
Material:	polypropylene wetted parts

D. Installation

1. All equipment and materials shall be furnished to the plumbing contractor complete and in proper condition for installation.

2. The site plumbing contractor shall be responsible for installation of piping and mechanical components. The pH neutralization system shall be installed according to instructions and specifications provided by the system supplier and in compliance with state and local plumbing codes. The installing contractor shall also comply with all job specifications that are pertinent to this system.

3. pH electrode sensor assemblies shall be wired to the neutralization system in a manner as to facilitate cleaning, calibration, and maintenance of these sensors. Cables shall be run in flexible conduit to allow removal of the sensors for maintenance.

4. The chemical feed tubing shall be continuous PE tubing housed in pipe or large-bore tubing to shield against damage or leakage danger to personnel working near the system. The chemical tubing shall be installed in secondary containment piping from the reagent station to the chemical injection containment boxed on the top of each reactor.

5. The site interconnection piping, including manual isolation valves and fittings shall be provided and installed by the plumbing contractor.

6. Electrically, the system is wired as follows:

   a. The pH system has one power feed, which is to the power disconnect in the main panel.
   b. The system power feed is 120V, 1phase, 30 amps.
   c. All of the system equipment is powered from the main panel (this allows the motor protection as well as e-stop and power disconnect lockout).
   d. The mixers are pumps are each to be hard wired from the tank to the panel. Each are home runs wired from the device to the panel motor starter.
   e. The chemical metering pumps power and control cable are each wired to the control panel.
   f. The pH sensors and level sensors are low voltage which are home runs wired from device to control panel.

7. Since the tank is located in a pit and the control panel wall mounted, the system components need to be site wired. Each mixer and transfer pump is wired separately so that they are protected by a circuit breaker and motor started. This also allows the power disconnect and e-stop to function for these items. The chemical metering pumps are wired from the auxiliary of the mixer starters so that in the even the mixed is not running (tripped or powered off), the chemical metering pumps are stopped for safety. The instrument wiring are each low voltage (24 vdc). The wiring is typically run as instrument cable (18gage twisted pair wired with shield and drain). The site wiring is usually handled by either the site electrician or the plumber's electrical subcontractor. The instrument connections, testing, startup and calibration is usually performed by the MFR's technician once the site installation is ready.

E. Start-up and Training

1. The system manufacturer shall provide on-site assistance for the installing contractors amounting to a minimum of eight hours at the job site.

2. The system manufacturer shall provide complete start-up services. These services shall include adjustment of all equipment and controls, calibration of sensors and instrumentation, tuning of the control systems, check of all alarm functions, and verification of proper operation. The system startup and tuning shall be performed by a factory trained engineer and licensed wastewater treatment operator.

3. A minimum of 15 gallons of 25-50% sulfuric acid and 15 gallons of 25-50% sodium hydroxide shall be included for the initial operation of the system by the plumbing contractor.

4. The system manufacturer shall provide not less than three manuals that include overall operating, repair and maintenance instructions. In addition to these instructions, any factory manuals for pre-manufactured sub-component equipment shall be included in the system manual.

5. The system manufacturer shall provide instruction to the designated personnel of the owner or operator of the system. This instruction shall include operation of the system, calibration and maintenance, technical explanation of pH, neutralization, and local discharge requirements.

F. Warranties/Maintenance: All equipment and materials comprising the system shall be warranted against defects in materials or workmanship for a period of one year from the date of delivery. This warranty shall exclude consumed materials such as charts, pens, chemicals, electrodes, etc.

2.43 ELECTRICAL WORK

A. The Plumbing Subcontractor shall hire the project electrician to perform all low voltage and control wiring as required by code. Minimum gauge of all control wiring is 18 AWG and shall be plenum rated.

1. Wiring of the science rooms gas detection / emergency gas shut-off panels with the gas detectors
2. Wiring of the kitchens CO/FG detector panel to the four (4) detectors in the kitchen and the gas solenoid valve. There shall be a manual reset relay installed between the panel and the gas solenoid valve to ensure that the system in not automatically reset.
3. Wiring of the pH neutralizing system panel and wiring from the panel to the system components. See paragraph 2.42.D.6 and 2.42.D.7 for additional information.
4. Wiring of the radon fans (See detail on drawing P4.7 for wiring details – all wiring by Electrical Contractor).

2.44 VIBRATION AND SEISMIC CONTROL FOR PLUMBING SYSTEMS

A. Intent:

1. All plumbing piping as noted on the equipment schedule or in the Specification shall be mounted on vibration isolators and with flexible connections to prevent the transmission of vibration and mechanically transmitted sound to the building structure.

Vibration isolators shall be selected in accordance with the weight distribution so as to produce reasonably uniform deflections.

2. All isolators and isolation materials shall be of the same manufacturer and shall be certified by the manufacturer.
3. It is the intent of the seismic portion of this Specification to keep all mechanical building system components in place during a seismic event.
4. All such systems must be installed in strict accordance with seismic codes, component manufacturer's and building construction standards. Whenever a conflict occurs between the manufacturer's or construction standards, the most stringent shall apply.
5. This Specification is considered to be minimum requirements for seismic consideration and is not intended as a substitute for legislated, more stringent, national, state or local construction requirements (i.e. MA Codes, IBC Building Code, California Title 24, California OSHPD, or other requirements).
6. Any variance or non-compliance with these Specification requirements shall be corrected by the Plumbing Contractor in an approved manner.
7. Seismic restraints shall be designed in accordance with seismic force levels as detailed in Section H.

B. The work in this Section includes, but is not limited to, the following:

1. Vibration isolation for plumbing piping.
2. Equipment isolation bases.
3. Flexible piping connections.
4. Seismic restraints for isolated equipment.
5. Seismic restraints for non-isolated equipment.
6. Certification of seismic restraint designs and installation supervision.
7. Certification of seismic attachment of housekeeping pads.

C. Definitions:

1. Life Safety Systems: Not Applicable.

2. Positive Attachment: A positive attachment is defined as a cast-in anchor, a drill-in wedge anchor, a double sided beam clamp loaded perpendicular to a beam, or a welded or bolted connection to structure. Single sided "C" type beam clamps for support rods of overhead piping, ductwork, or any other equipment are not acceptable on this project as seismic anchor points.

3. Transverse Bracing: Restraint(s) applied to limit motion perpendicular to the centerline of the pipe, duct or conduit.

4. Longitudinal Bracing: Restraint(s) applied to limit motion parallel to the centerline of the pipe, duct or conduit.

D. Manufacturer's Data:

1. The manufacturer of vibration isolation and seismic restraints shall provide submittals for products as follows:

   a. Descriptive Data:

      (1) Catalog cuts or data sheets on vibration isolators and specific restraints detailing compliance with the Specification.

      (2) Detailed schedules of flexible and rigidly mounted equipment, showing vibration isolators and seismic restraints by referencing numbered descriptive Drawings.

   b. Shop Drawings:

      (1) Submit fabrication details for equipment bases including dimensions, structural member sizes and support point locations.

      (2) Provide all details of suspension and support for ceiling hung equipment.

      (3) Where walls, floors, slabs or supplementary steel work are used for seismic restraint locations, details of acceptable attachment methods for ducts, conduit and pipe must be included and approved before the condition is accepted for installation. Restraint manufacturers' submittals must include spacing, static loads and seismic loads at all attachment and support points.

      (4) Provide specific details of seismic restraints and anchors; include number, size and locations for each piece of equipment.

   c. Seismic Certification and Analysis:

      (1) Seismic restraint calculations must be provided for all connections of equipment to the structure. Calculations must be stamped by a registered professional engineer with at least five years of seismic design experience, licensed in the state of the job location.

      (2) All restraining devices shall have a preapproval number from California OSHPD or some other recognized government agency showing maximum restraint ratings. Preapprovals based on independent testing are preferred to preapprovals based on calculations. Where preapproved devices are not available, submittals based on independent testing are preferred. Calculations (including the combining of tensile and shear loadings) to support seismic restraint designs must be stamped by a registered professional engineer with at least five years of seismic design experience and licensed in the state of the job location. Testing and calculations must include both shear and tensile loads as well as one test or analysis at 45 to the weakest mode.

      (3) Analysis must indicate calculated dead loads, static seismic loads and capacity of materials utilized for connections to equipment and structure. Analysis must detail anchoring methods, bolt diameter, embedment and/or welded length. All seismic restraint devices shall be designed to accept, without failure, the forces detailed in Section H acting through the equipment center of gravity. Overturning moments may exceed forces at ground level.

E. Code and Standards Requirements:

   1. Typical Applicable Codes and Standards - most recent or enforced code:

a. Massachusetts State Building Code.

b. International Mechanical Code (IMC).

F. Manufacturer's Responsibility:

1. Manufacturer of vibration isolation and seismic control equipment shall have the following responsibilities:

a. Determine vibration isolation and seismic restraint sizes and locations.

b. Provide vibration isolation and seismic restraints as scheduled or specified.

c. Provide calculations and materials if required for restraint of unisolated equipment.

d. Provide installation instructions, drawings and trained field supervision to insure proper installation and performance.

G. Related Work:

1. Housekeeping Pads:

a. Housekeeping pad reinforcement and monolithic pad attachment to the structure details and design shall be prepared by the restraint vendor if not already indicated on the Drawings.

b. Housekeeping pads shall be coordinated with restraint vendor and sized to provide a minimum edge distance of ten (10) bolt diameters all around the outermost anchor bolt to allow development of full drill-in wedge anchor ratings. If cast-in anchors are to be used, the housekeeping pads shall be sized to accommodate the ACI requirements for bolt coverage and embedment.

2. Supplementary Support Steel: Plumbing Contractor shall supply supplementary support steel for all piping as required or specified.

3. Attachments: Plumbing Contractor shall supply restraint attachment plates cast into housekeeping pads, concrete inserts, double sided beam clamps, etc. in accordance with the requirements of the vibration vendor's calculations.

H. Seismic Force Levels

1. The force levels described in the building code shall be used on this project.

I. Product Intent:

1. All vibration isolators and seismic restraints described in this section shall be the product of a single manufacturer. Mason Industry's products are the basis of these Specifications; products of other manufacturers are acceptable provided their systems strictly comply with the Specification and have the approval of the specifying engineer. Submittals and certification sheets shall be in accordance with Section D.

2. For the purposes of this project, failure is defined as the discontinuance of any attachment point between equipment or structure, vertical permanent deformation greater than 1/8 in. and/or horizontal permanent deformation greater that 1/4 in.

J. Product Description: Vibration Isolators and Seismic Restraints:

1. Two (2) layers of 3/4 in. thick neoprene pad consisting of 2 in. square waffle modules separated horizontally by a 16 gauge galvanized shim. Load distribution plates shall be used as required. Pads shall be Type Super "W" as manufactured by Mason Industries, Inc.

2. Bridge-bearing neoprene mountings shall have a minimum static deflection of 0.2 in. and all directional seismic capability. The mount shall consist of a ductile iron casting containing two (2) separated and opposing molded neoprene elements. The elements shall prevent the central threaded sleeve and attachment bolt from contacting the casting during normal operation. The shock absorbing neoprene materials shall be compounded to bridge-bearing Specifications. Mountings shall have an Anchorage Preapproval "R" Number from OSHPD in the State of California verifying the maximum certified horizontal and vertical load ratings. Mountings shall be Type BR as manufactured by Mason Industries, Inc.

3. Sheet metal panels shall be bolted to the walls or supporting structure by assemblies consisting of a neoprene bushing cushioned between 2 steel sleeves. The outer sleeve prevents the sheet metal from cutting into the neoprene. Enlarge panel holes as required. Neoprene elements pass over the bushing to cushion the back panel horizontally. A steel disc covers the inside neoprene element and the inner steel sleeve is elongated to act as a stop so tightening the anchor bolts does not interfere with panel isolation in three (3) planes. Bushing assemblies can be applied to the ends of steel cross members where applicable. All neoprene shall be bridge bearing quality. Bushing assemblies shall be Type PB as manufactured by Mason Industries, Inc.

4. A one piece molded bridge bearing neoprene washer/bushing. The bushing shall surround the anchor bolt and have a flat washer face to avoid metal to metal contact. Neoprene bushings shall be Type HG as manufactured by Mason Industries, Inc.

5. Spring isolators shall be free standing and laterally stable without any housing and complete with a molded neoprene cup or 1/4 in. neoprene acoustical friction pad between the baseplate and the support. All mountings shall have leveling bolts that must be rigidly bolted to the equipment. Spring diameters shall be no less than 0.8 of the compressed height of the spring at rated load. Springs shall have a minimum additional travel to solid equal to 50% of the rated deflection. Submittals shall include spring diameters, deflection, compressed spring height and leveling valves Type LV as manufactured by Mason Industries, Inc.

6. Restrained spring mountings shall have an SLF mounting as described in Specification 5, with a rigid housing that includes vertical limit stops to prevent spring extension when weight is removed. The housing shall serve as blocking during erection. A steel spacer shall be removed after adjustment. Installed and operating heights are equal. A minimum clearance of ½ inch shall be maintained around restraining bolds and between the housing and the spring so as not to interfere with the spring action. Limit stops shall be out of contact during normal operation. Since housings will be bolted or welded in position there must be an internal isolation pad. Housing shall be designed to resist all seismic forces. Mountings shall have Anchorage Preapproval “R” Number from OSHPD in the state of California certifying the maximum certified horizontal and vertical load ratings. Mountings shall be SLR as manufactured by Mason Industries, Inc.

7. Spring mountings as in Specification 5 built into a ductile iron or steel housing to provide all directional seismic snubbing. The snubber shall be adjustable vertically and allow a maximum of ¼ inch travel in all directions before contacting the resilient snubbing collars. Mountings shall have an Anchorage Preapproval “R” Number OSHPD in the State of California verifying the maximum certified horizontal and vertical load ratings. Mountings shall be SSLFH as manufactured by Mason Industries, Inc.

8. Air Springs shall be manufactured with upper and lower steel sections connected by a replaceable flexible nylon reinforced neoprene element. Air spring configuration shall be multiple bellows to achieve a maximum natural frequency of 3 Hz. Air Springs shall be designed for a burst pressure that is a minimum of three times the published maximum operating pressure. All air spring systems shall be connected to either the building control air or a supplementary air supply and equipped with three (3) leveling valves to maintain leveling within plus or minus 1/8 inch. Submittals shall include natural frequency load and damping tests performed by an independent lab or acoustician. Air Springs shall be Type MT and leveling valves Type LV as manufactured by Mason Industries, Inc.

9. Restrained air spring mountings shall have an MT air spring as described in Specification 8, within a rigid housing that includes vertical limit stops to prevent air spring extension when weight is removed. The housing shall serve as blocking during erection. A steel spacer shall be removed after adjustment. Installed and operating heights are equal. A minimum clearance of ½ in. shall be maintained around restraining bolts and between the housing and the air spring so as not to interfere with the air spring action. Limit stops shall be out of contact during normal operation. Housing shall be designed to resist all seismic forces. Mountings shall be SLR-MT as manufactured by Mason Industries, Inc.

10. Hangers shall consist of rigid steel frames containing minimum 1-1/4 in. thick neoprene elements at the top and a steel spring with general characteristics as in Specification 5 seated in a steel washer reinforced neoprene cup on the bottom. The neoprene element and the cup shall have neoprene bushings projecting through the steel box. To maintain stability the boxes shall not be articulated as clevis hangers nor the neoprene element stacked on top of the spring. Spring diameters and hanger box lower hole sizes shall be large enough to permit the hanger rod to swing through a 30 arc from side to side before contacting the rod bushing and short circuiting the spring. Submittals shall include a hanger Drawing showing the 30 capability. Hangers shall be Type 30N as manufactured by Mason Industries, Inc.

11. Hangers shall be as described in 10, but they shall be precompressed and locked at the rated deflection by means of a resilient seismic upstop to keep the piping or equipment at a fixed elevation during installation. The hangers shall be designed with a release mechanism to free the spring after the installation is complete and the hanger is subjected to its full load. Deflection shall be clearly indicated by means of a scale. Submittals shall include a Drawing of the hanger showing the 30 degree capability. Hangers shall be Type PC30N as manufactured by Mason Industries, Inc.

12. Seismic Cable Restraints shall consist of galvanized steel aircraft cables sized to resist seismic loads with a minimum safety factor of two (2) and arranged to provide all-directional restraint. Cable end connections shall be steel assemblies that swivel to final installation angle and utilize two (2) clamping bolts to provide proper cable engagement. Cables must not be allowed to bend across sharp edges. Cable assemblies shall have an Anchorage Preapproval "R" Number from OSHPD in the

State of California verifying the maximum certified load ratings. Cable assemblies shall be Type SCB at the ceiling and at the clevis bolt, SCBH between the hanger rod nut and the clevis or SCBV if clamped to a beam all as manufactured by Mason Industries, Inc.

13. Seismic solid braces shall consist of steel angles or channels to resist seismic loads with a minimum safety factor of 2 and arranged to provide all directional restraint. Seismic solid brace end connectors shall be steel assemblies that swivel to the final installation angle and utilize two through bolts to provide proper attachment. Seismic solid brace assembly shall have anchorage preapproval "R" Number from OSHPD in the state of California verifying the maximum certified load ratings. Solid seismic brace assemblies shall be Type SSB as manufactured by Mason Industries, Inc.

14. Steel angles, sized to prevent buckling, shall be clamped to pipe or equipment rods utilizing a minimum of three ductile iron clamps at each restraint location when required. Welding of support rods is not acceptable. Rod clamp assemblies shall have an Anchorage Preapproval "R" Number from OSHPD in the State of California. Rod clamp assemblies shall be Type SRC as manufactured by Mason Industries, Inc.

15. Pipe clevis cross bolt braces are required in all restraint locations. They shall be special purpose preformed channels deep enough to be held in place by bolts passing over the cross bolt. Clevis cross braces shall have an Anchorage Preapproval "R" Number from OSHPD in the State of California. Clevis cross brace shall be Type CCB as manufactured by Mason Industries, Inc.

16. All-directional seismic snubbers shall consist of interlocking steel members restrained by a one-piece molded neoprene bushing of bridge bearing neoprene. Bushing shall be replaceable and a minimum of 1/4 in. thick. Rated loadings shall not exceed 1000 psi. A minimum air gap of 1/8 in. shall be incorporated in the snubber design in all directions before contact is made between the rigid and resilient surfaces. Snubber end caps shall be removable to allow inspection of internal clearances. Neoprene bushings shall be rotated to insure no short circuits exist before systems are activated. Snubbers shall have an Anchorage Preapproval "R" Number from OSHPD in the State of California verifying the maximum certified horizontal and vertical load ratings. Snubber shall be Type Z-1225 as manufactured by Mason Industries, Inc.

17. All directional seismic snubbers shall consist of interlocking steel members restrained by shock absorbent rubber materials compounded to bridge bearing Specifications. Elastomeric materials shall be replaceable and a minimum of 3/4 in. thick. Rated loadings shall not exceed 1000 psi. Snubbers shall be manufactured with an air gap between hard and resilient material of not less than 1/8 in. nor more that 1/4 in. Snubbers shall be installed with factory set clearances. The capacity of the seismic snubber at 3/8 in. deflection shall be equal or greater than the load assigned to the mounting grouping controlled by the snubber multiplied by the applicable "G" force. Submittals shall include the load deflection curves up to ½ in. deflection in the x, y and z planes. Snubbers shall have an anchorage preapproval "R" Number from OSHPD in the state of California verifying the maximum certified horizontal and vertical load ratings. Snubbers shall be series Z-1011 as manufactured by Mason Industries, Inc.

18. Stud wedge anchors shall be manufactured from full diameter wire, not from undersized wire that is "rolled up" to create the thread. The stud anchor shall also have a safety shoulder which fully supports the wedge ring under load. The stud

anchors shall have an evaluation report number from the I.C.B.O Evaluation Service, Inc. verifying its allowable loads. Drill-in stud wedge anchors shall be Type SAS as manufactured by Mason Industries, Inc.

19. Female wedge anchors are preferred in floor locations so isolators or equipment can be slid into place after the anchors are installed. Anchors shall be manufactured from full diameter wire, and shall have a safety shoulder to fully support the wedge ring under load. Female wedge anchors shall have an evaluation report number from the I.C.B.O Evaluation Service, Inc. verifying to its allowable loads. Drill-in female wedge anchors shall be Type SAB as manufactured by Mason Industries, Inc.

20. Vibration isolation manufacturer shall furnish integral structural steel bases. Rectangular bases are preferred for all equipment. Centrifugal refrigeration machines and pump bases may be T or L shaped where space is a problem. Pump bases for split case pump shall include supports for suction and discharge elbows. All perimeter members shall be steel beams with a minimum depth equal to 1/10 of the longest dimension of the base. Base depth need not exceed 14 in. provided that the deflection and misalignment is kept within acceptable limits as determined by the manufacturer. Height saving brackets shall be employed in all mounting locations to provide a base clearance of 1 in. Bases shall be Type WF as manufactured by Mason Industries, Inc.

21. Vibration isolation manufacturer shall furnish rectangular steel concrete pouring forms for floating and inertia foundations. Bases for split case pumps shall be large enough to provide for suction and discharge elbows. Bases shall be a minimum of 1/12 of the longest dimension of the base but not less than 6 in. The base depth need not exceed 12 in. unless specifically recommended by the base manufacturer for mass or rigidity. Forms shall include minimum concrete reinforcing consisting of ½ in. bars welded in place on 6 in. centers running both ways in a layer 1-1/2 in. above the bottom. Forms shall be furnished with steel templates to hold the anchor bolts sleeves and anchors while concrete is being poured. Height saving brackets shall be employed in all mounting locations to maintain a 1 in. clearance below the base. Wooden formed bases leaving a concrete rather then a steel finish are not acceptable. Base shall be Type BMK or K as manufactured by Mason Industries, Inc.

22. Curb mounted rooftop equipment shall be mounted on spring isolation curbs. The lower member shall consist of a sheet metal Z section containing adjustable and removable steel springs that support the upper floating section. The upper frame must provide continuous support for the equipment and must be captive so as to resiliently resist wind and seismic forces. All directional neoprene snubber bushings shall be a minimum of 1/4 in. thick. Steel springs shall be laterally stable and rest on 1/4 in. thick neoprene acoustical pads. Hardware must be plated and the springs provided with a rust resistant finish. The curbs waterproofing shall consist of a continuous galvanized flexible counter flashing nailed over the lower curbs waterproofing and joined at the corners by EPDM bellows. All spring locations shall have access ports with removable waterproof covers. Lower curbs shall have provision for 2 in. of insulation. The roof curbs shall be built to seismically contain the rooftop unit. The unit must be solidly fastened to the top floating rail, and the lower Z section anchored to the roof structure. Curb shall have anchorage preapproval "R" from OSHPD in the state of California attesting to the maximum certified horizontal and vertical load ratings. Curb shall be Type RSC as manufactured by Mason Industries, Inc or approved equal.

23. Flexible spherical piping connectors shall employ peroxide cured EPDM in the covers, liners and Dacron tire cord frictioning. Solid steel rings shall be used within the raised face rubber ends to prevent pullout. Flexible cable bead wire is not acceptable. Sizes 2 in. and larger shall have two spheres reinforced with a ring between spheres to maintain shape and complete with split ductile iron or steel flanges with hooked or similar interlocks. Sizes 16 in. to 24 in. may be single sphere. Sizes 3/4 in. to 1-1/2 in. may have threaded bolted flange assemblies, one sphere and cable retention. 14 in. and smaller connectors shall be rated at 250 psi up to 190 F with a uniform drop in allowable pressure to 190 psi at 250 F. 16 in. and larger connectors are rated 180 psi at 190 F and 135 psi at 250 F. Safety factors to burst and flange pullout shall be a minimum of 3/1. All joints must have permanent markings verifying a 5 minute factory test at twice the rated pressure. Concentric reducers to the above Specifications may be substituted for equal ended expansion joints. Pipe connectors shall be installed in piping gaps equal to the length of the expansion joints under pressure. Control rods need only be used in unanchored piping locations where the manufacturer determines the installation exceeds the pressure requirement without control rods, as control rods are not desirable in seismic work. If control rods are used, they must have 1/2 in. thick Neoprene washer bushings large enough in area to take the thrust at 1000 psi maximum on the washer area. Expansion joints shall be installed on the equipment side of the shut off valves.

    Flexible pump connectors shall be installed at each base mounted pump discharge and suction connection. Connections shall be spool type multi-ply stainless steel bellows with tie rods, rated for 150 psig, Keflex type 150.

    Submittals shall include two (2) test reports by independent consultants showing minimum reductions of 20 DB in vibration accelerations and 10 DB in sound pressure levels at typical blade passage frequencies on this or a similar product by the same manufacturer. All expansion joints shall be installed on the equipment side of the shut off valves. Expansion joints shall be SAFEFLEX SFDEJ, SFEJ, SFDCR or SFU and Control Rods CR as manufactured by Mason Industries, Inc.

24. Flexible stainless steel hose shall have stainless steel braid and carbon steel fittings. Sizes 3 in. and larger shall be flanged. Smaller sizes shall have male nipples. Minimum lengths shall be as tabulated:

Flanged	Male Nipples
3 x 1410 x 26	1/2 x 91-1/2 x 13
4 x 1512 x 28	3/4 x 10 2 x 14
5 x 1914 x 30	1 x 112-1/2 x 18
6 x 2016 x 32	1/4 x 12 8 x 22

    Hoses shall be installed on the equipment side of the shut-off valves horizontally and parallel to the equipment shafts wherever possible. Hoses shall be Type BSS as manufactured by Mason Industries, Inc.

25. For vertical riser application more than 3 stories in height, all-directional acoustical pipe anchor, consisting of two sizes of steel tubing separated by a minimum ½ in. thick 60 durometer neoprene. Vertical restraint shall be provided by similar material arranged to prevent vertical travel in either direction. Allowable loads on the isolation material should not exceed 500 psi and the design shall be balanced for equal resistance in any direction. All-directional anchors shall be Type ADA as manufactured by Mason Industries, Inc.

26. For vertical riser application more than 3 stories in height, pipe guides shall consist of a telescopic arrangement of two sizes of steel tubing separated by a minimum ½ in. thickness of 60 durometer neoprene. The height of the guides shall be preset with a shear pin to allow vertical motion due to pipe expansion or contraction. Shear pin shall be removable and reinsertable to allow for selection of pipe movement. Guides shall be capable of ± 1-5/8 in. motion, or to meet location requirements. Pipe guides shall be Type VSG as manufactured by Mason Industries, Inc.

27. Split Wall Seals consist of two bolted pipe halves with minimum 3/4 in. thick neoprene sponge bonded to the inner faces. The seal shall be tightened around the pipe to eliminate clearance between the inner sponge face and the piping. Concrete may be packed around the seal to make it integral with the floor, wall or ceiling if the seal is not already in place around the pipe prior to the construction of the building member. Seals shall project a minimum of l in. past either face of the wall. Where temperatures exceed 240 deg. F., 10 lb. density fiberglass may be used in lieu of the sponge. Seals shall be Type SWS as manufactured by Mason Industries, Inc.

28. The horizontal thrust restraint shall consist of a spring element in series with a neoprene molded cup as described in Specification 5 with the same deflection as specified for the mountings or hangers. The spring element shall be designed so it can be preset for thrust at the factory and adjusted in the field to allow for a maximum of 1/4 in. movement at start and stop. The assembly shall be furnished with one (1) rod and angle brackets for attachment to both the equipment and the duct work or the equipment and the structure. Horizontal restraints shall be attached at the centerline of thrust and symmetrical on either side of the unit. Horizontal thrust restraints shall be Type WBI/WBD as manufactured by Mason Industries, Inc.

29. At all other platform (no curb) mounted equipment such as condensing units and the like provide 6”x6” neoprene vibration pads at all support points and as shown on the drawings, minimum of six per unit. Pads shall be similar to Mason Industries model #WMFB composite pad of two neoprene layers sandwiching a galvanized steel shim with through hole. Exposed edges of steel shim shall be painted with 2-coats of rustproof primer. Vibration isolators shall be securely bolted to unit and structural support frame with neoprene coated stainless steel bolts, washers and nuts. If required by the equipment manufacturer, provide continuous rail vibration support systems and submit for review and approval.

K. Execution - General:

1. All vibration isolators and seismic restraint systems must be installed in strict accordance with the manufacturers written instructions and all certified submittal data.

2. Installation of vibration isolators and seismic restraints must not cause any change of position of piping resulting in stresses or misalignment.

3. No rigid connections between equipment and the building structure shall be made that degrades the noise and vibration control system herein specified.

4. The Plumbing Contractor shall not install any equipment, piping, duct or conduit which makes rigid connections with the building unless isolation is not specified. "Building" includes, but is not limited to, slabs, beams, columns, studs and walls.

5. Coordinate work with other trades to avoid rigid contact with the building.

6. Any conflicts with other trades which will result in rigid contact with equipment or piping due to inadequate space or other unforeseen conditions should be brought to the architects/engineers attention prior to installation. Corrective work necessitated by conflicts after installation shall be at the responsible HVAC Subcontractor's expense.

7. Bring to the architects/engineers attention any discrepancies between the Specifications and the field conditions or changes required due to specific equipment selection, prior to installation. Corrective work necessitated by discrepancies after installation shall be at the responsible HVAC Subcontractor's expense.

8. Correct, at no additional cost, all installations which are deemed defective in workmanship and materials at the HVAC Subcontractor's expense.

9. Overstressing of the building structure must not occur because of overhead support of equipment. Plumbing Contractor must submit loads to the structural engineer of record for approval. Generally bracing may occur from:

    a. Flanges of structural beams.

    b. Upper truss cords in bar joist construction.

    c. Cast in place inserts or wedge type drill-in concrete anchors.

10. Specification 12 cable restraints shall be installed slightly slack to avoid short circuiting the isolated suspended equipment, piping or conduit.

11. Specification 12 cable assemblies are installed taut on non-isolated systems. Specification 13 seismic solid braces may be used in place of cables on rigidly attached systems only.

12. At locations where Specification 12 or 13 restraints are located, the support rods must be braced when necessary to accept compressive loads with Specification 14 braces.

13. At all locations where Specification 12 or 13 restraints are attached to pipe clevis's, the clevis cross bolt must be reinforced with Specification type 15 braces.

14. Drill-in concrete anchors for ceiling and wall installation shall be Specification type 18, and Specification type 19 female wedge type for floor mounted equipment.

15. Vibration isolation manufacturer shall furnish integral structural steel bases as required. Independent steel rails are not permitted on this project.

16. Hand built elastomeric expansion joints may be used when pipe sizes exceed 24 in. or specified movements exceed Specification 23 capabilities.

17. Where piping passes through walls, floors or ceilings the vibration isolation manufacturer shall provide Specification 27 wall seals.

18. Air handling equipment and centrifugal fans shall be protected against excessive displacement which results from high air thrust in relation to the equipment weight. Horizontal thrust restraint shall be Specification type 28 (see selection guide).

19. Locate isolation hangers as near to the overhead support structure as possible.

L. Vibration Isolation of Piping:

1. Horizontal Pipe Isolation: The first three (3) pipe hangers in the main lines near the mechanical equipment shall be as described in Specification 11. Specification 11 hangers must also be used in all transverse braced isolated locations. Brace hanger rods with SRC clamps Specification 14. Horizontal runs in all other locations throughout the building shall be isolated by hangers as described in Specification 10. Floor supported piping shall rest on isolators as described in Specification 6. Heat exchanger's and expansion tanks are considered part of the piping run. The first three (3) isolators from the isolated equipment will have the same static deflection as specified for the mountings under the connected equipment. If piping is connected to equipment located in basements and hangs from ceilings under occupied spaces the first three hangers shall have 0.75 in. deflection for pipe sizes up to and including 3 in., 1-1/2 in. deflection for pipe sizes up to and including 6 in., and 2-1/2 in. deflection thereafter. Hangers shall be located as close to the overhead structure as practical. Where piping connects to mechanical equipment install Specification 23 flexible piping connection or Specification 24 stainless hoses if 23 is not suitable for the service.

2. Riser Isolation: Risers shall be suspended from Specification 10 hangers or supported by Specification 5 mountings, anchored with Specification 25 anchors, and guided with Specification 26 sliding guides. Steel springs shall be a minimum of 0.75 in. except in those expansion locations where additional deflection is required to limit load changes to ± 25% of the initial load. Submittals must include riser diagrams and calculations showing anticipated expansion and contraction at each support point, initial and final loads on the building structure, spring deflection changes and seismic loads. Submittal data shall include certification that the riser system has been examined for excessive stresses and that none will exist in the proposed design.

M. Seismic Restraint of Piping:

1. Seismically restrain all piping listed as a, b or c below. Use Specification 12 cables if isolated. Specification 12 or 13 restraints may be used on unisolated piping.

   a. Gas piping that is 1 in. I.D. or larger.

   b. Piping located in boiler rooms, mechanical equipment (fan) rooms, and refrigeration equipment rooms that is 1-1/4 in. I.D. and larger.

   c. All other piping 2-1/2 in. diameter and larger.

2. Transverse piping restraints shall be at 40' maximum spacing for all pipe sizes, except where lesser spacing is required to limit anchorage loads.

3. Longitudinal restraints shall be at 80' maximum spacing for all pipe sizes, except where lesser spacing is required to limit anchorage loads.

4. Where thermal expansion is a consideration, guides and anchors may be used as transverse and longitudinal restraints provided they have a capacity equal to or greater than the restraint loads in addition to the loads induced by expansion or contraction.

5. For fuel oil and all gas piping transverse restraints must be at 20 ft. maximum and longitudinal restraints at 40 ft. maximum spacing.

6. Transverse restraint for one (1) pipe section may also act as a longitudinal restraint for a pipe section of the same size connected perpendicular to it if the restraint is installed within 24 in. of the elbow or TEE or combined stresses are within allowable limits at longer distances.

7. Hold down clamps must be used to attach pipe to all trapeze members before applying restraints in a manner similar to clevis supports.

8. Branch lines may not be used to restrain main lines.

9. Cast-iron pipe of all types, glass pipe and any other pipes joined with a four band shield and clamp assembly in Zones 2B, 3 and 4 shall be braced as in sections 3.02.C.2 and 3. For Zones 0, 1 and 2A, 2 band clamps may be used with reduced spacings of ½ of those listed in sections 3.02.C.2 and 3.

N. Seismic Restraint Exclusions:

1. Piping:

a. All piping less than 2-1/2 in. in diameter except those listed below.

b. All gas piping less than 1 in. I.D.

c. All piping in boiler and mechanical equipment rooms less than 1-1/4 in. I.D.

d. All clevis or trapeze supported piping suspended from hanger rods where the point of attachment is less than the 12 in. in length from the structure to the structural connection of the clevis or trapeze.

e. All PVC and fiberglass suspended waste or vent pipe 6 in. in diameter and smaller.

2.45 OIL SEPARATOR

A. Furnish and install OIL-1, in Outdoor Toilet and Storage Building one floor drain (required due to overhead garage door). Oil separator shall be similar to Watts Drainage OI series recessed epoxy coated steel oil interceptor with gasketed epoxy coated steel skid-proof cover secured with hex head center bolt, double wall deep seal trap, draw-off connection and dual vent connections, integral stainless steel flow control plate, and no-hub connections. Oil separator shall be sized for a flow rate of 10 GPM.

B. Provide interior oil separator of the type specified above; separator shall be Watts Drainage, Jay R. Smith, Josam, Mifab or approved equal.

2.46 COMPRESSED AIR SYSTEM ACCESSORIES

A. The proposed air compressor and receiver tank are being furnished by others. The basis of design is a Kaeser model #SM10 Rotary Screw Compressor with integral dryer and air filters which is rated for 45.9 CFM at an operating pressure of 125 PSIG.

B. Plumbing Contractor is responsible for piping the air compressor to the air receiver and then piping the compressed air system loop for the Auto/Diesel Shop. The compressed air requirements are for connections at each work bay and several pieces of equipment. This requires quick connect fittings and ball valves for every drop.

C. Connections to the air compressor shall be made with flexible braided stainless steel connector.

D. Provide quick-connect fittings for compressed air equipment connections.

E. Provide Safety Excess Flow Check Valve for compressed air system drops similar to Coilhouse Pneumatics #SV804 ½" pipe size (auto shop) and ¾" pipe size (diesel shop). The safety excess flow check valve is designed to automatically shut off air flow upon a sudden break in the air line, thereby protecting personnel and property from "whipping" air hoses. Allows full unrestricted flow of air while in normal (open) position. Entire unit is corrosion free. It automatically re-sets itself after repair is made. Unit is tamper-proof. Meets OSHA safety regulations.

F. Furnish and install Kimball Midwest or approved vendor 3/8" Push-Button Tru-Flate Female Air Coupler at each compressed air drop location in the Auto/Diesel Shop with the following specifications: Nitrited steel with composite sleeve material, 175 PSI maximum pressure, 5°F -160°F operating temperature, Tru-Flate style, ¼" NPT. Coordinate with the auto diesel instructors for exact requirements.

2.47 ELECTRIC HEAT TRACE FOR CANOPY ROOF DRAINS

A. In locations indicated for the canopy roof drains provide and install self-regulating freeze protection heat trace system as manufactured by Raychem (or engineer pre-approved alternate). Model 5XL1-CR (120v) or Model 5XL2-CR (208-277v) as required by pipe size and available electrical supply voltage. System shall be installed according to manufacturers' requirements including the testing of the electrical insulation properties of each section of the system using a 2500-Vdc Megger. Minimum insulation resistance shall be 20 megohms or greater. Contractor to coordinate correct voltage and amperage of electrical supply with electrical contractor. Each circuit to be supplied through a 30ma ground fault breaker. Provide Raychem ECW-GF controller for each circuit in locations indicated. Piping to follow insulation schedule. Contractor to provide system drawings along with component submittals. The complete heat trace system (heating cable, connection kits, and controller) shall be listed by a Nationally Recognized Testing Laboratory (NRTL), and marked for intended use of freeze protection of above ground water piping. Any question on the Raychem product contact Patrick Shea at Emerson Swan. Email: pshea@emersonswan.com / cell: 508-415-7510.

2.48 TEMPORARY FACILITIES AND CONTOLS

A. General: Filed Subcontractors shall obtain required permits for, and provide scaffolds, staging, and other similar raised platforms, required to access their Work as specified in Section 01 50 00 - TEMPORARY FACILITIES AND CONTROLS and herein.

1. Scaffolding and staging required for use by this Filed Subcontractor pursuant to requirements of Section 01 50 00 - TEMPORARY FACILITIES AND CONTROLS shall be furnished, erected, maintained in a safe condition, and dismantled when no longer required, by this Filed Sub-Trade requiring such scaffolding.

2. Each Filed Subcontractor is responsible to provide, maintain and remove at dismantling, all tarpaulins and similar protective measures necessary to cover scaffolding for inclement weather conditions other than those required to be provided, maintained and removed by the General Contractor pursuant to MGL (Refer to Section 01 50 00 - TEMPORARY FACILITIES AND CONTROLS and as additionally required for dust control).

3. Furnishing portable ladders and mobile platforms of all required heights, which may be necessary to perform the work of this trade, are the responsibility this Filed Subcontractor.

B. HOISTING MACHINERY AND EQUIPMENT: All hoisting equipment, rigging equipment, crane services and lift machinery required for the work by this Filed Subcontractor shall be furnished, installed, operated and maintained in safe conditions by this Filed Subcontractor, as referenced under Section 01 50 00 - TEMPORARY FACILITIES AND CONTROLS.

PART 3 - EXECUTION

3.1 SPECIAL RESPONSIBILITIES

A. Cooperate and coordinate with other trades in executing work of this Section. Perform work such that progress of entire project including work of other trades shall not be interfered with or delayed. Provide information on items furnished under this Section to be installed by other Sections.

1. Obtain detailed information from manufacturers of equipment as to proper method of installation. Give full information so that openings required for work of this Section might be coordinated with other work and other openings and many be provided for in advance. In case of failure to provide information, cutting and patching will be done at the expense of this Section to the satisfaction of the Architect.

B. During progress of work, remove and properly dispose of resultant dirt and debris and keep premises reasonably clean. Upon completion of work, remove equipment and unused material provided for work.

C. Conduct work so as not to interfere with functioning of existing sewer, water and gas mains. Extreme care shall be observed to prevent debris from entering piping. Confer with Architect as to disruption of water service or their utilities due to testing or connection of new work to existing.

D. All piping and equipment running within trusses must be supported from top chord of truss at panel point. For any alternate configurations or for heavy pieces of equipment coordinate fully with structural engineer for support location before installation.

3.2 MATERIALS AND WORKMANSHIP

A. Work shall be executed in a workmanlike manner and shall present neat appearance when completed. Piping shall run concealed except in mechanical rooms and areas where no hung ceiling exists. Material and equipment shall be installed according to manufacturer's recommended best practice.

B. Materials and equipment shall be new, unless otherwise noted.

3.3 ESCUTCHEONS

A. Escutcheons shall be installed around exposed pipe passing through finished floor, wall or ceiling. Escutcheons shall be heavy cast brass, chrome-plated, adjustable, of sufficient outside diameter to cover sleeve opening and to fit snugly around pipe or insulation.

3.4 SLEEVES AND INSERTS

A. Sleeves for piping between floors and through firewalls or smoke partitions shall be installed with approved packing between sleeves and piping to provide firestop. Coordinate with G.C. requirements.

B. This contractor is responsible for sleeving all pipe penetrations before pouring of slab. Where additional holes are required this contractor shall core drill such holes in coordination with the general contractor and with prior consent of the Architect.

3.5 INTERIOR WATER SUPPLY SYSTEM

A. Water supply piping shall be run as indicated on the Drawings, including new connections to mains and supplies to fixtures. Connections to fixtures shall be from top of mains and piping shall be pitched at least 1 inch in 40 feet in the direction of flow so that it can be drained completely at low points. Provide drain valves where necessary. Piping shall be pitched up towards fixtures for proper air relief.

B. Provide water hammer arrestors of proper size and type at end of each water branch with flush valves as shown on the drawings.

C. Provide ball type shut-off valves on water branches to individual areas and to each bathroom group and kitchen. Ball valve shut offs shall also be provided at the dishwasher and steam generation equipment.

3.6 STORM, SANITARY, WASTE AND VENT PIPING

A. Interior horizontal storm, sanitary and waste piping shall be installed in practical alignment at uniform grade of 1/8 inch per foot minimum up to1/4 inch per foot if possible or if required by code such as for waste piping smaller than 4". Coordinate invert of tie-ins to site piping with site contractor. Piping within building shall be coordinated closely with the work of other trades, in particular the HVAC ductwork.

B. In the kitchens, the grease waste and sanitary waste piping shall be sloped at 1/4 inch per foot. This is indicated on the drawings via the piping inverts, but all inverts shall be verified.

3.7 VENTS THROUGH ROOF

A. All vents extending through the roof which serve the sanitary and waste systems shall extend no less than 18" and no more than 24" above the roof. Where roofs are used for gardens, sun decks or similar purposes, the vent shall extend at least 8 feet above the roof and be increased one pipe size. Offset all vents requiring same in order to avoid interference with HVAC units, to facilitate flashing conditions as well as maintain minimum required distance from all natural and mechanical fresh air inlets.

B. All gas vents shall run through the roof and shall extend above the roof and shall be provided with ¾" by 1" increaser when required, pipe nipple and Fisher Controls Model No. Y602-17 umbrella type, weather proof bug vent. Off-set vents to avoid interference with roof top equipment, to facilitate flashing as well as maintain minimum required distance from all natural and mechanical fresh air inlets. This contractor is responsible for all gas pipe venting from HVAC equipment and Plumbing Boilers whether or not it is noted or shown on the drawings.

C. No vent terminal shall be located directly beneath any door, window, or other ventilating opening of the building or of an adjacent building, nor shall any vent terminal be within 10 feet horizontally of such an opening unless it is at least 2 feet above the top of such opening.

D. Vent terminals shall be located at least 25 feet horizontally from all fresh air intake openings. In two instances, the vent terminal is called out to extend at least 2 feet above the top of such opening. Note that this will affect some of the existing vent stacks through the roof.

3.8 ELECTRICAL ROOMS

A. Piping shall not be installed in or through Electrical Rooms, Electrical Closets, Transformer Rooms, Telephone Rooms or Elevator Machine rooms unless the piping is intended to serve these rooms. No piping shall be installed over electrical panels.

3.9 CLEANOUTS

A. All cleanouts shall be set flush with walls or floors. Finish shall be protected during construction with proper covering. Flush floor cleanouts shall be coordinated so as to not be located beneath any partitions, casework nor beneath any non-potable equipment.

3.10 VALVES

A. All valves shall be furnished and installed under this Section shall be located in a manner to allow proper access for service and repair.

B. In no case shall valve stem and handle on a gate or globe valve be installed below the center-line of the pipe it serves.

3.11 FLOOR DRAINS

A. Floor drains shall be furnished and installed by this contractor; he shall be responsible for correctly setting these drains to the proper grade to assure proper drainage from all surrounding areas. Sizes of drains shall be the same size as the pipe it serves.

3.12 WALL HYDRANTS

A. Hydrants shall be set approximately 18 inches above outside grade and shall include cross connection protection. Loose key stops shall be turned over to the Owner prior to completion.

3.13 JOINTS AND CONNECTIONS

A. Joints and connections of piping shall be made permanently gas and water tight.

B. Dielectric couplings, waterways or unions shall be used where dissimilar piping materials are joined.

C. Final plumbing and gas connections to all equipment furnished or installed by others shall be by this Section.

D. Cooper-Tubing Grooved Joints: Roll groove end of tube. Assemble coupling with housing, gasket, lubricant, and bolts. Join copper tube and grooved-end fittings according to AWWA C606 for roll-grooved joints. Grooved joint piping systems shall be installed in accordance with the manufacturer's guidelines and recommendations. The gasket style and elastomeric material (grade) shall be verified as suitable for the intended service as specified. Gaskets shall be developed and supplied by the system manufacturer. Grooved end shall be clean and free from indentations, projections and roll marks in the area from pipe end to groove. All grooved system components shall be provided by a single manufacturer. A factory trained field representative shall provide on-site training to contractor's field personnel in the installation of grooved piping products. Factory trained representative shall periodically review the product installation. Contractor shall remove and replace any improperly installed products

3.14 INSULATION

A. Insulation shall be applied over clean dry pipe with all joints butted firmly together and sealed with butt strips. Insulation shall run through all hangers and sleeves and have an 18 gauge sheet metal saddle equal to three (3) times the pipe diameter in length, on all pipes over 2 in. in diameter.

B. All fittings, valves, and exposed supply and waste piping to the handicapped lavatories, etc., shall be insulated as specified. The ends of the insulation shall be tucked snugly into the throat of the fitting and the edge adjacent to the pipe covering tufted and tucked in fully insulating the pipe fitting. The one-piece PVC fitting cover shall then be secured by taping the ends to the adjacent covering.

C. In addition to the regular insulation specified, all exposed piping from floor up to 10 ft. 0 in. shall have a PVC jacket cover applied over the insulation from finish to 10 ft. 0 in. above. All joints shall be sealed with tape.

3.15 CARRIERS

A. All carriers shall be of the hub and spigot type and quality as required under each fixture. Each face plate shall be firmly bolted to floor with 1/2 in. rods.

B. Single closet carriers shall have the rear foot anchored to floor with 1/2 in. rod.

3.16 FIXTURES

A. Fixtures shall be the best product of the manufacturer, shall be without defects in construction or appearance, shall be set true and level, and shall be firmly supported in place without rocking or strain. Fixtures shall be adjusted for proper operation and shall be tested in the presence of the Architect-Engineer. All fixtures shall be thoroughly cleaned and all labels, stickers, and dirt marks shall be removed.

B. The installation of all backing for plumbing fixtures and their accessories not affecting the structure shall be the work of the Plumbing Subcontractor. Cutting and chasing which does not affect the structure shall also be the work of the Plumbing Subcontractor. All

cutting and chasing, and installation of all backing for fixtures and accessories, which affects the structure, shall be the work of the Carpenters and/or General Contractor.

3.17 ADJUSTMENT

A. Adjust all flush valves, pressure reducing valves, meter faucets, and water temperature controllers, water heater, and recirculation pumps for proper outlet temperatures and pressure and flow rate (if applicable).

B. The Plumbing Subcontractor shall be responsible for adjusting and balancing the entire domestic hot water recirculation system. Provide recirculation pump balance report.

3.18 INSTALLATION OF EQUIPMENT

A. Install equipment to avoid interference with structure and work of other Sections, preserve adequate headroom and clear doors and passageways, to satisfaction of Architect, and in accordance with Code requirements. Installation shall permit clearance for access to equipment for repair, servicing and replacement.

B. Manufacturer's Recommendations: Where installation procedures or any part thereof are required to be in accordance with the recommendations of the manufacturer of the equipment being installed, printed copies of these recommendations shall be furnished to the Architect prior to installation.

C. All equipment running within trusses must be supported from top chord of truss at panel point. For any alternate configurations or for heavy pieces of equipment coordinate fully with structural engineer for support location before installation.

D. Provide factory start up on the gas-fired boilers and gas-fired water heater. The electric water heaters do not require factory start-up.

3.19 INSTALLATION OF MEGA PRESS SYSTEMS

A. Pipe ends shall be cut on a right angle (square) to the pipe. Pipe ends shall be reamed chamfered and all paint, lacquer, grease, oil or dirt shall be removed from the pipe end with an abrasive cloth or Viega pipe end prep tool. Visually examine the fitting sealing element to insure there is no damage, and it is properly seated into the fitting. Insert pipe fully into the fitting. Make a mark with a felt tip pen on the pipe at the face of the fitting. Always examine the pipe to insure it is fully inserted into the fitting prior to pressing the joint. MegaPress fittings hall be joined using Rigid MegaPress Tools. MegaPress fittings shall be installed according to the most current edition of the Viega installation guidelines. Sealing elements shall be verified for the intended use. Installers shall attend a Viega MegaPress installation training class.

3.20 INSTALLATION OF POLYPROPYLENE PIPING SYSTEM

A. Install fittings and joints using socket-fusion, electrofusion, butt-fusion or compression joining as applicable for the fitting or joint type. All fusion-weld joints shall be made in accordance with the specifications and product standards of Nupi Americas. Fusion-weld tooling, welding machines, and electrofusion devices shall be as approved by Nupi Americas. Prior to joining, the pipe and fittings shall be prepared in accordance with ASTM F 2389 and Nupi America’s specifications. Joint preparation, setting and alignment, fusion process, cooling times and working pressure shall be in accordance

with Nupi America's specifications. Installers should be trained and certified by Nupi Americas.

B. Where plenum-rated piping system is needed, the pipe shall be wrapped and/or insulated with standard pipe insulation, field installed. The pipe wrap or insulation shall meet requirements of ASTM E84. The system shall have a Flame Spread Classification of less than 25 and Smoke Development rating of less than 50.

3.21 INSTALLATION OF ELECTRIC WIRING FOR EMERGENCY GAS SHUT-OFF VALVE WITH FUEL GAS SENSORS AND THE ELECTRICAL SHUNT

A. By using dry contact, you can hook up multiple sensors to a single controller. These units can be installed wherever the engineer desires. The only word of caution is that since these are dry contact, the wiring CAN NOT be in the conduit with any voltage carrying wiring at any point, nor can the wiring be loose laid in such a position above the ceiling that it lies across a fluorescent lamp. Either of these situations MAY result in transient voltages appearing at the panic input and MAY place the unit into a panic state at random.

B. For the Isimet System, if used, the following is required to shunt an electrical panel: Any LA control panel will have the same configuration. You will need to run 18 gauge 4 conductor wire from CON 5A to an IRE/S, this is a single relay in an enclosure provided by Isimet. There will need jumpers placed on JP7 & JP3. So, the Plumbing Subcontractor needs to provide this additional relay enclosure (IRE/S). The shunt trip breaker must be 120V, and this 120V must be an external power source. The phase leg of the 120V will be wired through the relay contacts with the neutral staying at the shunt breaker.

3.22 INTERIOR GREASE TRAP INSTALLATION

A. Interior grease traps shall be located so as to provide working access to the secured cover.

B. In order to insure maximum efficiency, a flow control fitting shall be provided on the inlet drain to insure that the flow does not exceed the maximum rating of the grease trap.

C. The grease trap shall be installed in accordance with the manufacturers written installation instructions.

3.23 INSTALLATION OF TRAP PRIMERS

A. Install trap primers with piping pitched towards drain trap, minimum 1/8 inch per foot (1 percent). Adjust trap primer for proper flow.

B. This valve is designed to be installed on ½" to 1 ½" cold water line, feeding a flush valve or other open and closing valve supply line that is frequently used.

C. Trap Primer valve makeup line to floor drain is recommended to be a minimum of 12" off the finished floor before a 90° elbow can be installed.

D. The furthest recommended distance of makeup line is 20' to the floor drain.

E. Trap primer make up line must have continuous slope to the floor drain (consult local code requirements).

F. Install with a shut off valve for servicing on the inlet side and a union connection on the outlet side.

G. The valve must be installed level.

H. If using the distribution unit the clear plastic cover must be used.

I. Do not subject the valve to rough in pressure test.

3.24 DOMESTIC GAS WATER HEATER INSTALLATION

A. General: Install domestic gas water heaters in accordance with ANSI/Z223.1 and the manufacturers written installation instructions.

B. Support: Install gas water heaters on pads oriented so that controls and devices needing service and maintenance have adequate access. Install gas water heaters level.

C. Gas Supply: Provide gas pipe with drip leg, tee, gas cock and union. Provide gas pipe of size shown on drawings or the full size of unit inlet connection. Install piping so as not to interfere with service of unit.

D. Water Piping: Provide hot and cold water piping to units with shutoff valves and unions. Provide recirculating water line to unit with shut-off, check valve, and union connected to CW heater.

E. Flue: Connect flue and combustion air piping to water heaters with gas tight connections.

F. The boiler(s)/water heater(s) manufacturer representative shall be present with the plumber for start-up. Follow manufacturer's instructions in the Operations and Maintenance Manual for start-up procedures. Make any and all changes necessary to ensure that the boiler(s)/water heater(s) are operating properly.

3.25 INSTALLATION OF GAUGES AND THERMOMETERS

A. Thermometers and pressure gauges shall be installed in such a manner as to cause a minimum restriction to the flow in the pipes and so that they can be easily read from the floor.

B. Thermometers shall be install in the outlet piping from the water heaters.

C. Pressure gauges in the cold water system shall be installed at the water meter.

3.26 PUMP INSTALLATION

A. General: Install plumbing pumps where indicated on the drawings in accordance with manufacturer's published installation instructions.

B. Access: Provide access space around plumbing pumps for service, but in no case less than that recommended by manufacturer.

C. Support: Install in-line or cartridge pumps supported from piping system.

D. Electrical Wiring: Install electrical devices furnished my manufacturer, but not specified to be factory mounted. Verify that electrical wiring installation is in accordance with manufacturer's submittal and installation requirements of Division 26 sections.

E. Piping Connections: Provide piping, valves, accessories, gauges, supports, and flexible connections as indicated on the drawings.

F. Alignment: Check alignment, and where necessary, realign shafts of motors and pumps within recommended tolerances by manufacturer, and in the presence of manufacturer's service representative.

G. Start-up: Lubricate pumps before start-up. Start-up in accordance with manufacturer's instructions.

H. Cleaning: Clean factory-finished surfaces. Repair any marred or scratched surfaces with manufacturer's touch-up paint.

3.27 STRAINER INSTALLATION

A. General: Place strainers ahead of pressure reducing valves, automatic control valves, pumps, and elsewhere as indicated on the drawings or specified.

3.28 ROOF DRAIN INSTALLATION

A. Install roof drains at low points of roof areas, in accordance with the roof membrane manufacturer's installation instructions.

B. Install drain flashing collar or flange so that no leakage occurs between roof drain and adjoining roofing. Maintain integrity of waterproof membranes, where penetrated.

C. Position roof drains so that they are accessible and east to maintain.

D. Provide roof drain markers at every roof drain.

3.29 COMBUSTION AIR AND FLUE VENT INSTALLATION

A. The gas-fired boilers and water heater shall be vented and supplied with combustion air ventilation air as indicated in the installation and operations manuals for the equipment. The specified materials for the combustion air and flue vents shall be installed. Common venting is not allowed.

B. Per the drawings, the boiler flue vents have vertical terminations. The flue vent shall terminate a minimum of 30" above the roof surface. The flue vent terminations shall be spaced as directed by the manufacturer.

C. Per the drawings, the three domestic water boiler combustion air intakes terminate in an outdoor air plenum behind a louver along with the three heating boiler combustion air intakes. Coordinate with the HVAC Contractor to ensure proper louver sizing and piping coordination.

D. Per the drawings, the domestic water heater terminates with sidewall vents for both the flue and combustion air pipes. Install per manufacturer's instructions.

3.30 INSTALLATION OF PIPE INSULATION

A. GENERAL APPLICATION: The following general conditions apply to the insulation installation.

1. Insulation shall be clean and dry during installation and during application of any finish.

2. Provide removable and replaceable covers on all pumps and equipment requiring insulation that must be opened periodically for inspection, cleaning, or repair.

3. Install insulation, jackets, and coatings continuous through wall and floor openings and sleeves. Provide firestopping as a fire barrier sealing over insulated pipes passing through rated floors and walls.

4. Banding wires shall have the twisted terminals turned down into the insulation, except where vapor barrier would be punctured.

5. Finish open ends of pipe insulation as specified for fittings.

6. All piping and equipment that are scheduled to be insulated shall have a finished jacket, either factory or field applied.

7. Staples shall be installed only on insulation that does not contain a vapor barrier.

8. For all cold piping systems (waste piping receiving condensate discharge and domestic cold water), all components of the piping system shall be insulated and provided with a continuous vapor barrier. Vapor barriers shall be continuous for entire piping system and shall not be pierced except as specified otherwise.

9. Factory applied jacket shall be the finish jacket unless otherwise noted.

10. Maintain vapor barrier where dissimilar insulation products abut.

B. PIPE SHIELDS: For all piping, insulation shall be continuous on pipe at pipe hangers with protection shields bearing on the outside of the insulation.

C. INSULATION APPLICATION:

1. Type P3 – Glass Fiber Insulation:
   a. Cover pipe with insulation with each section tightly abutted one to another. Jacket shall be lapped and secured with self-adhesive strip.
   b. Abutting ends of insulation shall be covered with 4" wide butt strips smoothly secured with adhesive.
   c. Fittings and valves shall be covered with mitered or molded insulation sections secured with galvanized steel wire and finished with smooth coat of white glass fabric and mastic.

D. FINISH JACKETS:

1. Pre-sized glass cloth jackets shall be secured by a continuous coating of adhesive applied to a uniform thickness. Jacket shall be smooth without wrinkles. Jacket shall be applied to straight lengths of covering only.

2. Flexible glass cloth shall be applied to equipment, valves, fittings, and curved surfaces. Cloth tape shall be smoothly applied and secured with a continuous coat of adhesive. White fabric and mastic to be used on exposed pipe fittings. Tape shall overlap itself and adjacent jackets not less than two inches (2").

3. Apply PVC jacket where indicated with 2" overlap at longitudinal seams and at fitting covers. Seal longitudinal seams by joining with PVC welding solvent. Seal circumferential ends with 1-1/2" PVC tape.

3.31 ACCESS PANELS

A. Furnish and deliver access panels for access to all concealed parts of the Plumbing System that require accessibility for the proper operation and maintenance of the system. Access panels shall be installed by others.

3.32 DISINFECTION

A. Disinfection

1. Each potable water system (cold and hot water) shall be cleaned and disinfected by this Contractor. Cleaning and disinfection shall be performed after all pipes, valves, fixtures and other components of the systems are installed, tested and ready for operation.

2. All hot and cold water piping shall be thoroughly flushed with clean potable water, prior to disinfection, to remove dirt and other contaminants. Screens of faucets shall be removed before flushing and re-installed after completion of disinfection.

3. Disinfection shall be done using sodium hypochlorite in the following manner:

a. A service cock shall be provided and located at the water service entrance. The disinfecting agent shall be injected into and through the system from this cock only.

b. The disinfecting agent shall be injected by a proportioning pump or device through the service cock slowly and continuously at an even rate. During disinfection, flow of disinfecting agent into main water supply is not permitted.

c. All sectional valves shall be opened during disinfection. All outlets shall be fully opened at least twice during injection and the residual checked with orthotolidin solution.

d. When the chlorine residual concentration, calculated on the volume of water the piping will contain indicated not less than 50 ppm (parts per million) at all outlets, than all valves shall be closed and secured.

e. The residual chlorine shall be retained in the piping systems for a period of not less than 24 hours.

f. After the retention, the residual shall be not less than five parts per million. If less, then the process shall be repeated as described above.

g. If satisfactory, then all fixtures shall be flushed with clean potable water until residual chlorine by orthotolidin tests shall be not greater than the incoming water supply (This may be zero).

4. All work and certification of performance shall be performed by approved applicators or qualified personnel with chemical and laboratory experience. Certification of performance shall indicate:

   a. Name and location of the job and date when disinfection was performed.

   b. Material used for disinfection.

   c. Retention period of disinfectant in piping system.

   d. PPM chlorine during retention.

   e. PPM chlorine after flushing.

   f. Statement that disinfection was performed as specified.

   g. Signature and address of company or person performing disinfection.

5. Upon completion of final flushing (after retention period), the plumbing trade contractor shall obtain a minimum of one water sample from each hot and cold water line and submit samples to a State-approved laboratory. Samples shall be taken from faucets located at highest floor and furthest from meter or main water supply. The laboratory shall show the following:

   a. Name and address of approved laboratory testing the samples.

   b. Name and location of job and date the samples were obtained.

   c. The coliform organism count. (An acceptance test shall show the absence of coliform organisms).

6. If analysis does not satisfy the above minimum requirements, the disinfection procedure shall be repeated.

7. Before acceptance of the systems, this Contractor shall submit to the Project Manager and Clerk of Works for his review, three (3) copies of Certification of Performance as specified above.

8. Under no circumstances shall this contractor permit the use of any portion of domestic water systems until properly disinfected, flushed and tested.

B. Cleaning and Adjusting

1. At the completion of the work, all parts of the installation shall be thoroughly cleaned. All equipment, pipe, valves and fittings shall be cleaned of grease, metal cuttings and sludge which may have accumulated by operation of the system for testing.

2. Any stoppage or discoloration or other damage to parts of the building, its finish, or furnishings due to the Plumbing Trade Contractor's failure to properly clean the piping system shall be repaired by this Contractor at no increase in Contract costs.

3. At the completion of the work, all water systems shall be adjusted for quiet operation.

4. All automatic control devices shall be adjusted for proper operation.

5. All plumbing fixtures and exposed metal work shall be cleaned and polished. Floor drain strainers and traps shall be cleaned of all debris.

6. All items of equipment shall be thoroughly inspected. Any items dented, scratched or otherwise damaged in any manner shall be replaced or repaired and painted to match the original finish. All items so repaired and refinished shall be brought to the attention of the Architect and Clerk of Work for inspection and approval.

3.33 CLEANING

A. Upon completion of work but prior to final system testing, all parts of installation shall be thoroughly cleaned. Fixtures, pipe, valves and fittings shall be completely cleaned of grease, metal cuttings, dirt, etc. Protective covers shall be removed and fixtures shall be cleaned and ready for use.

3.34 TESTING

A. Provide testing of plumbing systems as required by authorities having jurisdiction, including Owner and Architect. Tests shall be conducted as part of work of this Section and shall include labor, equipment, apparatus and services required to perform tests. All tests results shall be documented and signed off on by the Owner, Architect and Engineer.

B. Prior to final acceptance, furnish Architect with certificates of testing and inspection for plumbing systems indicating approval of authorities having jurisdiction and conformance with requirements of Contract Documents.

C. Notify Architect and authorities involved at lest 48 hours prior to testing and inspection. Do not paint, cover or conceal work prior to testing, inspecting and obtaining approval.

D. Provide temporary piping and connections for testing, flushing or draining systems to be tested. Leaks, damage or defects discovered or resulting from test shall be repaired or replaced to like-new condition. Piping must be absolutely tight before it will be accepted and joints shall be made tight without caulking.

E. Tests for Plumbing Systems: Soil, waste, vent, gas, and water piping shall be tested by the Plumbing Subcontractor and approved before acceptance. Underground soil, rain conductor, and waste piping shall be tested prior to backfilling. Equipment required for tests shall be furnished by the Plumbing Subcontractor at no additional cost to the Owner. All tests shall be witnessed and approved by the Plumbing Inspector.

F. Drainage And Venting System Piping: All vent, soil, waste, acid waste, acid vent, and rain conductor shall be tested with water or air before the fixtures are installed.

1. Water Test: Water test shall be applied to the drainage and venting system in their entirety or in sections. If the entire system is tested, all openings in the pipe shall be

tightly closed, except the highest opening, and the system shall be filled with water to the point of overflow. If the system is tested in sections, each opening, except the highest opening of the section under test, shall be tightly plugged and each section shall be filled with water and tested with at least a 10 ft. head of water. In testing successive sections, at least the upper 10 ft. of the next preceding section shall be tested so that each joint of pipe in the building, except the uppermost 10 ft. of the system, has been submitted to a test of at least 10 ft. head of water. The water shall be kept in the system, or in the portion under test, for at least two (2) hours before the inspection starts. The system shall be tight at all joints.

2. Air Test: If tests are made with air, a pressure of not less than 5 lbs. per sq. in. shall be applied with a force pump and maintained at least one (1) hour without leakage.

G. Water System: When the roughing-in is complete, and before fixtures are set, the entire hot water recirculation and cold water piping system shall be tested at a hydrostatic pressure of not less than 125 PSI gauge and proved tight at this pressure for not less than four (4) hours in order to permit inspection of all joints. Where a portion of the water piping system is to be concealed before completion, this portion shall be tested separately as specified for the entire system. All water entrance piping up to PRV-station shall be tested at 50 PSI in excess of the street pressure, but not to exceed 200 PSI.

H. Gas System: Gas system shall be tested with air at a pressure of 100 lbs. per sq. in. and maintained at least one (1) hour without leakage.

I. Defective Work: If inspection or test indicates defects, such defective work or material shall be replaced or repaired as necessary and inspection and tests repeated. Repairs to piping shall be made with new materials. No caulking of screwed joints or holes will be acceptable.

J. System Start-Up: The Plumbing Contractor must be present for system start-ups for all plumbing equipment and for the heating boiler start-up since they are gas-fired.

3.35 TESTING, BALANCING AND ADJUSTING

A. Procedures:

1. All domestic hot water generators and hot water circulating systems shall be tested, adjusted, and balanced to the conditions specified and/or shown on the drawings.

2. Performance of systems and components at specified conditions shall be verified by testing.

3. Before request for final inspection, calibrate, adjust, set, test and check all valves, temperatures, and flow rates of systems for operation and performance.

4. All test and balance work shall be performed in accordance with AABC or NEBB procedures.

5. TAB fieldwork shall not begin on any system/equipment item until signed pre-function checklists (PFCs), pertaining to applicable equipment, have been submitted by the installing contractor to the Cx Team.

6. Copies of all TAB agency generated deficiency reports shall be submitted to the Cx team to ensure that the appropriate installing contractors, and the EOR have received

copies of the reports, and to help ensure that immediate attention can be given to addressing and resolving the various deficiencies identified. No retesting of submitted deficiency items shall be attempted by the TAB agency until signed copies of the deficiency reports, certifying completion of the item, have been received back from the applicable installing contractor.

7. A copy of the final TAB report shall be made available to the Cx team at the completion of the TAB fieldwork for the TAB performance verification phase of the Cx procedures. In addition, furnish any data gathered during TAB fieldwork, but not shown in the final TAB paperwork, upon request of same from the Cx Authority.

8. The TAB agency shall provide one (1) technician with full instrumentation for the purpose of verifying the data submitted in the final TAB report. The verification will be conducted by the Cx agency. The Cx authority (CxA) will randomly select a minimum of 25% of the final TAB report data for performance verification purposes, and oversee the TAB agency's retesting of these items. If 10% or more of the retested items are found to be plus or minus 10% or more out of tolerance of published final TAB report values, then the TAB agency shall be liable for retesting part or all of the specific system before undergoing further performance verification. However, all out-of-design-tolerance values identified shall be reported, and corrected by the construction team.

B. Reports:

1. Report shall indicate pressure, temperature and flow in GPM at the discharge side of each balancing valve referencing the valve tag number.

2. Report shall indicate pressure, temperature and flow in GPM at the suction side of each recirculation pump.

3. Preliminary and final reports shall be prepared and issued to the General Contractor, Architect and Engineer. Copies of final approved balancing report are to be included in the O&M manuals.

C. Products:

1. Provide all instruments, charts, materials, and equipment required to develop a complete test and balance report.

2. The test and balance contractor shall provide testing, adjusting and balancing of the hot water system after the system is fully installed and operational.

D. Execution: Test and balance report shall be a complete document, not limited to, but including at least the following:

1. Domestic Hot Water Balancing Valves: Provide the following as a minimum at the discharge side of each balancing valve referencing the valve tag number.

   a. Pressure.
   b. Temperature.
   c. Flow in GPM.

2. Domestic Hot Water Circulating Pumps: Provide the following as a minimum at each recirculation pump.

a. Flow rates.
b. Entering and leaving pressures.
c. Verify alignment.
d. Pump speed.

3. Thermostatic Mixing Valves at Domestic Hot Water Generators: Setup instructions vary per manufacturer. Setup and balance thermostatic mixing valves per manufacturer recommended instructions found in the mixing valve installation instructions. Provide the following as a minimum.

a. Initial flow and temperature.
b. Intermediate flow and temperature as balancing occurs.
c. Final flow and temperature when system is operational.

3.36 LUBRICATION

A. After complete installation by the Plumbing Subcontractor of any equipment which depends on lubrication for efficient operation, the Plumbing Subcontractor shall properly lubricate per instructions of the manufacturer. This shall be done before any test runs or final operation.

3.37 TRASH AND DEBRIS REMOVAL

A. The General Contractor shall provide dumpsters for use by all subcontractors. During the course of the work, at the end of each work day, subcontractors shall clean up trash and debris caused by their work, and deposit it in the dumpsters, or, at the subcontractor's option, haul it away and dispose of the trash legally. The subcontractor shall do a thorough cleaning of all their debris after scaffold and staging has been removed from an area.

B. Comply with the requirements of Section CONSTRUCTION WASTE MANAGEMENT, for removal and disposal of construction debris and waste.

3.38 PAINTING

A. Equipment installed under this Section shall have shop coat of non-lead gray paint, unless otherwise specified. Hangers and supports shall have one coat of non-lead red primer. Machinery shall be stenciled with equipment name. Finish painting, including painting of pipe systems, shall be done under other Sections.

B. Prime all gas piping installed under this contract with one (1) coat read lead-free rustproof primer for finish painting by others.

3.39 SIGNAGE

A. The Plumbing Subcontractor shall provide signage as required by the Plumbing Specification, the Worcester Plumbing and Building inspectors, and per the MA Plumbing Code. Signage shall be provided at a minimum as follows:

1. For the condensate neutralizer tanks at the domestic hot water boilers and gas fired water heater regarding frequency of servicing.
2. For the emergency showers and eyewash units regarding flushing of units to minimize water stagnation.

3. For the cooking lines above any equipment with a standing pilot light stating that the pilot needs to be re-lit if the CO Detection System shuts off the gas to the cooking line due to elevated CO levels.
4. For the protected water hose bibs in several Janitor's Closets stating that they are for connecting the chemical dispensers only and that the chemical dispensers should not be connected to the janitor sink faucet directly.
5. At the emergency gas shut-off valve in the boiler room indicating that it should only be used in an emergency.

3.40 SPARE STOCK

A. The Plumbing Trade Contractor shall provide spare parts for some of the plumbing components as listed below:

1. One (1) Flushometer valve for a water closet and a urinal.
2. Six (6) Service Parts for a water closet and urinal Flushometer Valve. Service Parts include a handle, o-ring, vacuum breaker, diaphragm, etc.
3. Six (6) stems for each faucet for lavatories and sinks with at least six (6) installed. Note: If the faucet is used for multiple fixtures, then only six (6) stems for that model faucet are required.
4. Five (5) water filters for the water coolers (i.e. one spare filter for each one).
5. Backflow preventer repair kits, one per backflow preventer, bagged and affixed to the backflow preventer using zip ties.

B. Coordinate with owner where to deliver and store the spare parts. Provide names of plumbing supply houses where these items and more are available in case plumbing components are needed.

END OF SECTION 22 00 00

SECTION 22 08 00

COMMISSIONING OF PLUMBING SYSTEMS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this section.

1.02 SUMMARY

A. This section includes commissioning process requirements for Plumbing systems, assemblies, and equipment.

B. Related Sections:

1. Division 01 Section "General Commissioning Requirements" for general commissioning process requirements.

1.03 DESCRIPTION

A. Refer to Division 01 Section “General Commissioning Requirements” for the description of commissioning.

1.04 DEFINITIONS

A. Refer to Division 01 Section “General Commissioning Requirements” for definitions.

1.05 SUBMITTALS

A. Refer to Division 01 Section “General Commissioning Requirements” for CxA’s role.

B. Refer to Division 01 Section “Submittals” for specific requirements. In addition, provide the following:

C. Certificates of readiness

D. Certificates of completion of installation, prestart, and startup activities.

E. O&M manuals

F. Test reports

1.06 QUALITY ASSURANCE

A. Test Equipment Calibration Requirements: Plumbing Contractors will comply with test manufacturer’s calibration procedures and intervals. Recalibrate test instruments immediately after instruments have been repaired resulting from being dropped or damaged. Affix calibration tags to test instruments. Furnish calibration records to CxA upon request.

1.07 COORDINATION

A. Refer to Division 01 Section “General Commissioning Requirements” for requirements pertaining to coordination during the commissioning process.

PART 2 - PRODUCTS

2.01 TEST EQUIPMENT

A. All standard testing equipment required to perform startup, initial checkout and functional performance testing shall be provided by the contractor for the equipment being tested. For example, the plumbing contractor of Division 22 shall ultimately be responsible for all standard testing equipment for the plumbing system in Division 22, except for equipment specific to and used by TAB in their commissioning responsibilities.

B. Special equipment, tools and instruments (specific to a piece of equipment and only available from vendor) required for testing shall be included in the base bid price to the Owner and left on site, except for stand-alone data logging equipment that may be used by the CxA.

C. Proprietary test equipment and software required by any equipment manufacturer for programming and/or start-up, whether specified or not, shall be provided by the manufacturer of the equipment. Manufacturer shall provide the test equipment, demonstrate its use, and assist in the commissioning process as needed. Proprietary test equipment (and software) shall become the property of the Owner upon completion of the commissioning process.

D. All testing equipment shall be of sufficient quality and accuracy to test and/or measure system performance with the tolerances specified in the Specifications. If not otherwise noted, the following minimum requirements apply: Temperature sensors and digital thermometers shall have a certified calibration within the past year to an accuracy of 0.5°F and a resolution of + or - 0.1°F. Pressure sensors shall have an accuracy of + or - 2.0% of the value range being measured (not full range of meter) and have been calibrated within the last year.

PART 3 - EXECUTION

3.01 GENERAL DOCUMENTATION REQUIREMENTS

A. With assistance from the installing plumbing contractors, the CxA will prepare Pre-Functional Checklists for all commissioned components, equipment, and systems.

B. Red-lined Drawings: The plumbing contractor will verify all equipment, systems, instrumentation, wiring and components are shown correctly on red-lined drawings. Preliminary red-lined drawings must be made available to the Commissioning Team for use prior to the start of Functional Performance Testing. Changes, as a result of Functional Testing, must be incorporated into the final as-built drawings, which will be created from the red-lined drawings. The contracted party, as defined in the Contract Documents will create the as-built drawings.

C. Operation and Maintenance Data: Plumbing Contractor will provide a copy of O&M literature within 45 days of each submittal acceptance for use during the commissioning process for all commissioned equipment and systems. The CxA will review the O&M literature once for conformance to project requirements. The CxA will receive a copy of the final approved O&M literature once corrections have been made by the contractor.

D. Demonstration and Training: Plumbing Contractor will provide demonstration and training as required by the specifications. A complete training plan and schedule must be submitted by the contractor to the CxA four weeks (4) prior to any training. A training agenda for each training session must be submitted to the CxA one (1) week prior the training session

3.02 PLUMBING CONTRACTOR'S RESPONSIBILITIES

A. Perform tests as required by Division 22.

B. Attend construction phase controls coordination meetings as required.

C. Participate in Plumbing systems, assemblies, equipment, and component maintenance orientation and inspection as directed by the CxA.

D. Provide information requested by the CxA for final commissioning documentation.

E. Include requirements for submittal data, operation and maintenance data, and training in each purchase order or sub-contract written.

F. Prepare preliminary schedule for Plumbing system orientations and inspections, operation and maintenance manual submissions, training sessions, pipe and duct system testing, flushing and cleaning, equipment start-up, testing and balancing and task completion for owner. Distribute preliminary schedule to commissioning team members.

G. Update schedule as required throughout the construction period.

H. Assist the CxA in all verification and functional performance tests.

I. Provide measuring instruments and logging devices to record test data, and provide data acquisition equipment to record data for the complete range of testing for the required test period.

J. Gather operation and maintenance literature on all equipment, and assemble in binders as required by the specifications. Submit to CxA 45 days after submittal acceptance.

K. Coordinate with the CxA to provide 48-hour advance notice so that the witnessing of equipment and system start-up and testing can begin.

L. Notify the CxA a minimum of two weeks in advance of the time for start of the balancing work..

M. Participate in, and schedule vendors and plumbing contractors to participate in the training sessions.

N. Provide written notification to the CM/GC and CxA that the following work has been completed in accordance with the contract documents, and that the equipment, systems, and sub-system are operating as required.

1. Plumbing equipment including domestic water heaters, controls, pumps, valves plumbing fixtures, and all other equipment furnished under this Division.

O. The equipment supplier shall document the performance of his equipment.

P. Provide a complete set of red-lined drawings to the CxA prior to the start of Functional Performance Testing.

Q. Balance Contractor

1. At the completion of the balancing work, and the submittal of the final balancing report, notify the Plumbing contractor and the CM/GC.

R. Equipment Suppliers

1. Provide all requested submittal data, including detailed start-up procedures and specific responsibilities of the Owner, to keep warranties in force.
2. Assist in equipment testing per agreements with plumbing contractors.
3. Provide information requested by CxA regarding equipment sequence of operation and testing procedures.

S. Refer to Division 01 Section “General Commissioning Requirements” for additional contractor responsibilities.

3.03 CxA'S RESPONSIBILITIES

A. Refer to Division 01 Section “General Commissioning Requirements” for CxA’s Responsibilities.

3.04 TESTING PREPARATION

A. Certify in writing to the CxA that Plumbing systems, subsystems, and equipment have been installed, calibrated, and started and are operating according to the Contract Documents.

B. Certify in writing to the CxA that Plumbing instrumentation and control systems have been completed and calibrated, that they are operating according to the Contract Documents, and that pretest set points have been recorded.

C. Certify in writing that balancing procedures have been completed and that testing, adjusting, and balancing reports have been submitted, discrepancies corrected, and corrective work approved.

D. Set systems, subsystems, and equipment into operating mode to be tested (e.g., normal shutdown, normal auto position, normal manual position, unoccupied cycle, emergency power, and alarm conditions).

E. Inspect and verify the position of each device and interlock identified on checklists.

F. Check safety cutouts, alarms, and interlocks with smoke control and life-safety systems during each mode of operation.

G. Testing Instrumentation: Install measuring instruments and logging devices to record test data as directed by the CxA.

3.05 DOMESTIC WATER BALANCING

A. Notify the CxA at least ten (10) days in advance of testing and balancing Work, and provide access for the CxA to witness balancing Work.

3.06 GENERAL TESTING REQUIREMENTS

A. Provide technicians, instrumentation, and tools to perform commissioning test at the direction of the CxA.

B. Scope of Plumbing testing shall include entire Plumbing installation. Testing shall include measuring capacities and effectiveness of operational and control functions.

C. Test all operating modes, interlocks, control responses, and responses to abnormal or emergency conditions, and verify proper response of building automation system controllers and sensors.

D. The CxA along with the Plumbing contractor, balancing subcontractor shall prepare detailed testing plans, procedures, and checklists for Plumbing systems, subsystems, and equipment.

E. Tests will be performed using design conditions whenever possible.

F. Simulated conditions may need to be imposed using an artificial load when it is not practical to test under design conditions. Before simulating conditions, calibrate testing instruments. Provide equipment to simulate loads. Set simulated conditions as directed by the CxA and document simulated conditions and methods of simulation. After tests, return settings to normal operating conditions.

G. The CxA may direct that set points be altered when simulating conditions is not practical.

H. The CxA may direct that sensor values be altered with a signal generator when design or simulating conditions and altering set points are not practical.

I. If tests cannot be completed because of a deficiency outside the scope of the Plumbing system, document the deficiency and report it to the Owner. After deficiencies are resolved, reschedule tests.

J. If the testing plan indicates specific seasonal testing, complete appropriate initial performance tests and documentation and schedule seasonal tests.

3.07 PLUMBING SYSTEMS, SUBSYSTEMS, AND EQUIPMENT TESTING PROCEDURES

A. Equipment Testing and Acceptance Procedures: Testing requirements are specified in individual Division 22 sections. Provide submittals, test data, inspector record, and certifications to the CxA.

B. Plumbing Instrumentation and Control System Testing: Field testing plans and testing requirements are specified in Division 22 Sections. Assist the CxA with preparation of testing plans.

C. Pipe system cleaning, flushing, hydrostatic tests, and chemical treatment: Test requirements are specified in Division 22 piping Sections. Plumbing Contractor shall prepare a pipe system cleaning, flushing, and hydrostatic testing plan. Provide cleaning, flushing, testing, and treating plan and final reports to the CxA. Plan shall include the following:

1. Sequence of testing and testing procedures for each section of pipe to be tested, identified by pipe zone or sector identification marker. Markers shall be keyed to Drawings for each pipe sector, showing the physical location of each designated pipe test section. Drawings keyed to pipe zones or sectors shall be formatted to allow each section of piping to be physically located and identified when referred to in pipe system cleaning, flushing, hydrostatic testing, and chemical treatment plan.
2. Description of equipment for flushing operations.
3. Minimum flushing water velocity.
4. Tracking checklist for managing and ensuring that all pipe sections have been cleaned, flushed, hydrostatically tested, and chemically treated.

D. Plumbing Distribution System Testing: Provide technicians, instrumentation, tools, and equipment to test performance of domestic water distribution systems.

E. Vibration and Sound Tests: Provide technicians, instrumentation, tools, and equipment to test performance of vibration isolation and seismic controls as required.

F. The work included in the commissioning process involves a complete and thorough evaluation of the operation and performance of all components, systems and sub-systems. The following equipment and systems shall be evaluated:

Plumbing Systems
Natural gas systems
Compressed air systems
Backflow preventers
Water heaters
Hot water storage
Recirculation pumps
Water closets and sinks
Laboratory waste and acid neutralization systems
Safety shower/eyewash stations
Mixing valves
Rain water reclamation systems

3.08 DEFICIENCIES/NON-CONFORMANCE, COST OF RETESTING, FAILURE DUE TO MANUFACTURER DEFECT

A. Refer to Division 01 Section “General Commissioning Requirements” for requirements pertaining to deficiencies/non-conformance, cost of retesting, or failure due to manufacturer defect.

3.09 APPROVAL

A. Refer to Division 01 Section “General Commissioning Requirements” for approval procedures.

3.10 DEFERRED TESTING

A. Refer to Division 01 Section “General Commissioning Requirements” for requirements pertaining to deferred testing.

3.11 OPERATION AND MAINTENANCE MANUALS

A. The Operation and Maintenance Manuals shall conform to Contract Documents requirements as stated in Division 01.

B. Refer to Division 01 Section “General Commissioning Requirements” for the AE and CxA roles in the Operation and Maintenance Manual contribution, review and approval process.

3.12 TRAINING OF OWNER PERSONNEL

A. Refer to Division 01 Section “General Commissioning Requirements” for requirements pertaining to training.

END OF SECTION

Section 23 00 00

HVAC

(Trade Contract Required)

PART 1 - GENERAL

1.01 PUBLICLY BID TRADE CONTRACTOR

A. Sub-bids for work under this Section shall be for the complete work and shall be filed in a sealed envelope with the City of Worcester, Department of Public Works and Parks, Architectural Division, 50 Skyline Drive, Worcester, MA 01605 at time and place stipulated in the “Invitation to Bid/Notice to Contractors”. The following shall appear on the upper left hand of the envelope:

Name of Sub-Bidder: *Print Name of Sub-bidder*

Project: SOUTH HIGH COMMUNITY SCHOOL

Sub-Bid for Section: 23 00 00 - HVAC

B. Each sub-bid submitted for work under this Section shall be on forms furnished by the City of Worcester as required by Section 44F of Chapter 149 of the General Laws, as amended. Sub-Bid forms may be obtained at the Department of Public Works and Parks, Architectural Division, 50 Skyline Drive, Worcester, MA 01605 in person, or by written request.

C. Sub-bids filed with the City of Worcester shall be accompanied by a BID BOND or CASH or CERTIFIED CHECK or a TREASURER’S or CASHIER’S CHECK issued by a responsible bank or trust company payable to the City of Worcester in the amount of five (5) percent of the bid. A sub-bid accompanied by any other form of bid deposit than those specified will be rejected.

D. Additional Requirements:

1. Sub-bidder's attention is directed to Massachusetts G.L. Chapter 149 §44H, as amended, which provides in part as follows:
2. Each sub-bidder shall list in Paragraph E of the "Form for Sub-bids" the name and bid price of each person, firm or corporation performing each class of work or part thereof for which the Section of the Specifications for that sub-subtrade requires such listing, provided that, in the absence of a contrary provision in the Specifications, any sub-bidder may, without listing any bid price, list his own name or part thereof and perform that work with persons on his own payroll, if such sub-bidders, after sub-bid openings, shows to the satisfaction of the Awarding Authority that he does customarily perform such class of work with persons on his own payroll and is qualified to do so. This Section of the Specifications requires that the following classes of work shall be listed in Paragraph E under the conditions indicated herein.
Sub-Subs required:

Class of Work	Reference Spec.	Paragraphs
Sheet Metal	23 00 00	2.01 & 2.02
Insulation	23 00 00	2.06
Auto. Temperature Control	23 00 00	2.43

Testing, Adjusting & Balancing	23 00 00	3.05

E. The work to be completed by the Trade Contractor for the work of this Section is shown on the following listed Drawings, not just those pertaining particularly to this Trade Contract, unless specifically called out otherwise, regardless of where among the Drawings it appears:

1. The Work of this Trade Contract is shown on the following Drawings:

H3.1 Ground Level HVAC Ductwork Floor Plan Section B1
H3.2 Ground Level HVAC Ductwork Floor Plan Section B2
H3.3 First Floor HVAC Ductwork Plan Section A
H3.4 First Floor HVAC Ductwork Plan Section AB
H3.5 First Floor HVAC Ductwork Plan Section B1
H3.6 First Floor HVAC Ductwork Plan Section B2
H3.7 Second Floor HVAC Ductwork Plan Section A
H3.8 Second Floor HVAC Ductwork Plan Section AB
H3.9 Second Floor HVAC Ductwork Plan Section B1
H3.10 Second Floor HVAC Ductwork Plan Section B2
H3.11 Third Floor HVAC Ductwork Plan Section A
H3.12 Third Floor HVAC Ductwork Plan Section AB
H3.13 Roof HVAC Plan Section A
H3.14 Roof HVAC Plan Section AB
H3.15 Roof HVAC Plan Section B1
H3.16 Roof HVAC Plan Section B2
H4.1 Ground Level HVAC Piping Floor Plan Section B1
H4.2 Ground Level HVAC Piping Floor Plan Section B2
H4.3 First Floor HVAC Piping Plan Section A
H4.4 First Floor HVAC Piping Plan Section AB
H4.5 First Floor HVAC Piping Plan Section B1
H4.6 First Floor HVAC Piping Plan Section B2
H4.7 Second Floor HVAC Piping Plan Section A
H4.8 Second Floor HVAC Piping Plan Section AB
H4.9 Second Floor HVAC Piping Plan Section B1
H4.10 Second Floor HVAC Piping Plan Section B2
H4.11 Third Floor HVAC Piping Plan Section A
H4.12 Third Floor HVAC Piping Plan Section AB
H5.1 HVAC Details
H5.2 HVAC Details
H5.3 HVAC Details & Enlarged Mechanical Room Plan
H6.1 HVAC Controls
H6.2 HVAC Controls
H6.3 VRF System & Controls Schematic
H7.1 HVAC Schedules
H7.2 HVAC Schedules
H7.3 HVAC Schedules

2. Related items which may require coordination or impact work of this trade are shown on the following Drawings:
EX1.0, EX2.0, EX2.1, EX2.2, EX2.3, EX2.4, C1.0, C2.0, C3.0, C3.1, C3.2, C3.3, C3.4, C4.0, C4.1, C4.2, C4.3, C4.4, C5.0, C5.1, C5.2, C5.3, C5.4, C6.0, C6.1, C6.2, C6.3, C7.0, C7.1, C7.2, C7.3, C7.4, C8.0, C8.1, C8.2, C8.3, C8.4, C9.0, C9.1, C9.2, C9.3, C9.4, C10.0 C10.1, C10.2, C10.3, C10.4, C10.5, C10.6, C10.7, C11.0, C11.1, C11.2, C11.3, C11.4, C11.5, C11.6, C11.7, CA1.1, CA2.1, CA2.2, CA3.1, CA3.2, CA3.3,

CA4.1, CA4.2, CA4.3, CA4.4, CA4.5, CA4.6, CA4.7, CA4.8, L1.0, L2.0, L2.1, L2.2, L2.3, L2.4, L2.5, L2.6, L2.7, L2.8, L2.9, L3.0, L3.1, L3.2, L3.3, L3.4, L3.5, L4.0, L4.1, L4.2, L4.3, L5.0, L5.1, L5.2, L5.3, L5.4, L5.5, L5.6, S1.1, S1.2, S1.3, S3.1, S3.2, S3.3, S3.4, S3.5, S3.6, S3.7, S3.8, S3.9, S3.10, S3.11, S3.12, S3.13 S3.14, S3.15, S3.16, S4.11, S4.12, S4.13, S4.14, S4.15, S4.16, S4.17, S4.18, S4.19, S4.20, S4.21, S4.22, S4.23, S4.24, S5.1, S5.2, S5.3, S5.4, S5.5, S5.6, S6.1, S7.1, S7.2, S7.3, S7.4, S7.5, AD1.0, A1.1, A2.1, A2.2, A2.3, A2.4, A2.5, A3.0, A3.0A, A3.1, A3.2, A3.3, A3.4, A3.5, A3.6, A3.7, A3.8, A3.9, A3.10, A3.11, A3.12, A3.13, A3.14, A3.15, A3.16, A3.17, A3.18, A4.1, A4.2, A4.3, A4.4, A4.5, A4.6, A4.7, A4.8, A4.9, A4.10, A4.11, A4.12, A5.0, A5.1, A5.2, A5.3, A5.4, A5.5, A5.6, A5.7, A5.8, A5.11, A5.12, A6.1, A6.2, A6.3, A6.4, A6.5, A6.6, A6.7, A6.8, A6.11, A6.12, A6.13, A6.14, A6.15, A6.16, A6.17, A6.18, A6.21, A6.22, A6.23, A6.24, A6.25, A6.26, A6.27, A6.28, A6.29, A6.31, A6.32, A6.33, A6.34, A6.35, A7.1, A7.2, A7.3, A7.4, A7.5, A7.6, A7.7, A8.1, A8.2, A8.3, A8.4, A8.5, A8.6, A8.7, A8.8, A8.9, A8.10, A8.11, A8.12, A8.13, A8.14, A8.15, A8.16, A8.17, A8.18, A8.19, A8.20, A8.21, A8.22, A8.23, A8.24, A8.25, A8.26, A8.27, A8.28, A8.29, A9.1, A9.2, A9.3, A9.4, A9.5, A9.6, A10.1, A10.2, A10.3, A10.4, A11.1, A11.2, A11.3, A12.1, A12.2, A12.3, A12.4, A12.5, A12.6, A12.7, A12.8, A12.9, , A12.10, A12.11, A12.12, K1.1, K1.2, K1.3, K2.1, K2.2, K2.3, K2.4, K3.1, K3.2, K3.3, K3.4, K3.5, K3.6, K3.7, K4.1, K4.2, K4.3, K4.4, K4.5, K4.6, K5.1, K5.2, K6.1,K6.2, K6.3, K6.4, K6.5, FP1.1, FP1.2, FP1.3, FP1.4, FP4.1, FP4.2, FP4.3, FP4.4, FP4.5, FP4.6, FP4.7, FP4.8, FP4.9, FP4.10, FP4.11, FP4.12, FP7.1, P2.1, P2.2, P2.3, P2.4, P3.1, P3.2, P3.3, P3.4, P3.5, P3.6, P3.7, P3.8, P3.9, P3.10, P3.11, P3.12, P3.13, P3.14, P3.15, P3.16, P4.1, P4.2, P4.3, P4.4, P4.5, P4.6, P4.7, P4.8, P4.9, P4.10, H3.1, ,H,3.2, H3.3, H3.4, H3.5, H3.6, H3.7, H3.8, H3.9, H3.10, H3.11, H3.12, H3.13, H3.14, H3.15, H3.16, H4.1, H4.2, H4.3, H4.4, H4.5, H4.6, H4.7, H4.8, H4.9, H4.10, H4.11, H4.12, H5.1, H5.2, H5.3, H6.1, H6.2, H6.3, H7.1, H7.2, H7.3, AV0.0, AV0.1, AV0.2, AV3.3, AV3.4, AV3.5, AV3.7, AV3.8, AV3.9, AV3.10, AV3.18, AV4.5, AV4.6, AV4.7, AV4.8, AV4.9, AV5.0, AV5.1, AV5.2, AV5.3, AV5.4, AV5.5, AV5.6, AV5.7, AV6.1, AV6.2, AV6.3, AV7.1, AV7.2, TL1, TL2, TL3, TL4, TR1, TR2, TR3, TR4, E0.1, E0.2, E0.3A, E0.3B, E0.3C, E0.3D, E0.4A, E0.4B, E0.4C, E0.4D, E0.4E, E0.4F, E0.5, E0.6, E0.7, E0.8, E0.9, E1.1, E1.2, E1.3, E1.4, E1.5, E1.6, E1.7, E1.8, E1.9, E1.10, E1.11, E1.12, E1.13, E1.14, E2.1, E2.2, E2.2A, E2.3 ,E2.4 ,E2.4A, E2.4B, E2.5, E2.6, E2.7, E2.8, E2.9, E2.10, E2.11, E2.12, E3.1, E3.2, E3.3, E3.4 , E3.5, E3.6, E3.7, E3.8, E3.9, E3.10, E3.11, E3.12, E3.13, E3.14, E3.15, E3.16, E3.17, E3.18, E4.1, E4.2, E4.3, E4.4, E4.5, E4.6, E4.7, E4.8, E4.9, E4.10, E4.11, E4.12, E5.1, E5.2, E5.3, E5.4, E5.5, E5.6, E5.7, E5.8, E5.9, E5.10, E5.11, E5.12, E5.13, E5.14, E5.15, E5.16, E6.1, E6.2, E6.3, E6.4, E6.5, E6.6A, E6.6B, E6.7A, E6.7B, E6.7C, E7.0, E7.1, E7.2, E7.3, E7.4, E7.5, E7.6, E7.7, E8.0A, E8.0B, E8.0C, E8.0D, E8.0E, E8.0F, E8.0G, E8.1A, E8.1B, E8.2A, E8.2B, E8.2C, E8.2D, E8.3A, E8.3B, E8.3C, E8.3D, E8.4A, E8.4B, E8.4C, E8.5A, E8.5B, E8.5C, E8.5D, E8.6A, E8.6B, E8.7, E8.8A, E8.8B, E8.8C, E9.01, E9.02, E9.03, E9.04, E9.05, E9.06, E9.07, E9.08, E9.09, E9.10, E9.11, E9.12, E9.13, E9.14, E9.15

3. The complete List of Drawings for the Project is provided in Section 00 01 15 – LIST OF DRAWINGS.

1.02 RELATED DOCUMENTS

A. All of the Contract Documents, including General and Supplementary Conditions and Division 1 General Requirements, apply to the work of this section. Where paragraphs of this Section conflict, the more stringent requirements shall govern.

B. All work shall comply with all federal, state and local codes and any other authorities having jurisdiction.

C. Sustainable Design Intent: Comply with project requirements intended to achieve the intended certification, measured and documented according to the LEED rating system. Contractor must refer too and comply with Section 018113 - Sustainable Design Requirements.

D. Refer to Section 01 60 00 – Product Requirements: Owner's proprietary products and requirements for the same.

1.03 SUMMARY OF WORK

A. Provide all materials, labor and equipment required to perform the work of this section, as shown on the Contract Drawings and as specified herein, to include the following. When the word "provide" is used in this specification it shall mean to furnish & install. Provide the following:

1. Complete HVAC duct system including diffusers, registers, grilles, dampers, etc.
2. Miscellaneous steel, dunnage, supports, hangers, pads, etc., as shown, and as required.
3. Computer Room AC Units
4. Hot water unit heaters, cabinet heaters & Fin-Tube Radiation.
5. In-Slab radiant heat, mixing valves, pumps and accessories.
6. Electric baseboard and cabinet unit heaters.
7. Ductless Split Units
8. Packaged Roof-top HVAC Energy Recovery units
9. Variable Refrigerant Flow System
10. Air Handling Units.
11. Energy Recovery Units.
12. Fan Coil Units.
13. Remote condensing units and associated refrigerant piping.
14. Boilers, flue piping and safety interlocks.
15. Heat Exchangers
16. Pumps, piping and all related hydronic accessories.
17. Glycol Feeders
18. Condensate piping and traps.
19. Exhaust Fans and associated ductwork.
20. Insulation, thermal and/or acoustic, for ductwork and piping.
21. Automatic temperature controls.
22. Motor starters and drives.
23. Instruction manuals and startup instructions.
24. Testing and balancing.
25. Water treatment.
26. Equipment bases and supports.
27. All rigging and hoisting of equipment as required.
28. Coring, sleeving and firestopping all holes required of the respective work.
29. Access doors on sheet metal ductwork, sheet metal panels and enclosures.
30. Prefabricated or field erected curbs.
31. Obtain and pay for all permits, fees and approvals required for work under this Section.

B. Related Work Specified Under Other Divisions

1. Contractor must coordinate with other trades for all related work including but not limited to housekeeping pads, electrical interface, roofing, coring, firestopping, painting, electrical, commissioning, etc…

C. For cutting and patching, this contractor shall refer to and conform to the requirements of 01 73 00 - Cutting and Patching. All penetrations through the structure shall be sealed air and water tight or where penetrating a fire rated element must be firestopped by the HVAC subcontractor. All penetrations of the floors and ceiling and other fire rated walls and assemblies shall be firestopped by the HVAC contractor. Refer to section 07 84 00 Firestopping for products, etc…

D. Provide seismic bracing shall be provided regardless of exceptions allowed by code for this seismic category in conformance with the Commonwealth of Massachusetts building code 780 CMR, 9th edition, Chapter 16. Contractor shall hire a seismic consultant to comply with requirements of the code. All equipment and ductwork shall be seismically supported and all piping over 2". Mechanical seismic control exceptions noted in the code for the buildings seismic category shall not apply. For the purposes of seismic design of the mechanical systems, the building shall be considered an emergency shelter.

E. Reference To Drawings: Work specified is shown on the HVAC drawings and also includes all of the Contract Drawings.

1. The HVAC Trade contractor shall refer to all the Drawings enumerated in the List of Drawings on the title sheet for a full comprehension of the work to be done and for conditions affecting the location and placement of his equipment and materials. These Drawings are intended to be supplementary to the Specifications and any work indicated, mentioned, or implied in either is to be considered as specified by both. Should the character of the work herein contemplated or any matter pertaining thereto be not sufficiently explained in the Specifications or Drawings, the HVAC Trade contractor may apply to the Architect-Engineer for further information and shall conform to such when given, as it may be consistent with the original intent. The Architect-Engineer reserves the right to make any reasonable changes in location prior to installation at no expense to the Owner. All lines are diagrammatic and exact locations are subject to the approval of the Architect-Engineer.

2. The HVAC Trade contractor shall, at all times, have a foreman or superintendent on the project authorized to make decisions and receive instructions as if the HVAC Trade contractor himself were present. The foreman or superintendent shall not be removed or replaced without the express approval of the Architect-Engineer after construction work begins. The HVAC Trade contractor shall employ only competent and experienced workmen at a regular schedule in harmony with the other tradesmen on the job. The HVAC Trade contractor shall also exercise care and supervision of his employees in regard to proper and expeditious layout of his work.

F. ALTERNATES:

Special attention is called to the fact that it shall be the responsibility of all the General and Trade contractors to thoroughly examine all the alternates and evaluate for themselves as to whether or not these alternates in any way affect their respective sections. In the event that a contractor feels that any alternate(s) do reflect a cost difference, additional or a deduction, in his bid proposal, then he shall stipulate his sum and/or sums under the proper alternate(s) as provided for in the bid proposals. Failure to do so will in no way relieve the herein before

stated contractors of their responsibilities regardless of what alternate(s) are selected and no extra cost will be charged to the Owner.

G. This project shall comply with the LEED rating system. The HVAC Contractor must comply with LEED requirements for this project including but not limited to the requirements of the following sections:

1. SECTION 01 81 13 – SUSTAINABLE DESIGN REQUIREMENTS
2. SECTION 01 74 19 – CONSTRUCTION WASTE MANAGEMENT & DISPOSAL
3. SECTION 01 81 19– INDOOR AIR QUALITY MANAGEMENT
4. SECTION 01 91 00 - COMMISSIONING

It shall be the HVAC contractors responsibility to submit all documentation required of these sections pertaining to division 23 00 00 work. For Section 01 91 00 - Commissioning, division 23 00 00 must provide all personnel as required to fully coordinate with the commissioning agent. The hours of training and instruction outlined in division 23 00 00and the Testing and Balancing requirements shall be in addition to those tests and requirements outlined in Commissioning section and required to the fulfill commissioning obligations.

H. Air Filters:

It is the intent of this specification that all equipment requiring or specified with air filters be furnished with two (2) spare sets of filters (both pre and final) for each piece of equipment in addition to those supplied with the unit and after flush-out. Presuming the unit has not been operated during construction (operation during construction only allowed with written approval from Architect) the set of filters initially installed in the unit shall be utilized during testing and balancing and building flush out. After flush out, a new set of air filters shall be installed leaving the Owner with two (2) full spare sets. All pre-filters shall have a minimum efficiency of MERV 8 and all final filters and single filter units shall have a minimum efficiency of MERV 13. Note: All units included in the 3-year warranty and maintenance plan shall not be supplied with spare filters as the contractor shall own filter changes for 3 years as part of the contract.

All RTU, AHU and MAU filter sections must be fitted with differential pressure gauges viewable from the outside of the unit. Gauges shall be connected to EMS where specified elsewhere in this specification.

I. Belts & Spare Stock:
It is the intent of this specification that all equipment requiring or specified with belt drives (i.e. fans, energy recovery wheels in RTU's, AHU's, MAU's exhaust fans, etc…) be furnished with two (2) spare sets of belts for each piece of equipment in addition to those supplied with the unit.

In addition, any items considered consumable or required for routine maintenance and service replacement within the first 18 months of an equipment's operation shall be supplied of adequate quantity to operate the equipment for a period of 24 months.

Note: All units included in the 3-year warranty and maintenance plan shall not be supplied with spare belts as the contractor shall own belt changes for 3 years as part of the contract.

J. Building Flush Out:

After construction contractor must coordinate and implement building wide flush to meet the requirements of LEED Construction IAQ Management. All equipment with filters shall be fitted with MERV 13 filters during the flush put period. After the flush out period the units shall have MERV 13 filters installed as specified. Contractor shall assemble a flush out schedule which shall achieve a minimum of 14,000 CF of outside air while holding the spaces between 60°F and 80°F and no higher than 60% RH.

1.04 SUBMITTALS

A. Refer to Section 01 33 00, SUBMITTALS for submittal provisions and procedures. Contractor must also refer too and comply with Section 018113 - Sustainable Design Requirements.

B. Product data: within 30 calendar days after the Contractor has received the Owner's Notice to Proceed, submit (7) copies of the following:

1. Coordinated shop drawings, showing proposed layout of equipment, piping, ducts, registers, grilles, controls and other components of the system. All heights, transitions, dimensions, etc… shall be clearly shown.
2. Manufacturers catalog cuts, Samples and other items needed to fully demonstrate the quality of the proposed materials and equipment. In addition to the submittals formerly mention herein submit equipment specification sheets and dimensional data on all equipment including but not limited to the following:
   - Ductwork, registers, grilles, etc..
   - Flue Piping, Combustion air ductwork and accessories
   - Computer Room AC Units
   - Hot water unit heaters, cabinet heaters, radiant panel heaters & fin-tube radiation.
   - In-Slab radiant heat, mixing valves, pumps and accessories.
   - Electric baseboard and cabinet unit heaters.
   - Ductless Split Units
   - Variable Refrigerant Flow System
   - Packaged Roof-top HVAC Energy Recovery units
   - Energy Recovery units
   - Air Handling / Make-Up Air Units
   - Fan Coil Units.
   - Remote condensing units and associated refrigerant piping.
   - Boilers, flue piping and safety interlocks.
   - Heat Exchangers
   - Glycol Feeders
   - Pumps, piping and all related hydronic accessories.
   - Exhaust Fans and associated ductwork.
   - Insulation, thermal and/or acoustic, for ductwork and piping.
   - Automatic temperature controls.
   - Motor starters and drives.
   - Instruction manuals and startup instructions.
   - Testing and balancing.
   - Water treatment.
   - VAV Boxes
   - Automatic Temperature Controls

B. Record Drawings

1. Include a copy of the Record Drawings in each copy of the operation and maintenance manual described below. A reproducible set of as-built drawings shall be updated continually through the project and delivered to the Architect at project completion. Record drawings shall also be delivered in both ACAD format and PDF format on a CD.

C. Testing and Balancing Reports

1. Submit four (4) copies of a certified testing and balancing report to the Architect for review and approval. Include all air flow, water flow and temperature readings as outlined herein.

D. Operating Instructions

1. Prior to the completion of all work and the final inspection of the installation by the owner, four (4) copies of a complete Instruction Manual, bound in booklet form and suitably indexed, shall be submitted to the Architect for review and approval. All written material contained in the manual shall be typewritten. In addition, provide a copy of the manual in an index PDF format on a CD.

1.05 INSTRUCTION OF OWNER'S PERSONNEL

A. After completion of all work and all tests and at such time as designated by the owner, provide the necessary skilled personnel to operate the entire installation for a period of forty (40) hours. Training shall be broken up into multiple four (4) hour periods at the direction of the Owner. Training must be recorded by the contractor and distributed to the Owner on DVD with a copy in each O&M manual. Training shall be videotaped onto indexable CD in compliance with other parts of the specification.

B. During the operating period, fully instruct the owner's representative in the complete operation, adjustment and maintenance of the entire installation.

C. It shall be division 23 00 00 responsibility to provide all personnel as required to fully coordinate with the commissioning agent. The hours of training and instruction outlined in division 23 00 00 and the Testing and Balancing requirements shall be in addition to those tests and requirements outlined in Commissioning section and required to fulfill commissioning obligations.

1.06 QUALITY ASSURANCE

A. Use adequate numbers of skilled workmen who are thoroughly trained and experienced in the necessary crafts and who are completely familiar with the specified requirements and the methods needed for proper performance of the work of this Section.

B. The Contractor's superintendent shall conduct all coordination between the Contractor, the Architect, the Engineers, etc., and shall fully represent the Contractor's position in his absence. All decisions by the superintendent shall become the responsibility of the Contractor and binding to the Contract. The Contractor shall be responsible for the drawings, and that which is written or implied in the specifications.

C. Without additional cost to the Owner, provide such other labor and materials as are required to complete the work of this Section in accordance with the requirements of governmental agencies having jurisdiction, regardless of whether such materials and associated labor are called for elsewhere in these Contract Documents.

D. Completely coordinate with work of other trades and provide for complete and fully functional installation. Although not specifically shown, provide supplementary or miscellaneous items, devices, appurtenances and materials incidental to or necessary for sound, secure and complete installation

E. Before submitting the final proposal examine the site of the proposed work to determine existing conditions that may effect the work, as this section will be help responsible for any assumption in regard thereto.

F. All equipment, ductwork, piping and materials utilized for this project must be protected from exposure to weather until installed. Interior equipment and materials shall not be installed unless the area in which they are being installed is adequately weather tight.

G. Contractor must comply with requirements of Section – Construction Indoor Air Quality (IAQ) Management as well as the SMACNA IAQ Guidelines defined in paragraph 3.02 of this section.

H. Condensate evaporation trays are expressly forbidden on all HVAC equipment.

I. To assure uniformity and compatibility of piping components in grooved end piping systems, all grooved products utilized shall be supplied be a single manufacturer. Grooving tools shall be supplied by the same manufacturer as the grooved components.

1.07 EXAMINATION OF SITE AND DOCUMENTS

A. Bidders are expected to examine and to be thoroughly familiar with all contract documents and with the conditions under which work will be carried out. The Awarding Authority (Owner) will not be responsible for errors, omissions and/or charges for extra work arising from Construction Manager's or Trade Contractor's failure to familiarize themselves with the Contract Documents or existing conditions. By submitting a bid, the Bidder agrees and warrants that he has had the opportunity to examine the site and the Contract Documents, that he is familiar with the conditions and requirements of both and where they require, in any part of the work a given result to be produced, that the Contract Documents are adequate and that he will produce the required results.

1.08 BUILDING FLUSH OUT

A. Upon completion of construction, prior to building occupancy and with all interior finishes and furnishings installed the building shall undergo a flush-out period. to meet the requirements of LEED Construction IAQ Management. All equipment with filters shall be fitted with MERV 13 filters during the flush put period. After the flush out period the units shall have MERV 13 filters installed as specified. During this period the systems shall operate, providing the outdoor quantities scheduled on the drawings for each system and all occupancy or demand ventilation reset schedules which could reduce the outside air levels below those scheduled shall be overridden. For systems with the ability to provide 100% outside air (i.e. economizer), these systems shall be set to operate at 100% outside air with the exception that this operation shall not be allowed if outdoor ambient conditions could damage interior

finishes or systems such as if ambient conditions were below freezing. Contractor shall assemble a flush out schedule which shall achieve a minimum of 14,000 CF of outside air rotation through all spaces while holding the spaces between 60°F and 80°F and no higher than 60% RH.

1.09 GUARANTEE & MAINTENANCE CONTRACT

A. The Contractor shall guarantee every component part of each system for a minimum of one-year parts and labor from date of substantial completion. The contractor shall also provide the Owner with factory warranties for all equipment. For equipment with compressors such as the condensing units, packaged rooftop and ERU units, heat pumps, etc… provide extended five-year (or longer per manufacturer such as on VRF condensers) warranty on compressors. Refer to extended warranty below and respective specification sections herein for additional warranty requirements.

B. For the following pieces of equipment provide extended 3-year full warranty and maintenance contract starting from the date of substantial completion:
- RTU's
- AHU's
- MAU's
- Boilers
- Condensing Units
- VRF related condensers, branch selectors, fan coils and controls.

Contract shall cover all parts and labor for all components of the equipment as well as all routine scheduled maintenance specified by the manufacturer including but not limited to, filter changes, belts, lubrication, cleaning of coils and heat exchangers, related factory and field mounted controls for these devices, inspection of ignition components and replacing ignitors as required, cleaning condensate traps & change acid neutralizer cartridges, etc… for the entire 3-year period.

1.10 SEQUENCING

A. Phasing: Refer to Section 01 10 00 - SUMMARY, and Drawings for phasing and milestone completion requirements which affect the Construction Manager's Work and the Work of this Trade Contractor.

B. Coordinate work of this Trade Contract with that of other trades, affecting or affected by this work, and cooperate with the other trades as is necessary to assure the steady progress of work.

C. Do not order or deliver any materials until all submittals, required in the listed Specification Sections included as part of this Trade Contract, have been received and approved by the Architect.

D. Before proceeding with installation work, inspect all project conditions and all work of other trades to assure that all such conditions and work are suitable to satisfactorily receive the work of this Section and notify the Architect in writing of any which are not. Do not proceed further until corrective work has been completed or waived.

PART 2 - PRODUCTS

2.01 DUCTWORK

A. All duct runs shall be checked for clearances before installation of any ductwork. Above hung ceilings, duct locations, and elevations must be coordinated with work of other trades to avoid conflicts with structure, piping, conduit, light fixtures, and cable trays.

B. All sheet metal ducts shall be constructed of galvanized iron sheet G-60 galvanized steel meeting ASTM A924 and A653 of bend forming quality. The following specialty ducts shall be used:
   1. Ducts forming exterior louvers plenums as well as exhaust ducts from clothes dryers shall be fabricated from aluminum.
   2. Ducts for the dishwasher exhaust shall be 20 gauge #316 stainless steel with watertight seams. If welded than 18 gauge shall be used.
   3. Ducts for the kitchen hood exhaust systems shall be 18 gauge #316 stainless steel all welded construction.
   4. Ducts for fume hood exhaust systems shall be 18 gauge #316 stainless steel.
   5. Ducts for elevator shaft ventilation and smoke control systems where applicable shall be 18 gauge.
   6. Exhaust ducts serving wet areas such as shower rooms and locker rooms shall be fabricated out of aluminum.
   7. Ducts serving vehicle exhaust system shall be spiral round galvanized steel, minimum 18 gauge.

C. Duct construction shall be in accordance with best practices and latest SMACNA requirements for metal gauges, joints, reinforcing, and supports. Ductwork within 20 feet of an air handler (AHU), rooftop unit (RTU) or energy recovery unit (ERU) supply and return or exhaust fan shall be minimum 16 gauge or 2 gauges heavier than SMACNA standard, whichever is greater (heavier gauge), to reduce breakout noise. All ductwork shall be rated for a minimum pressure classification of 3”w.g. where located upstream of VAV terminals or used for the smoke control system, kitchen hood exhaust or elevator shaft exhaust. Ductwork connecting to the dust collector as well as vehicle exhaust ductwork shall be rated for 15”w.g. Elsewhere the ductwork shall be rated for 2” w.g. or higher rating as recommended by SMACNA standards. All exposed ductwork shall be constructed and hung to provide a neat, smooth, finished appearance. Cadmium plated sheet metal screws shall be used on all exposed ductwork. Ducts shall be free from expansion or contraction noises or rattling when fans are turned on or off.

D. Round ductwork shall be spiral formed galvanized steel of standard gauge as manufactured by United Sheet Metal, Spiramatic, Semco, or equal. Refer to Articles on Spiral Round and Double Wall Spiral Round for additional information.

E. Duct sizes change in shape or dimensions and offset as required to clear structural members and to coordinate with other trades. All changes must maintain the same friction loss as the original duct (i.e. similar free area) and must meet the latest ASHRAE and SMACNA standards.

F. The centerline radius of all duct elbows where shown on Drawings shall be at least one and one-half the width of the duct. Where building conditions do not allow for this radius, provide double wall airfoil turning vanes or, if in a sound attenuated duct, provide acoustical attenuating turns.

G. Duct sections 1 ft. 6 in. wide or less shall be butted together and jointed with flat drive cleats 2-1/8 in. wide. Top and bottom cleats shall be cut flush with duct and side cleats

bent over to make a tight joint. Standing bar slips as specified for ducts over 18 in. may be used at the HVAC Trade contractor's option.

H. Ducts from 18 in. to 30 in. wide shall be jointed with 1/8 in. standing bar slips made of metal the same as or heavier than duct sheets. Joints in ducts with either dimension over 30 in. shall have 1 in. standing bar slips on those sides over 30 in. Where sides are over 42 in., the standing bar slips will be reinforced with 1-1/2 in. by 1-1/2 in. by 1/8 in. angles. Additional angle stiffeners not over 60 in. apart shall be provided between joints. Ducts over 60 in. in width shall be jointed with 1-1/2 in. by 1/8 in. angle irons riveted to ductwork on all sides with 1/8 in. rivets at not more than 4-1/2 in. on centers, sections bolted with 3/16 in. stove bolts at not over 6 in. centers, sheets turned over angles into joint at least 1/4 in.

I. Sheet metal screws 3/4 in. No. 10 may be used to attach stiffener angles to ductwork to secure seams, spaced not over 12 in. on centers and not less than two (2) per side of 12 in. or more, except where specified otherwise. Button punching shall not be used, except for pre-erection attachment of fittings.

J. Provide hinged galvanized steel access and inspection doors opposite each motorized & gravity damper, at each fire damper, and at every duct mounted control device. In addition, provide access doors of sufficient quantity and location to allow for complete internal access of all ductwork systems for future cleaning and inspection but in no case less than every 20 feet and at every change in direction. Doors shall be of rigid construction with cast type rotary latches. Where space limitations do not allow full swing of the access door, two (2) rotary type latches shall be used. Doors located in insulated ducts shall be furnished with extended frames to serve as a stop for insulation. Insulate doors located in insulated ductwork. All doors shall be gasketed. Door shall be 10 in. by 12 in. minimum except where limited by duct width and shall be larger where necessary for access to fire damper fusible links or other devices. Access on exposed ductwork shall be located so as to conceal them from obvious view from building occupants (i.e. top side of ductwork).

K. Hangers for all rectangular ducts 4 sq. ft. in area or above shall be round bar type fastened to 1-1/4 in. by 1-1/4 in. by 1/8 in. angles under the ducts.
   1. Ducts less than 4 sq. ft. in area shall be hung with black 1 in. by l/8 in. strap iron bent 1 in. under bottom side of the duct and fastened to the duct with sheet metal screws, using not less than two (2) screws per side and as many more so that they are not greater than 6 in. centers.

L. Supports for round and oval ductwork shall be 1 in. by 1/8 in. black strap iron rolled to the perimeter of the duct with ends bent on top of duct and bolted. Hangers at supply diffusers shall be similar but separated at bottom and riveted to ductwork as required for adequate support.

M. Hangers for the round ductwork shall be 1 in. by 1/8 in. black strap iron bolted to supports and lagged into the ceiling construction. Hangers over 24 in. long shall be 3/8 in. rod type with bolted and threaded ends and angle bracket at ceiling.

N. Hangers are to be placed on not greater than 8 ft. 0 in. centers or closer where required so that the ductwork can support the weight of a 200 pound man at any point.

O. Wherever sound insulation lining is called for, the sheet metal duct size shown on the Drawings must be increased to provide the clear inside dimensions or cross sectional area shown on the Drawings. Dimensions shown on the drawings are clear inside.

P. Duct joint sealing, reinforcing, flanges, etc. for square sheet metal ducts shall be based on maintaining airtight ducts at 3 in. w.g upstream of VAV or used for smoke control system and 2 in. w.g. elsewhere maximum static pressure with maximum of 5 percent leakage of total fan capacity, 1/2 of one percent for round and oval ducts. All joints in round and rectangular ductwork shall be sealed with UL classified NFPA approved duct sealer. Off gasing of sealer must comply with LEED requirements for the construction of this building. Seal all ductwork at joists and seams with LEED EQ. Credit compliant water based duct sealer DuctMate® EZ-Seal or approved equal. All ductwork shall be pressure tested as required by code. All smoke control ductwork must be fully pressure tested.

Q. Upon completion of construction and before testing, the interior of all plenums shall be vacuum cleaned. When unit is first turned on, open duct access doors and blow out all foreign matter. Do not run fan without filter.

R. Fire Dampers

1. Construction: UL listed and rated for 1-1/2-hour fire rating in conformance with NFPA 90A and authorities having jurisdiction. All shall be. Note: For the fire dampers at the interface to the PAC building, provide 3-hour out-of-air stream type dynamic rated fire dampers.
2. Provide fire dampers with access doors where indicated on the plans and in openings in the following locations:
   a. Fire rated wall and fire partition.
   b. Fire rated ceilings and floors.
   c. When required by local and state codes.
3. After installation and prior to building turn over to Owner, test each fire damper, reset and replace fusible links in accordance with NFPA. Submit certified test report.

S. Smoke and Fire/Smoke Dampers:

1. Combination Fire Smoke Dampers meeting the following specifications shall be furnished and installed where shown on plans and/or as described in schedules. Dampers shall meet the requirements of NFPA 80, 90A, 92A, 92B, 101 & 105 and further shall be tested, rated, and labeled in accordance with the latest edition of UL Standards 555 and 555S. Dampers shall have a UL555 fire rating of 1 1/2 hours and be of low leakage design qualified to UL 555S Leakage Class I.
2. Each damper /actuator combination shall have a UL555S elevated temperature rating of 250 F minimum and shall be operational and dynamic rated to operate at maximum design air flow at its installed location. Each damper shall be supplied with an appropriate actuator installed by the damper manufacturer at the time of damper fabrication. Damper actuator shall be electric type for 120 or 24 Volt operation.
3. Damper blades shall be 16 gauge galvanized steel 3V type with three longitudinal grooves for reinforcement. Damper frame shall be galvanized steel formed into a structural hat channel shape with reinforced corners. Bearings shall be sintered bronze sleeve type rotating in extruded holes in the damper frame. Blade edge seals shall be silicone rubber designed to inflate and provide a tighter seal against leakage as

pressure on either side of the damper increases. Jamb seals shall be stainless steel compression type. Blades shall be completely symmetrical relative to their axle pivot point, presenting identical resistance to airflow in either direction or pressure on either side of the damper.

4. The Damper Manufacturer's submittal data shall certify all air performance pressure drop data is licensed in accordance with the AMCA Certified Ratings Program for Test Figures 5.2, 5.3, and 5.5. Damper air performance data shall be developed in accordance with the latest edition of AMCA Standard 500-D. Dampers shall be labeled with the AMCA Air Performance Seal.
5. Damper must be rated for mounting vertically (with blades running horizontal) or horizontally and be UL 555S rated for leakage and airflow in either direction through the damper. Each damper shall be supplied with a 165 F RRL. The RRL/OCI has built in open closed indicators and switches.
6. The basis of design is Greenheck Model FSD-211, Ruskin or approved equal.
7. After installation and prior to building turn over to Owner, test each smoke damper and fire/smoke dampers, reset and replace fusible links as applicable in accordance with NFPA. Submit certified test report.

T. At branch ducts, provide manually operated dampers of the type and arrangement shown on the Drawings, two gages heavier that the duct in which installed and equipped with locking quadrants. All branch take-offs shall be made with 45° or full Bellmouth type fittings. Spin-in and stick-on take-offs shall not be allowed.

U. Volume dampers, provide single and multi blade manually adjustable dampers as shown on drawings in all duct splits and branch connection of supply and exhaust air systems.

V. For all areas where dampers will be made inaccessible either due to height or hard ceiling without access panels, remote balancing dampers shall be of either the low voltage electric design or cable design shall be used. This shall apply to all volume dampers in the Auditorium space and elsewhere where needed. Provide Greenheck model #RBD-10 series (rectangular), #RBDR50 (round) or #RBD-15 (rectangular over 1” w.g.) or approved equal for all volume dampers in the auditorium space and elsewhere where shown on the drawings or required for access. Dampers shall have a minimum UL555 differential pressure rating of 1” (4” for #RBD-15) and a minimum velocity rating of 2,000 fpm. Dampers shall be constructed of 20 gauge galvanized steel and have a 9-volt actuator. Provide stainless steel multi-port connectors, single gang outlet box, plenum rated cable and cable couplers. Provide EZ Balance Remote controller with open close toggle buttons and damper position and battery status lights and deliver to Owner at completion of project balancing.

W. Flexible duct shall be 2.2” thick insulated low-pressure type with foil vapor barrier as manufactured by Automation Industries, Thermaflex type MKE ATCO Greenguard or equal. Minimum installed R-value shall be 8.0 within the heated building envelope and 12.0 outside the buildings heated envelope. Maximum length of flex duct is 5 feet. Secure with tie straps and seal with duct tape. Flexible duct upstream of a VAV terminal shall be metal type Class 0 similar. Secure with metal band fasteners and seal joints with duct sealer. Flexible duct shall not be allowed in areas where the duct is not concealed by a ceiling.

X. Acoustic insulation: All supply, return, and exhaust air ducts as well as return air plenums and shafts shall be lined internally with 1.5” inch thick acoustical liner equal to Owens Corning QuietR® Type R-6 or Knauf Insulation Rigid Plenum Liner Board manufactured with ECOSE® Technology or equal, k=0.25 at 75 degree F. mean temperature for rectangular

ductwork and Owens Corning QuietZone® 1.5”thick spiral duct liner, k+0.25 at 75 degree F. mean temperature for spiral and round ductwork. Minimum installed R Vlaue shall be 6.0. Liner shall extend for a minimum of 20 feet (or more if indicated on drawings) from all air moving equipment (ERU’s, AHU’s RTU’s & EF and Fans). Apply minimum 5 feet downstream of all VAV dampers unless drawing reflects more liner. All ductwork serving and within the auditorium area shall be internally lined inclusive of the return air chases. Liner shall clipped and cemented to the inside of the duct or chase/shaft. All seams and edges of liner shall be sealed to prevent fraying in the airstream. Liner shall have an acrylic polymer fiberglass reinforced facing with an antimicrobial coating. Liner shall conform to NFPA and U.L. and ASTM C1071 & ASTM C1104 requirements and have a 25/50 flame/smoke rating. Kitchen hood exhaust and dishwasher exhaust are exempt from the internal lining requirement.

Y. SOUND ATTENUATING UNITS

1. Casing gage weight shall be no less as schedule but not less than 20 gage galvanized sheet steel or heavier than 10 gage galvanized sheet metal as reflected on the schedules, with suitable flanges to make clean airtight connections to ductwork. Sound-absorbent material faced with glass fiber cloth and covered with not less than 22 gage or heavier galvanized perforated sheet steel or perforated aluminum. Perforations shall not exceed 4 mm (5/32-inch) diameter, approximately 25 percent free area. Sound absorbent material shall be long glass fiber acoustic blanket meeting requirements of NFPA 90A with microbial coating. Sound absorbent material shall conform to NFPA and U.L. and ASTM C1071 & ASTM C1104 requirements and have a 25/50 flame/smoke rating.
2. Entire unit shall be completely air tight and free of vibration and buckling at internal static pressures up to 2000 Pa (8 inches W.G.) at operating velocities.
3. Pressure drop through each unit: Not to exceed indicated value at design air quantities indicated.
4. Submit complete independent laboratory test data showing pressure drop and acoustical performance.
5. Cap open ends of attenuators at factory with plastic and heavy duty paper, cardboard, or other appropriate material to prevent entrance of dirt, water, or any other foreign matter to inside of attenuator. Caps shall not be removed until attenuator is installed in duct system.

Z. Provide seismic bracing shall be provided regardless of exceptions allowed by code for this seismic category in conformance with the Commonwealth of Massachusetts building code 780 CMR, 9th edition, Chapter 16. Contractor shall hire a seismic consultant to comply with requirements of the code. All equipment and ductwork shall be seismically supported and all piping over 2”. Mechanical seismic control exceptions noted in the code for the buildings seismic category shall not apply. For the purposes of seismic design of the mechanical systems, the building shall be considered an emergency shelter.

AA. DOUBLE WALL DUCTS

Where indicated on the drawings, double wall, acoustically insulated ducts shall be supplied. Double wall duct shall be constructed of an outer shell, a 1" thick layer of fiberglass insulation, and an inner metal liner. Insulation shall have a thermal conductivity "K" factor of .26 BTU/hr/sq. ft./ºF or less. The inner metal liner for all spiral and longitudinal seam duct shall be perforated metal. All fittings from fan discharge to a point where 35 lineal feet of spiral duct has been used shall have a perforated metal liner. All other fittings shall have a solid metal liner which may be one even gauge lighter than that shown for perforated liners.

BB. All painting of the exterior of ductwork (all types, spiral, round & rectangular) where noted within the contract drawings such as in the Auditorium, Stage, Gym and elsewhere shall be completed by the painting contractor. However, the HVAC contractor must prepare the galvanized ductwork in these areas prior to erection by properly pre-cleaning and etching the surface with ammonia or alkaline cleaning solution cleaning solution with a PH of between 11 and 12 and sweep blasting the surface with 200 to 500 micron particles. Final in place cleaning, priming and painting of the ductwork shall be by the painting contractor.

CC. All ductwork specified in article 2.01 and 2.02 and all other ductwork shall be shipped to the site with protective film on all open connections to prevent dust from entering. Film shall be reapplied to all open ends as the duct is installed until such time as building is clean and system is ready for start-up.

DD. VEHICLE EXHAUST SYSTEM

1. Provide a complete vehicle exhaust system as shown on the drawings and specified herein. The operating components of the vehicle exhaust system including articulated arm assemblies, hose storage reels, hose assemblies, suspension systems, and exhaust fans shall be the standard products of a United States exhaust system manufacturer and be provided by a single source as a complete package to ensure the integrity of the system. However, the exhaust fan shall be allowed to be from a different manufacturer to support the specific requirements of this project. Basis of design is Car-Mon Products, Inc. or approved equal by Monoxivent.

2. Hazardous Fume Exhaust Fan shall be licensed to bear the AMCA seal for certified performance in accordance with AMCA Standard 210. The fan shall be in-line style as scheduled and shall have a backward inclined fan wheel with single thickness flat blades welded to both the shroud and back plate. The fan wheel shall be statically and dynamically balanced before assembly. Any required balance weights shall be welded to the outside of the shroud or back plate; no weights are to be installed in the blade air stream. All surfaces of the centrifugal fan shall be painted completely with an acid resistant, polyester powder coating.

   The bearings shall be of the pillow block type with cast steel frame and shall be bolted to the structural bearing supports. The fan shaft shall be fabricated of ground and polished cold drawn steel with machined centers and key slots for both the fan wheel and the drive sheave. It shall be given a rust inhibitive asphaltic coating after assembly. The V-belt drive shall be adjustable. The variable pitch sheave shall be factory set at the appropriate position to provide the specified capacity in the approximate midpoint of the adjustment range. All fans shall be provided with a belt guard enclosing both sheaves and V-belts. The belt guard shall have a tachometer hole. All drives shall be rated for no less than 150% of motor load.

   The scroll and side sheets of the fan housing shall be fabricated of cold rolled steel of 12-gauge minimum thickness. The scroll and side sheets shall be joined through continuous welding. Spot welded or standing seam construction is not acceptable. The fan housing shall have a minimum of 8 attachment studs with flange locking nuts. Any bolts, self-tapping screws or fasteners that protrude into the housing interior are not acceptable. The fan base shall be fabricated of cold rolled steel of 12-gauge minimum thickness. The bearing supports within the base shall be fabricated of cold rolled steel

angles having a minimum 3/16" thickness and they shall be welded to the sides of the base. All seams in the individual components shall be continuous welded. The motor base shall be fabricated of cold rolled steel of 12-gauge minimum thickness. Its position shall be adjustable through the use of bolts that travel in slots in the sides of the fan base. A non-hardening, high elasticity caulking shall be applied during assembly between the mating surfaces of the fan housing and the fan base, of the inlet cone and the fan housing, and the inlet support and the inlet cone.

The assembled fan shall be test run before shipment with "total frequency" vibration measured at each bearing in both the vertical and horizontal planes. Any fan having an average reading of over 3 mils deflection is not acceptable.

Furnish fan platform as required to match specified fan. The platform shall include vibration rail base with suitable vibration isolation for weight load and distribution.

3. AT Articulated Arm Assembly: The two section articulated arm assembly shall be Series AT, comprised of a welded mounting base constructed of structural steel, utilizing a minimum 2" x 2" x 1/8" square tube and 2" x 3" x 3/16" angle iron with integral load bearings of sufficient capacity to handle the torsional stress while providing bind free rotation at the pivot arm connection, one triangular structural support section of 2" x 4" x 1/8" tubular steel and one outboard support strut of 2" x 4" x 1/8" tubular steel joined by a welded steel pivot joint assembly.

   The ducting shall consist of a swivel connection, elbows, and round duct of galvanized construction mounted to the articulating arm sections with two - piece support brackets with adjustable height capability and high temperature flexible hose section with duct attachment collars

4. Hose Suspension System - LFT Spring Retractor: The flexible hose suspension system shall support the flexible hose from overhead when not in use, allowing it to be lowered to the operating level when required. The lifting device shall be a single spring retractor with ratchet stop and ¼" steel suspension frame with cast eyelet and heavy-duty snap ring. The spring retractor shall be capable of lifting at least 25 pounds with 25' of travel.

5. TSR-S Spring Operated Hose Storage Reel: The hose storage reel frame is to be comprised of formed 12 gauge and 2 x 2 x 1/8 square tubular steel and shall be of welded construction. The hose drum shall be constructed of 16 gauge steel welded to 12 gauge steel end plates, forming an airtight cylinder. The internal assembly, combined with a low resistance inlet, shall provide efficient airflow through the drum.

   The flange-mounted flexible hose assembly shall be bolted to the air inlet of specified diameter; draw band connection is unacceptable. The drum shall be supported at one end by a 1" internally gusseted steel shaft through a heavy cast frame platform bearing, and at the other end by a sealed rotating outlet fitting of a lubristic synthetic material. The hose reel must be of sufficient size to accommodate the specified hose. The outlet fitting diameter, hose length, hose diameter, shall be as shown on the plans and specifications.

   The hose storage reel is to be fitted with an enclosed spring mechanism with balanced torque characteristics, factory tuned for hose type and length. Ratchet stops are to be provided so that the flexible hose assembly can be partially or completely extended. The

reel is to be equipped with a spring loaded mechanical stop mechanism that limits the number of drum rotations so that it cannot be over extended, and so that it will automatically stop when fully rewound on the drum without stress on the flexible hose assembly.

6. 6" and 7" Hose – HTC Flexible Hose: The hose shall be fabricated of silicone coated glass fabric inner layer and silicone coated nomex outer layer, clinched with an external galvanized steel helix. No adhesives may be used in the construction. The flexible hose is to be capable of withstanding temperatures of 1000°F interior, and be both flame retardant and oil resistant.

7. CTA Exhaust Adapter: The clamping type exhaust adapter shall be of 20 gauge stainless steel construction. Standard features include Safe-T-Edge for safe handling, heavy duty locking vise grip for secure connection, and an exhaust analyzer opening for emission testing. The adapter and flange set are to match the hose diameter as indicated on plans and specifications and shall be attached to the hose at the factory to maintain the integrity of the assembly. Field assembly is not acceptable.

8. Adapter for Stack Exhaust – DCA Diesel Cane: The diesel cane assembly shall be of aluminum construction with adjustable heat resistant handles. The welded aluminum diesel stack head shall be of a flow efficient design, and must be adaptable to a wide range of exhaust pipe configurations.

9. 4" Hose – NUX Flexible Hose: Hose shall be of an abrasion resistant type, constructed of a lightweight crush resistant fabric. The hose wall shall be of welded construction with a reinforced exterior scuff strip to provide additional abrasion resistance. Hose shall withstand exhaust temperatures up to 400°F. A connecting flange is to be provided for bolt-up attachment of hose to the hose storage reel.

10. RSC Exhaust Adapter: The exhaust adapter shall be molded of an advanced resin EPDM compound, having an adjustable over center clamp with tapered aluminum jaws for secure pipe attachment. Adapter and flange are to match hose diameter as indicated on plans and specifications and shall be attached to the hose at the factory to maintain the integrity of the assembly.

11. RYA Dual Assembly: A dual fitting assembly shall be provided for use with dual exhaust vehicles. The dual fitting assembly shall consist of an EPDM dual fitting, two exhaust hoses, two exhaust adapters, and a stainless steel tapered nozzle

2.02 SPIRAL DUCTWORK

A. GENERAL

All round and/or flat oval spiral duct and fittings shall be manufactured by a company whose has been in the business of manufacture of ductwork and spiral duct and fittings for at least ten (10) years. All spiral duct and fittings shall be manufactured by the same firm and shall be as shown on the contract drawings. Acceptable manufactures shall be SEMCO Incorporated or approved equal sheetmetal fabricator. Requirements of Article 2.01 shall also apply to this Article.

All spiral duct and fittings shall be manufactured from G-60 galvanized steel meeting ASTM A924 and A653 requirements. Corrugations between spiral seams on all exposed applications shall not be accepted.

B. CONSTRUCTION

Branch connections shall be made with 90° conical and 45° straight taps as shown on the drawings. All branch connections shall be made as a separate fitting. Factory or field installation of taps into spiral duct shall not be allowed without written approval of the engineer. Manufacturer's published individual fitting performances shall be on file with the design engineer ten (10) days prior to bid.

90º and 45º elbows in diameters 3" round through 10" round shall be stamped or pleated elbows. All other elbows shall be of the gored type, fabricated in accordance with the following:

	Centerline Radius	Elbows less than 30°	Elbows 37° thru 71°	Elbows 72° thru 90°
Up to 1000 fpm	1.0 x diameter	2 gores	2 gores	3 gores
1001 to 1500 fpm	1.0 x diameter	2 gores	3 gores	4 gores
Above 1500 fpm	1.5 x diameter	2 gores	3 gores	5 gores

Where it is necessary to use two-piece mitered elbows, they shall have a minimum number of vanes in accordance with the following:

Duct Diameter	Number of Vanes
3" thru 9"	2
10" thru 20"	3
21" and up	5

Circumferential and longitudinal seams of all fittings shall be a continuous weld or spot welded and sealed with mastic. All welds shall be painted to prevent corrosion.

All field joints for round ducts up to and including 36" diameter and oval ducts up to and including 41” major axis shall be made with a 2" slip-fit or slip coupling. Diameters 38" round and larger shall be provided with AccuFlange, or equal, flanged connections. AccuFlange, or equal, flanged connections may also be used in lieu of slip connections on smaller sizes.

Access doors shall be supplied by the duct manufacturer at all fire and/or smoke dampers.

All flanges and access doors shall be factory installed. Shipments of loose flanges, access doors, or taps for field installation into spiral duct will not be allowed.

C. DOUBLE WALL DUCTS

Where indicated on the drawings, double wall, acoustically insulated round ducts shall be supplied.

Double wall duct shall be constructed of an outer shell, a 1" thick layer of fiberglass insulation (see also acoustic insulation), and an inner metal liner. Liner shall have an acrylic polymer fiberglass reinforced facing with an antimicrobial coating. Insulation shall have a thermal conductivity "K" factor of .26 BTU/hr/sq. ft./ºF or less.

The inner metal liner for all spiral and longitudinal seam duct shall be perforated metal. All fittings from fan discharge to a point where 35 lineal feet of spiral duct has been used shall have a perforated metal liner. All other fittings shall have a solid metal liner which may be one even gauge lighter than that shown for perforated liners.

D. METAL GAUGES

Metal gauges for single wall round ducts shall be as follows:

1. Round Ducts with Maximum 2" W.G. Positive Static Pressure. For 3" w.g. increase all gauges listed 1 gauge heavier. Ducts within 20 feet of air handler and RTU supply, return and exhaust fans shall be minimum 10 gauge to reduce breakout noise.

DUCT DIAMETER	SPIRAL DUCT	FITTINGS AND LONGITUDINAL SEAM DUCT
3" thru 26"	26	24
28" thru 36"	24	22
38" thru 50"	22	20
52" thru 60"	20	18
62" thru 78"	18	16

2. Round Ducts with Maximum -2" W.G. Negative Static Pressure. For 3" w.g. increase all gauges listed 1 gauge heavier.

DUCT DIAMETER	SPIRAL DUCT	FITTINGS AND LONGITUDINAL SEAM DUCT
3" thru 17"	26	24
18" thru 20"	24	22
21" thru 22"	24	20
24" thru 26"	22	20
28" thru 30"	22	18
32" thru 34"	20	18
36" thru 42"	20	16
44" thru 48"	20	18 (Note 1 & 3)
50" thru 60"	18	18 (Note 2 & 3)

Notes:
1. Reinforce with 1" x 1" x $^{1}/_{8}$" girth rings every 6 ft.
2. Reinforce with 1¼" x 1¼" x $^{3}/_{16}$" girth rings every 4 ft.
3. When companion flange joints are used as reinforcement,
   44" to 48" diameter shall be 2" x 2" x $^{3}/_{16}$"
   50" to 60" diameter shall be 2½ x 2½ x $^{3}/_{16}$"

E. Metal gauges for dual wall round ducts shall be as follows unless heavier gages are specified in article 2.01 or elsewhere within this specification:

1. Round Ducts with Maximum 2" W.G. Positive Static Pressure. For 3" w.g. increase all gauges listed 1 gauge heavier.

INSIDE DIAMETER	SPIRAL DUCT SHELL	SPIRAL DUCT PERF. LINER	FITTINGS AND LONGITUDINAL SEAM DUCT SHELL	FITTINGS AND LONGITUDINAL SEAM DUCT PERF. LINER
3" thru 8"	26	26 (non-ribbed)	24	24
9" thru 24"	26	26 (ribbed)	24	24
26" thru 34"	24	26 (ribbed)	22	24
36" thru 48"	22	26 (ribbed)	20	22
50" thru 58"	20	26 (ribbed)	18	22
60" thru 62"	18	26 (ribbed)	16	22
62" thru 76"	18	22 (non-ribbed)	16	22

2. Round Ducts with Maximum -2" W.G. Negative Static Pressure. For 3" w.g. increase all gauges listed 1 gauge heavier.

INSIDE DIAMETER	SPIRAL DUCT SHELL	SPIRAL DUCT PERF. LINER	FITTINGS AND LONGITUDINAL SEAM DUCT SHELL	FITTINGS AND LONGITUDINAL SEAM DUCT PERF. LINER
3" thru 8"	26	26 (non-ribbed)	24	24
9" thru 15"	26	26 (ribbed)	24	24
16" thru 20"	24	26 (ribbed)	22	24
22" thru 24"	22	26 (ribbed)	20	24
26" thru 28"	22	26 (ribbed)	18	24
30" thru 32"	20	26 (ribbed)	18	24
34" thru 40"	20	26 (ribbed)	16	22
42" thru 46"	20	22 (non-ribbed)	18 (Notes 1 & 3)	22
48" thru 58"	18	22 (non-ribbed)	18 (Notes 1 & 3)	22

Notes:
4. Reinforce with 1" x 1" x $^1/_8$" girth rings every 6 ft.
5. Reinforce with 1¼" x 1¼" x $^3/_{16}$" girth rings every 4 ft.
6. When companion flange joints are used as reinforcement,
   44" to 48" diameter shall be 2" x 2" x $^3/_{16}$"
   50" to 60" diameter shall be 2½ x 2½ x $^3/_{16}$"

2.03 AIR INLETS/OUTLETS

A. Diffusers, registers and grilles shall be installed where shown on the drawings and shall be of the type, sizes and quantities as indicated on drawings. Manufacturers shall be Titus, Krueger or MetalAire. On return grilles/registers, a sound line plenum box the full duct dimension of the grille/register shall be provided for connection to the branch duct. If entering a return plenum, plenum box shall be lined elbow. For square neck supply diffusers connecting to a round duct, the transition piece shall have a minimum 45 deg. angle.

B. Final color selection of all diffusers registers and grilles shall be by Architect. Submit color chart for review and selection.

C. Displacement Diffusers: Provide displacement diffusers in each area as shown on the drawings and as scheduled.

1. Ceiling units shall be similar to Price model #DF1L-HC as shown on the plans or equal by Metal Aire made for mounting within a suspended ceiling system or other system as shown on the plans. The units shall have an aluminum equalizing baffle behind the displacement face plate and shall also incorporate a 1" custom flow slot diffuser with adjustable pattern controllers for vertical flow defection when providing heated air. The face plate shall be constructed of powdered coated polyester painted heavy gauge steel with no visible fasteners. Frame and plenum shall be fabricated of coated steel. Provide standard white finish on entire exposed face unless a custom color is noted in the schedule or plans. Unit shall be provided with ½" thick foil faced insulation on all exposed above ceiling elements. Unit shall have a 24 volt electric actuator and damper which shall be controlled by the EMS to divert air to the heating segment when in unoccupied heating mode or the cooling segment during all occupied ventilation periods.

2. Wall units shall be similar to Price model #DF1W as shown on the plans or equal by Metal Aire made for mounting concealed within a wall as shown on the plans. The units shall have an aluminum equalizing baffle behind the displacement face plate and have a concealed top ducted inlet collar. The face plate shall be constructed of powdered coated polyester painted heavy gauge steel with no visible fasteners, minimum 18 gauge. Frame and plenum shall be fabricated of coated steel. Provide standard white finish on entire exposed face unless a custom color is noted in the schedule or plans. Unit shall be provided with ½" thick foil faced insulation on all concealed elements. Face shall have stiffeners mounted behind the grid for extra rigidity painted flat black facing the perforation.

D. All diffusers, registers and grilles shall be shipped with protective film on face and connections to prevent dust from entering.

2.04 PIPING MATERIALS – GENERAL

A. Reference is made to specifications of recognized authorities to establish quality. Latest edition of their publications at time of bidding shall be in force.

B. All piping shall have manufacturer's name or trade mark rolled into each and every length of pipe.

C. All threads for screwed joints shall be National Taper Pipe Thread conforming to ANSI B2.1.

D. Grooved mechanical joint pipe, fittings and couplings shall be allowed as an acceptable substitution for welded, threaded or flanged pipe fittings except as otherwise not allowed by applicable codes. Product shall be as manufactured by Victaulic Company of America, Grinnell Mechanical Products, Anvil International Gruvlok or an Engineer approved equal. Fittings shall comply ASTM A536 with grooves or shoulders to accept grooved end couplings. Mechanical couplings shall consist of ductile iron housing, synthetic rubber gasket of a central cavity pressure-responsive design, nuts, bolts, locking pin, locking toggle, or lugs to secure grooved pipe and fittings.

1. Rigid type: Housings (12" and smaller) shall be cast with offsetting, angle-pattern bolt pads or tongue and groove design to provide system rigidity and support and hanging in accordance with ASME B31.1 and B31.9..Only designs that require metal-to-metal pad contact permitted. Designs that permit spaces or gaps at bolt pads or require a torque as a primary means of ensuring joint rigidity per written manfuacturer's instructions not permitted. Victaulic Style 107H, Style 07 or W07 or Gruvlok Style 7401, Style 7402, Style 7400.
2. Flexible Type: Use in locations where vibration attenuation and stress relief are required. Victaulic Style 177, 77 and W77 or Anvil International Gruvlok Style 7001.. Three (3) flexible couplings may be used in lieu of each flexible connector at major equipment in accordance with published guidelines.
3. Flange Adapters: Ductile iron housing, flat face, for use with grooved end pipe and fittings, for mating directly with ANSI Class 125, 150, and 300 flanges. Victaulic Style 741, W741 or 743 or Anvil International Gruvlok Style 7012, 7013 or 7788.

E. Any piping conveying well/ground water shall be either schedule 40 PVC or type 'L' copper. Steel piping shall not be allowed. PVC shall only be allowed underground and stubbed into the building wall except as otherwise noted on the plan such as for the spin down filters.

F. Copper Hydronic Pipe Mechanical Fittings by Viega ProPress or approved equal by Elkhart or Nibco: Bronze or copper shall conform to the material requirements of ASME B16.18 or ASME B16.22, and the performance requirements of IAPMO PS117, and ICC LC1002. ProPress fittings ½-inch thru 4-inch for use with ASTM B88 copper tube type K, L, or M and ½-inch up to include 1-1/4-inch annealed copper tube. ProPress fittings shall have an EPDM sealing element and Smart Connect (SC) feature. 2-1/2-inch thru 4-inch shall have a 420 stainless steel grip ring, PBT separator ring, EPDM sealing element and Smart Connect (SC) feature. Sealing elements shall be verified for the intended use

ProPress bronze, or copper fittings: Pipe ends shall be cut on a right angle (square) to the pipe. Pipe ends shall be reamed and chamfered, all grease, oil or dirt shall be removed from the pipe end with a clean rag. Visually examine the fitting sealing element to insure there is no damage, and it is properly seated into the fitting. Insert pipe fully into the fitting. Make a mark with a felt tip pen on the pipe at the face of the fitting. Always examine the tube to insure it is fully inserted into the fitting prior to pressing the joint. ProPress fittings ½-inch thru 4-inch shall be joined using Ridgid ProPress Tools. 2-1/2-inch thru 4-inch ProPress copper fittings shall utilize Ridgid ProPress XLC Rings, and 2-1/2-inch thru 4-inch bronze ProPress fittings shall utilize Ridgid ProPress XL Rings. ProPress fittings shall be installed according to the most current edition of the Viega installation guidelines. Sealing elements shall be verified for the intended use. Installers shall attend a Viega ProPress installation training class.

After ProPress fittings have been installed a "step test" shall be followed. Utilizing air, water, or dry nitrogen, pressurize the system not to exceed 85 psi. Walk the system and check for leaks. If you do not locate any leaks proceed to pressurize the system to the recommended pressures, not to exceed 600 psi. Should you locate a leaking joint that has not been pressed, relieve the pressure from the system, ensure the tube is fully inserted into the fitting and press the fitting. Resume test procedure, after the necessary repairs have been made. This test shall be in addition to the required hydrostatic tests specified elsewhere within the specification.

G. Refer to section on radiant heat and underslab tubing for materials required for those applications.

H. Steel Hydronic Pipe Mechanical Fittings by Viega MegaPress or approved equal via welded, threaded or grooved piping system method: ½-inch through 2-inch shall conform to ASME B31.1, ASME B31.3, or ASME B31.9 MegaPress fittings with zinc and nickel coating for use with IPS carbon steel pipe conforming to ASTM A53, ASTM A106, ASTM A135, or ASTM A795. MegaPress fittings shall have an EPDM sealing element, 420 stainless steel grip ring, separator ring, and an un-pressed fitting leak identification feature. Sealing elements shall be verified for the intended use. Installation must be in accordance to manufacturer's instructions and specifications

Mega Press Systems: Pipe ends shall be cut on a right angle (square) to the pipe. Pipe ends shall be reamed chamfered and all paint, lacquer, grease, oil or dirt shall be removed from the pipe end with an abrasive cloth or Viega pipe end prep tool. Visually examine the fitting sealing element to insure there is no damage, and it is properly seated into the fitting. Insert pipe fully into the fitting. Make a mark with a felt tip pen on the pipe at the face of the fitting. Always examine the pipe to insure it is fully inserted into the fitting prior to pressing the joint. MegaPress fittings hall be joined using Ridgid MegaPress Tools. MegaPress fittings shall be installed according to the most current edition of the Viega installation guidelines. Sealing elements shall be verified for the intended use. Installers shall attend a Viega MegaPress installation training class.

2.05 STEEL PIPE: HEATING WATER SUPPLY AND RETURN (HWS&R)

A. Pipe: Black, Schedule 40 conforming to ANSI B125.2 or B125.1. Pipe to be used for welding shall be furnished with beveled ends.

B. Fittings:

1. 2 in. and smaller, screwed, 125 lb. cast iron conforming to ANSI B16.4.

2. 2-1/2 in. and larger, screwed, 150 lb. malleable iron conforming to ANSI B16.3.

3. For welded pipe, all sizes, standard weight black steel welding pattern conforming to ANSI B16.5, B16.9, and B16.25.

C. Joints: Screwed joints shall be made up with Teflon pipe thread tape, Teflon liquid, or other approved non-hardening joint compound applied to male thread only. Welded joints shall be made by oxyacetylene or electric
arc process and comply with latest ASA "Code for Pressure Piping" requirements.

D. Any pipe 1-1/4 in. and larger may be welded, no pipe larger than 3 in. shall be screwed.

F. Coil connections are to be made so the coil can be removed without cutting pipe.

2.06 HEATING WATER SUPPLY AND RETURN (HWS&R), (LESS THAN 3 IN.) AND CONDENSATE DRAIN (C) PIPING (ALL SIZES)

A. Copper Tube Pipe: Type L, hard drawn, conforming to ANSI H23.1.

B. Fittings: Wrought copper solder pattern conforming to ANSI B16.22.

C. Joints: Made with 95-5 tin-antimony solder using non-corrosive flux.

E. The Contractor has the option to use copper pipe on heating supply and return and heating/cooling water supply and return for 2 in. diameter piping or less.

F. Exception: Condenser water supplied by the geothermal well system shall be scheduled 40 PVC with solvent welded joints.

2.07 REFRIGERANT PIPING & ACCESSORIES

A. All refrigerant piping, liquid, and suction shall be type "ACR" copper tube, hard drawn, shipped to job site with end caps in place. Fittings shall be refrigerant grade copper fittings. Pipe and fittings shall conform to ANSI B31.5 and ANSI B9.1. Piping shall be complete with all refrigerant specialties, of line size, as indicated on the Drawings, and as required by installation requirements. Joints shall be silver soldered or brazed.

B. Piping shall be ASTM B88 type L hard drawn copper tube, cleaned and capped in accordance with ASTM B280, and marked "ACR", with ANSI B16.22 wrought copper or forged brass solder-type fittings.

C. REFRIGERANT PIPING ACCESSORIES
Provide all refrigerant piping specialties with a maximum working pressure of full vacuum to 450 psig and a maximum working temperature of 225 deg F. For systems using R-410A, provide all refrigerant piping specialties with a maximum working pressure of full vacuum to 800 psig and a maximum working temperature of 225 deg F.

Flexible pipe connectors: Double braided bronze hose flexible pipe connectors with brazed end connections.

Filter Dryers: For circuits 15 tons and over provide angle pattern filter dryers with replaceable core. For circuits below 15 tons provide straight pattern filter dryers without replaceable core.

Sight glasses: Two-piece brass construction with brazed end connections. Include color indicator for sensing moisture.

Solenoid Valves: Two way normally closed with two piece brass body, full port, stainless steel plug, stainless steel spring, teflon diaphragm and solder end connections. Provide replaceable coil assembly.

Hot Gas Bypass Valves: Provide with integral solenoid valve, external equalizer connection and adjustable pilot assembly.

Thermostatic Expansion Valves: Brass body, bronze disc, neoprene seat, bronze bonnet, stainless steel spring and solder end connections.

Charging Valves: Provide ¼" SAE brass male flare access ports with finger tight, quick seal caps. Provide 2-inch long copper extension sections.

Check valves: Spring loaded type with bronze body, bronze disc, neoprene seat, bronze bonnet, stainless steel spring and solder end connections.

D. PREPARATION
Remove all foreign material from interior and exterior of pipe and fittings.

E. ERECTION & INSTALLATION
Install all piping parallel to building walls and ceilings and at heights which do not obstruct any portion of a window, doorway, stairway, or passageway. Where interferences develop in the field, offset or reroute piping as required to clear such interferences. In all cases, consult drawings for exact location of pipe spaces, ceiling heights, door and window openings, or other architectural details before installing piping.

Do not route piping through transformer vaults or above transformers, panel boards, or switchboards, including the required service space for this equipment, unless the piping is serving this equipment

Install all valves and piping specialties, including items furnished by others, as specified and/or detailed. Make connections to all equipment installed by others where that equipment requires the piping services indicated in this section.

Refrigeration piping to be installed by firms who are experienced in installation of such piping.

All joints to be brazed and have a melting point greater than 1,125 degrees F. Filler impurities shall not exceed 0.15%. Tubing to be new and delivered to the job site with the original mill end caps in place. Purge all lines with nitrogen during brazing. Provide manual shut-off and check valves as required.

No refrigerant is to be vented directly to the atmosphere except that which may escape through leaks in the system during leak testing. During evacuation procedures, use equipment designed to recover and allow recycling of the refrigerant.

Leak test the system by charging the system with nitrogen to a low 10 psig pressure at first and with the compressor suction and discharge valves closed and with all other system valves open. Increase pressure to 300 psig with dry nitrogen. Rap all joints with a mallet and check for leaks with an electric leak detector having a certified sensitivity of at least one ounce per year. Seal any leaks that may be found and retest.

After completion of the leak test, evacuate the system with a vacuum pump to an absolute pressure not exceeding 1500 microns while the system ambient temperature is above 60°F. Break the vacuum to 2 psig with the refrigerant to be used in the system. Repeat the evacuation process, again breaking the vacuum with refrigerant. Install a drier of the required size in the liquid line, open the compressor suction and discharge valves, and evacuate to an absolute pressure not exceeding 500 microns. Leave the vacuum pump running for not less than two hours without interruption. Raise the system pressure to 2 psig with refrigerant and remove the vacuum pump.

Charge refrigerant directly from original drums through a combination filter-drier. Each drier may be used for a maximum of three cylinders of refrigerant and then must be replaced with a fresh drier. Charge the system by means of a charging fitting in the liquid line. Weigh the refrigerant drum before charging so that an accurate record can be kept of the weight of refrigerant put in the system. If refrigerant is added to the system through the suction side of the compressor, charge in vapor form only.

2.08 UNIONS

A. Unions shall be of the same class and material as the pipe and fittings of the system in which they are installed. In black steel piping systems, they shall be 200 lbs. black malleable iron with brass ground joint equal to Dart Figures 0832, 0834, 0835, 0836, or 0838. In copper and brass piping, they shall be 125 lb. bronze or brass with ground joint.

B. Flanged unions for welded pipe shall be weld neck, 150 lb. raised face. Flanged joints shall be packed with impregnated asbestos gaskets placed inside the bolt circle with graphite applied to both faces.

C. Dielectric unions shall be provided between ferrous and non-ferrous piping to prevent galvanic corrosion. The dielectric unions shall meet the requirements for tensile strength of pipe fittings in accordance with Federal Specification WW-U-531 and shall be suitable for temperatures and pressures encountered. The ends shall be threaded, flanged, brazed, or soldered to match adjacent piping. The metal parts of the union shall be separated so that the electrical current is below 1 percent of the galvanic current which would exist with metal to metal contact.

2.09 INSULATION

A. General

1. Provide materials complying with NFPA Bulletin 90-A, as determined by UL method 723,NFPA 225-ASTM E 84, and complying with the governing code, with flame spread rating under 25 and smoke developed rating under 50.
2. Insulation properties must meet or exceed the minimum R-values required by the IMC 2012, IECC 2015 and the applicable Stretch Energy Code adopted by the City/Town as applicable and those indicated herein.
3. Where vapor barriers are used, provide intact and continuous throughout.
4. Minimum post consumer recycled content of 58.5%.
5. Acceptable manufacturers:
   - Owes/Corning Fiberglass
   - Knauf
   - Manville
   - Certainteed

B. Supply, Return & Relief Air Ductwork

1. The following ductwork shall be insulated:
   - All supply air, return air and mixed air ductwork shall be insulated. Supply and mixed air ductwork located within a return air ceiling plenum must be insulated and are not exempt from insulation. Return air ductwork located within a ceiling cavity within the building thermal envelope, where a conditioned area matching the air conditions of the conveying duct is located above and below this ceiling cavity need not be insulated.
   - Relief and exhaust air ductwork from the discharge point to the backdraft or isolation damper (see outdoor air ductwork).
   - All supply air duct and exhaust air ductwork connecting to an energy recovery unit. This includes recovery unit exhaust air ductwork from the unit to the building envelope discharge point.

2. Above ductwork shall be insulated with 2 inch thick flexible blanket duct insulation with vapor barrier, 1.0 lbs. per cu. ft. density glass fiber with maximum K factor of 0.25 at 75 degree F. mean temperature with fire retardant foil/Kraft (FSK) vapor barrier facing. Product shall be Owens Corning SOFTR™ Type 100 or equal with an installed R-value of 6.0 or greater. All seams and joints shall be taped with matching fiberglass reinforced foil vapor barrier tape. Exposed supply and return ductwork located within the conditioned it serves need not be insulated. Duct indicated as being internally lined need not be externally insulated except when located on the roof or within an unconditioned space.

C. Outdoor Air Ductwork

1. All outdoor air ductwork including combustion air ductwork and outdoor and relief/exhaust air louver plenums shall be insulated with 2 inch thick flexible blanket duct insulation with vapor barrier, 1.5 lbs. per ft. density glass fiber with maximum K factor of 0.24 at 75 degree F mean temperature with fire retardant foil/Kraft (FSK) vapor barrier facing. Ductwork within mechanical rooms shall be rigid type insulation. Product shall be Owens Corning SOFTR™ Type 150 or equal. All seams and joints shall be taped with matching kraft paper vapor barrier tape.

D. Exterior Ductwork

1. Exterior Supply & Return Air Ductwork: All supply air and return air ductwork located outside the heated building envelope shall be insulated with 2” thick polyisocyanurate closed-cell rigid duct insulation, ASTM C 591, type IV, K=0.19), for use at temperatures up to 149 degree C (300 degree F) regardless of whether internal lining is present. Insulation shall be sloped so as to pitch water towards edge of ductwork.

2. Provide covering on all exterior insulated ductwork and equipment. Product shall be field-applied or pre-applied protective finishing and/or vapor sealing, operating within the range of -94°F (-70°C) and 300°F (149°C), jacketed with laminated, flexible, self-adhering, protective jacketing, vapor barrier and weather proofing membrane, having a high performance acrylic adhesive capable of installation with no additional mechanical attachment. Material is to be VentureClad 1577CW (5ply) Natural, White (White Membrane “WM”), or approved equal finish selected based on availability and desired final appearance of insulated system. Jacketing material is to have a maximum flame spread/smoke developed index of 10/20 per UL 723 test, a .000 water vapor permeance rating per ASTM E-96, and mold inhibitors incorporated. All products are UV stable. Fabrication and installation shall conform to the manufacturer’s installation instructions and Midwest Insulation Contractors Association National Insulation Standards Manual. If there is conflicting information, manufacturer’s installation instructions are to be followed.

E. Ductwork in Mechanical Rooms:

1. All ductwork exposed within the mechanical room shall be insulated with rigid duct insulation (1.5” thick for supply and return and heat reclaimed exhaust and 2” thick for outdoor air ductwork) with vapor barrier, 3.0 lbs. per ft. density glass fiber with maximum K factor of 0.23 at 75 degree F mean temperature with fire retardant foil/Kraft (FSK) vapor barrier facing. Duct indicated as being internally lined need not be externally insulated (except when located on roof).

F. Piping Insulation

1. All hot water and glycol water piping (supply and return) shall be insulated with 2" thick pipe insulation with a conductivity of 0.21 BTU-inch/HR-SF-F. Hot water piping insulation shall be equivalent to Owens Corning Fiberglas™ with Evolution™ Paper Free all service jacket. All condensate piping and domestic water feed lines to the hydronic system shall be insulated with minimum ½" thick pipe insulation similar to that specified above. Provide Zeston, Proto or equal polymer fittings at all elbows and fittings. Seal all joints and seams vapor tight. For piping 2" or greater in size provide high-density crush resistant (calcium silicate blocking or equal) insulation at all hangers. Provide 14 gauge 18" insulation shields at every hanger. Vapor barrier must be maintained continuously on all piping.
2. Refrigerant vapor (suction, hot gas and evaporating liquid) piping shall be insulated with 1" thick closed cell pipe insulation as manufactured by Armorcell or equal with seams and joints cemented vapor tight. All insulation exposed to the exterior of the building shall be covered with U.V. resistant PVC jacket.
3. Provide covering on all exterior insulated piping and equipment. Product shall be field-applied or pre-applied protective finishing and/or vapor sealing, operating within the range of -94°F (-70°C) and 300°F (149°C), jacketed with laminated, flexible, self-adhering, protective jacketing, vapor barrier and weather proofing membrane, having a high performance acrylic adhesive capable of installation with no additional mechanical attachment. Material is to be VentureClad 1577CW (5ply) Natural, White (White Membrane "WM"), or approved equal finish selected based on availability and desired final appearance of insulated system. Jacketing material is to have a maximum flame spread/smoke developed index of 10/20 per UL 723 test, a .000 water vapor permeance rating per ASTM E-96, and mold inhibitors incorporated. All products are UV stable. Fabrication and installation shall conform to the manufacturer's installation instructions and Midwest Insulation Contractors Association National Insulation Standards Manual. If there is conflicting information, manufacturer's installation instructions are to be followed.

E. All kitchen hood exhaust ductwork and elevator vent ductwork shall be insulated with two (2) layers of 1-1/2" (3" total installed thickness) of Fire Master, Duct Wrap or approved equal. Install per manufacturer's instructions. Support system with approved thermally isolated hangers.

F. Where specifically noted herein or noted on the drawings provide acoustical sound absorption of equipment externally wrap devices with acoustical insulation as noted herein. Acoustical insulation shall be Sound Seal #BBC-15 or approved equal composite wrap consisting of a 1" thick nonwoven pourous scrim faced quilted fiberglass absorber/decoupler that is bonded to a reinforced 1 psf loaded vinyl noise barrier. Pieces shall be custom fabricated to fit each unit with seams for service to equipment provided with Velcro seals. Product shall have a fame spread of 12.5 and a smoke developed or 19.5 and in no case shall exceed 25 flame spread & 50 smoke developed. Sound Transmission Loss ratings shall be across the full octave spectrum with an STC of no less than 27.

G. Refer to Ductwork Article for internal acoustical insulation.

2.10 HANGERS AND SUPPORTS

A. Provide seismic bracing shall be provided regardless of exceptions allowed by code for this seismic category in conformance with the Commonwealth of Massachusetts building code 780 CMR, 9th edition, Chapter 16. Contractor shall hire a seismic consultant to comply with requirements of the code. All equipment and ductwork shall be seismically supported and all piping over 2". Mechanical seismic control exceptions noted in the code for the buildings

seismic category shall not apply. For the purposes of seismic design of the mechanical systems, the building shall be considered an emergency shelter.

All horizontal piping shall be supported for its entire length. Suspended piping shall have hangers located within 2 ft. 0 in. of elbows and spacing shall be reduced, where required, to support heavy groups of fittings and valves. Grinnell Figure numbers are used to establish the desired style and quality. Other equal manufacturer, as approved by the Architect-Engineer, will be acceptable. All hangers shall be UL or FM approved for the application and use.

B. Maximum spacing of hangers and supports shall be as follows:

1. Steel Pipe: 1-1/2 in. and smaller - 6 ft. 0 in.

2. Steel Pipe: 2 in. to 8 in. - 8 ft. 0 in.

3. Copper Tube: 1-1/4 in. and smaller - 5 ft. 0 in.

4. Copper Tube: 1-1/2 in. and larger - 8 ft. 0 in.

C. Pipe attachments shall be as follows:

1. All piping up to 2 in. diameter shall be supported using pipe rings or bands.

2. All systems 2-1/2 in. to 6 in. pipe sizes and
insulated pipe 1-1/2 in. and smaller - Grinnell Figure 260 adjustable clevis type.

3. All systems, bare or insulated pipe 6 in. and larger - Grinnell Figure 174 or 181 adjustable swivel roll type.

4. All systems, where overhead space is limited and pipes are close to underside of beams or slabs - Grinnell Figure 171 double rod roll hanger. Pipe installed on rack supports shall be supported on pipe roll chairs or stands equal to Grinnell Figure 175 or Figure 271.

5. All vertical drops of pipe 2-1/2 in. and larger shall be supported from the floor, including all pump suction and discharge piping.

6. Pipe attachments in metal to metal contact with copper and brass pipe shall be copper plated or PVC coated.

7. On all insulated pipes, provide attachments sized for outside diameter of insulation to permit insulation to pass through hanger. Include pipe covering protection shields at all hangers.

D. Supporting rods for hangers shall be adjustable, threaded with locknuts sized as follows:

1. Pipe: 2 in. and smaller - 3/8 in.
2-1/2 in. to 3-1/2 in. - 1/2 in.
4 in. and 5 in. - 5/8 in.
6 in. - 3/4 in.
8 in. to 12 in. - 7/8 in.

2. Where double rod hangers are used, the rod size may be reduced one (1) size below the above sizes.

E. Hanger rods shall be secured to building by one of the following approved structural attachments:

1. To concrete structure - use inserts, Grinnell Figure 28, galvanized steel. Where additional supports are needed after concrete work is completed or where required in solid masonry, use self-drilling inserts equal to Phillips "Red Head" or expansion shields equal to Grinnell Figure 117. Cadmium plated piping 10 in. and larger is to be supported from wall, floor, or steel structure.

2. To overhead steel deck - use Grinnell Figure 209 toggle bolt with washers and Figure 209 rod coupling; or weld rod to 1/4 in. thick by 4 in. by 4 in. fish plate laid across top of steel deck; or bolt and weld Grinnell Figure GS-l00H channels not less than 12 in. long to underside of steel deck at right angle to ribs and attach hanger rods with GS-40 nuts.

3. To structural steel beams for pipes 2-1/2 in. to 5 in. - by beam clamps, Grinnell Figure 229, 265, or 267; 6 in. to 10 in. by bolted and welded beam attachments - Grinnell Figure 66 or 252. For pipes 2 in. and smaller, use malleable iron C-type beam clamps with retaining clip, Grinnell Figure 87; all piping is to be hung from the top chord of all steel joists. All piping 4 in. and larger shall be supported from 2 in. angle iron spanning between two (2) joists to spread loading. For joists, pipes and/or supplemental support steel must be attached to top of joist at panel points.

F. Pipes running along walls or close to floor shall be supported as follows:

1. Piping along walls may have hanger rods supported from welded steel brackets, Grinnell Figure 195, or in lieu of the above, for 4 in. and larger, may rest on adjustable roll stands supported by welded channel or I-beam wall brackets.

2. 2 in. and smaller - supported from floor on legs of angle iron, channels, or pipe legs.

3. 2-1/2 in. to 4 in. - adjustable pipe saddles, Grinnell Figure 264, supported from floor to pipe legs.

3. 4 in. and larger - pipe roll and plate, Grinnell Figure 277 supported as masonry piers and shimmed to provide proper pitch as required, or Grinnell Figure 276 adjustable pipe roll stands supported on masonry piers, welded steel channels, or I-beams.

G. Groups of horizontal pipe 3 in. and smaller, running at the same elevation, may be supported by means of vertical hangers and horizontal angles, channels, or "Unistrut" on which pipes shall rest and be held in alignment with suitable pipe clamps. Building attachments must be sized for total load of all pipes. Details of such hangers must first be approved by the Architect-Engineer. No contact between dissimilar metal is permitted.

H. Equipment Supports:

1. All floor mounted machinery and equipment shall be installed on minimum 4 in. thick concrete housekeeping bases with top edge of base chamfered at a 45 degree angle. Bases will be provided under other Sections of these Specifications. Furnish scaled layouts of all required bases, with dimensions of bases, and location to column center lines. Furnish templates, anchor bolts, and accessories necessary for base construction.

2. Furnish and install all supplementary steel, channels, and supports required for the proper installation, mounting, and support of all equipment. Supplementary steel and channels shall be firmly connected to the building construction.

3. The type and size of the supporting channels and supplementary steel shall be of sufficient strength and size to allow only a minimum deflection in conformance with the manufacturer's requirements for loading.

4. All supplementary steel and channels shall be installed in a neat and workmanlike manner parallel at the walls, floor, and ceiling construction. All turns shall be made with 90 degree and 45 degree fittings, as required to suit the construction and installation conditions. Provide factory-fabricated tank saddles for tanks mounted on steel stands.

5. Where ceiling mounting is indicated or specified, use suspended platform or hangers, brackets, or shelf, whichever is most suitable for equipment and its location. Construct structural steel members, steel plates, rods, as required; brace and fasten to building structure or to inserts as approved.

I. Rooftop pipe support shall be similar to Portable Pipe Hangers item number PP10 w/roller. Base Material: Injection molded high impact polypropylene with UV-inhibitors and Antioxidants. Hardware: Nuts, Washers, Rod and Roller: Hot Dip Galvanized. Coordinate with roofer prior to installation."

J. Roof ductwork shall be supported by galvanized steel tube supports and cross angles anchored to the roof steel and fully flashed to roof. Coordinate fully with structural steel and roofer and provide misc. steel supports as required.

K. Rooftop condensing units shall be set and fully flashed roof curbs and be fixed on a rail support system by Roof-Pro model #PF-1-T or equal by Uni-Strut. Supports system shall be anchored to flashed roof curbs with gasketed connections so as to prohibit water infiltration of the flashed curb.

2.11 PIPE SLEEVES AND ESCUTCHEONS

A. Standard IPS steel or wrought iron sleeves shall be provided wherever exposed pipes pass through masonry walls or partitions. Pipe sleeves are to be two (2) pipe sizes larger than line size. On insulated piping, sleeves shall be sized to allow insulation to pass through the sleeve without gouging. Within continuous vertical enclosed pipe chases, sleeves through floors may be 24 gauge galvanized sheet steel in lieu of iron pipe.

B. Iron pipe sleeves shall be provided through "wet" floors (such as kitchens, toilets, janitor's closets) and shall be extended 1 in. above finished floors. Sheet metal screws may be used in other locations and shall be cut flush with floor. Pipe sleeves in walls shall be flush with face of wall both sides. Pipe sleeves through outside walls must be caulked watertight or installed with Eclipse flanged service entrance sets.

C. Provide escutcheons equal to Grinnell Figure 10 or Figure 13, chrome plated, at all locations (except inside unfinished mechanical equipment rooms and enclosed pipe chases) wherever exposed bare pipes 4 in. or smaller pass through walls, floors, or ceilings.

2.12 VALVES

A. All valves shall be of a design, which the manufacturer lists for service and shall be of the materials allowed by the latest edition of the ASME Code for pressure piping for the pressure and temperature contemplated, unless higher grade or quality is specified herein. All valves shall be of the same manufacturer except for special applications.

B. The system shall be supplied with valves in all branch mains and risers, at all pumps, tanks, reducing and control valves, heating and cooling surfaces and at all apparatus; so located, arranged and operated as to give complete shut-off. Except where flanged valves are used, each connection to equipment shall be made with screwed or flanged unions on the equipment side of the valves.

C. All valves 2” in diameter and smaller shall be bronze with bronze bodies. Valves 2-1/2” in diameter and over shall have iron bodies with bronze trim (except where otherwise noted).

D. Ball valves shall be full port bronze body, bronze or stainless steel ball and stem, Teflon seats and seals, threaded ends, 400 psig cold W.O.G. by Apollo, Watts or Jenkins.

E. All bronze and iron valves shall be furnished with Teflon impregnated packing.

F. Butterfly valves shall only be allowed on piping 3” and larger and shall be tight shut- off type with angle/worm gear handle mechanism with position marker.

G. All valves on PVC piping systems shall be PVC full port ball type.

H. Provide valves of the type as shown on the drawings as specified herein and as scheduled:

Service	Valve Type	Rating	Remarks
Water	Ball	400 W.O.G.	all sizes
Water Throttling	Globe	200	3” and larger
Water Shut-off & Throtl.	Butterfly	200	3” and larger
Drain Valves	Ball	200 W.O.G.	Hose end & cap

2.13 ELECTRIC CABINET & BASEBOARD HEATERS

A. Electric heaters shall be factory assembled for surface mount field installation. Enclosures shall be 16-gauge steel with corrosion resistant finish; color selection shall be by Architect. Cabinet and unit heaters shall be Berko, Qmark, Electromode or equal.

B. Coils shall be single terminal, long life electrical fin tube with helical coiled fins. Fan shall be either squirrel cage type or propeller. Provide automatic reset thermal overload protector, integral tamper resistant thermostat, fan speed switch and disconnect switch. Provide EMS interface package for EMS operation where noted or required elsewhere by the specification or on the plans.

2.14 VAV TERMINALS

A. Provide variable air volume (VAV) terminals as scheduled and shown on the drawings and specified herein. Units shall be manufactured by Krueger, Titus, Nailor or approved equal. All terminals shall be certified under ARI Standard 880-94. Physical size and dimension of box and sound criteria is critical to acceptance as an approved equal.

B. The terminal casing shall be constructed of minimum 22 gauge galvanized steel, internally lined with 1" hospital grade closed cell insulation with moisture resistant and anti microbial coating all complying with UL 181 and NFPA 90A.

C. The damper shall be constructed of heavy gauge steel with shaft rotating in bronze self-lubricating bearings. Damper shall include a synthetic seal to limit full closed damper leakage to no more than 4 CFM at a pressure difference of 1.5"w.g.

D. All boxes shall be furnished with electronic digital controls matching the building EMS including flow/velocity sensor, modulating damper motor & actuator. Fully coordinate with EMS contractor for factory or field installed controls. Refer to Automatic Temperature Controls for additional information. All box controls shall match DDC system control manufacturer.

E. Hot water coil where scheduled shall be copper tube type with aluminum fins leak tested to 300 psi and burst tested to 2000 psi. All coils shall be tested and rated in accordance with ARI Standard 410.

2.15 VARIABLE FREQUENCY DRIVES

A. For the all equipment specified within this specification section and/or shown on the drawings, provide variable frequency drives of the characteristics described herein. Acceptable manufacturers contingent on compliance with this specification are as follows:
- Allen Bradley
- ABB
- Toshiba

B. This contractor shall furnish and install VFD's. Electrical contractor shall provide power wiring to VFD and from VFD to respective motor.

C. Unit must be capable of interfacing with the buildings energy management system to openly communicate all faults, points and operational data (i.e. fan speed, amperage draw, wattage, etc…). Units shall be provided with required interface hardware and software and communication port (RS-485 or equal) for open protocol interface to the building EMS.

D. Input and monitoring control signals must be compatible with automatic control system. Submit acceptance and compatible letter with submittal.

E. The VFD shall comply with the latest applicable standards of ANSI, IEEE 519 and NEMA. All drives must be U.L. or E.T.L. listed.

F. The VFD shall submit harmonic calculations in accordance with IEEE 519 standards. In any event the total harmonic voltage and current distortion levels shall be no greater than 5%. Provide line reactors as required to achieve this specification.

G. The VFD shall be of the pulse width modulating design with an efficiency greater than 96% at 100% speed and load. Power factor displacement shall exceed 0.95 regardless of speed and load.

H. VFD shall be capable of receiving start/stop and modulating 4-20mA input signals. In turn the VFD shall be capable of modulating the speed of the respective motor accordingly and send 4-20mA feedback signals to the EMS system in addition to alarm conditions. VFD's shall be provided with a BacNet (type as determined by selected EMS system vendor) communication interface card for communication to the building EMS.

I. VFD shall have door-mounted controls and status indication from an LED display capable of showing as a minimum RPM, Amperage draw, elapsed operating time, frequency, etc. The door-mounted keypad shall allow you to access these features and override the input signal.

J. For fans VFD's shall come equipped with a true bypass circuit which shall allow the user to bypass all the internal circuitry of the VFD and place the respective motor in manual operation with a Bypass-Auto, Hand-Off selector switch.

K. Testing, checkout and start-up of the VFD equipment shall be performed under the technical direction of the manufacturer's service engineer. During setup all critical speeds shall be locked out to protect connected equipment. Under no circumstances are any portions of the drive system to be energized without authorization from the manufacturer's representative.

L. Contractor shall provide all supplemental steel, supports, rods and hangers necessary to hang or mount the VFD's.

2.16 EXHAUST FANS

A. Exhaust fans shall be of the type and capacity shown on the Drawings; Greenheck, Carnes, Penn or equal. Fans shall be tested in accordance with AMCA and bear the AMCA Certified Performance Ratings Seal; fans shall be UL Listed. Provide all with disconnect switches (NEMA 3R weatherproof where exposed on roof).

B. Centrifugal roof exhaust fans shall be heavy gauge aluminum mounted on a rigid support structure to provide minimal resistance to airflow and minimal noise generation. Fan wheel shall be of the aluminum backward curved centrifugal type belt driven. Motorized backdraft dampers shall be provided on each roof exhaust fan. Backdraft damper shall be interlocked with operation of exhaust fan to open fully, or modulate as specified, upon fan activation and close completely when fan is disabled. If dampers are not shown connected on the electrical plans, this Contractor shall hire the project electrician to wire the dampers to interlock with fan operation. Fans shall come with a factory wired and mounted disconnect switch.

C. Ceiling exhaust fans shall be direct drive centrifugal type. Motor and fan shall be removable from housing; motor shall have ball bearings. Housings shall be steel with acoustic insulation; provide ceiling grille. Provide factory mounted disconnect switch and backdraft dampers. Provide hanging vibration isolators. For fans in emergency electrical rooms and elevator machine rooms provide 1-1/2 hour ceiling radiation fire damper at fan grille.

D. For kitchen hood exhaust fans provide an upblast fan as scheduled rated for kitchen hood duty. Fan shall all be U.L. 762 listed and NFPA 96 compliant. Blower fans shall be constructed of heavy gauge galvanized steel mounted on a rigid support structure. Fan blades shall be non-overloading self cleaning type heavy gauge galvanized welded steel construction. Provide motor weather cover and OSHA guard. All components shall be factory painted with a baked enamel finish. Fan blade shall be spark resistant. Provide pressure class fan as required by the application. Provide a polypropylene or equal side mount grease trap filled with grease absorbent material. Provide two (2) spare absorbant material replacement segments per fan.

E. Utility blower fans shall be constructed of heavy gauge galvanized steel mounted on a rigid support structure. Fan blades shall be non-overloading backward incline type heavy gauge welded steel construction. Provide weather cover, vibration pads, flexible inlet connector, backdraft damper. All components shall be factory painted with a baked enamel finish. Fan blade shall be spark resistant and motor shall be explosion proof. Provide pressure class fan as required by the application.

F. High Plume Hood Fans

1. Provide high plume fume hood fans where scheduled on the drawings similar to Greenheck Vektor-H or approved equal. Provide laboratory rated chemical resistant fan. Performance ratings shall conform to AMCA standard 211 and 311. Fan shall be licensed to bear the AMCA ratings seal for both sound and air performance. Classification for Spark Resistant Construction shall conform to AMCA 99. Fan shall be direct drive or belt drive, be equipped with #316 stainless steel lifting lugs and fasteners and be designed for a minimum of 125 MPH wind loading, without the use of guy wires. All fan and system components (fan, nozzle, windband and plenum) shall be corrosion resistant coated with a two part electrostatically applied and baked, sustainable, corrosion resistant coating system with a minimum total thickness of 6 mils shall exceed 4,000 hour ASTM B117 Salt Spray Resistance. Standard finish color to be gray.
2. Fan housing to be aerodynamically designed with high-efficiency inlet, engineered to reduce incoming air turbulence. Fan housing shall be welded steel with similar corrosion resistant coating. No uncoated metal fan parts shall be acceptable. A high velocity conical discharge nozzle shall be supplied by the fan manufacturer and be designed to efficiently handle an outlet velocity of up to 6000 FPM. Discharge stack caps or hinged covers, impeding exhaust flow shall not be permitted. Provide housing drain for removal of rain and condensation.
3. A bolted and gasketed access door shall be supplied in the fan housing allowing for impeller inspection or removal of impeller, shaft and bearings without removal of the fan housing. Fan impeller shall be centrifugal, backward inclined, with non-stall characteristics. The impeller shall be electronically balanced both statically and dynamically per AMCA Standard 204. Fan impeller shall be manufactured of aluminum (AMCA type B spark resistant), fully welded and must meet corrosion resistant coating. Provide access panel for duct and fan cleaning.
4. For variable volume systems a bypass air plenum shall be provided as shown on

drawings. The plenum shall be equipped with a bypass air damper and intake air hood with bird screen for introducing outside air at roof level upstream of the fan. The plenum shall be constructed of fully welded steel, meet specification section for corrosion resistant coating, and mount on roof curb as shown on the project drawings. The bypass air plenum shall be mounted on factory fabricated roof curb provided by the fan manufacturer. Bypass air dampers shall be opposed-blade design, and coated with up to 4 mils of Hi-Pro Polyester resin, electrostatically applied and baked. A fan isolation damper two position actuated, fabricated of steel or aluminum and coated with minimum 4 mils of Hi-Pro Polyester resin, electrostatically applied and baked, shall be provided. Damper shall be rated for the application.

5. Exhaust system manufacturer shall supply a structural support curb for the plenum, of specified height, as shown on the drawings or required by code or indicated herein. Laboratory hoods shall have a minimum outlet height of 10 feet. Curb shall be fabricated of a minimum of 14 gauge corrosion resistant coated steel and structurally reinforced. Seismic certification requires a minimum of 12 gauge corrosion resistant coated steel and structurally reinforced roof curb be provided. Curbs shall be insulated. When properly anchored to the roof structure, the standard curb / plenum / blower assembly shall withstand wind loads of up to 125 mph without additional structural support.
6. Motors shall be premium efficiency, inverter rated standard NEMA frame, 1800 or 3600 RPM, TEFC with a 1.15 service factor. A factory-mounted NEMA 3R disconnect switch shall be provided for each fan. Motor maintenance shall be accomplished without fan impeller removal or requiring maintenance personnel to access the contaminated exhaust components.
7. Drive belts and sheaves shall be sized for 200% of the motor horsepower, and shall be readily and easily accessible for service, if required. Drive shall consist of a minimum of two belts under all circumstances.
8. Fan shaft to be turned and polished of 316 stainless steel coated with corrosion resistant coating. Fan shaft bearings shall be Air Handling Quality, ball or roller pillow block type and be sized for an L-10 life of no less than 100,000 hours. Bearings shall be fixed to the fan shaft using concentric mounting locking collars, which reduce vibration, increase service life, and improve serviceability. Bearings that use set screws shall not be allowed. All shaft bearings shall have extended lube lines with zerk fittings.
9. Install fans in accordance with manufacturer's instructions. Provide variable frequency drive with true H-O-A bypass circuit for each fan compatible with utility requirements.

G. Fans specified have critical sound performance criteria and configuration requirements that must be adhered to. Any equal substitutions must meet or exceed the quality of the specified unit and have sound performance at or below the levels of the specified fans. Fans shall be licensed to bear the AMCA Seal for sound and air performance.

H. Motors over ½ HP in size shall be premium efficiency type. Refer to schedules for electrical voltage & phase requirements. Provide ECM motors where scheduled. ECM motors shall be equipped with integral control transformer for 0 to 10 VDC control by EMS. Where scheduled ECM motors shall also be fitted with potentiometers for balancing.

I. Each motor on a VFD shall be provided with a shaft grounding device to harmlessly bleed potential induced shaft voltages to ground

J. Furnish H-O-A type combination disconnect and motor starters for each exhaust fan for interface to EMS. Refer to variable frequency drive section, schedules and automatic temperature controls for additional information on fan starters required (i.e. H-O-A's, VFD's, line voltage t'stats, relays, etc.…. Electrical contractor to mount and wire H-O-A starters. All fans shall be furnished with disconnect switch.

2.17 BOILERS

A. Furnish and install as shown on plans in accordance with all codes and authorities having jurisdiction, a condensing type boiler plant as manufactured by Lochinvar, Viessman or Aerco. Boiler plant specified is Lochinvar Crest, consisting of three (3) boiler modules. Acceptable alternate boiler must be capable of properly operating (including full fire) at 4" w.c. entering natural gas pressure. Each boiler shall be UL/FM approved and have a total input of 4,000 mbh each with a gross output of 3,720 MBH (dependent upon return water temperature) when fired with natural gas (total plant input 12,000,000 BTUH and 11,160,000 BTUH output). Overall plant design shall be 140°F supply water temp and 120°F return water temp. Boiler shall be capable of delivering 180°F supply water.

B. Boiler modules shall be of natural gas-fired, condensing fire tube design with a modulating power burner and positive pressure discharge. Water tube design boilers shall not be acceptable. Each boiler shall be capable of 20:1 turndown of firing rate without loss of combustion efficiency. Heat exchanger/combustion chamber shall incorporate a helical fire tube design that will be self supporting, baffle free, and warranted to withstand thermal shock. Heat exchanger shall be ASME stamped for a working pressure not less than 150 psig. Unit shall have an ASME approved relief valve with a setting of 50 psig. Exhaust manifold shall be of corrosion resistant porcelain enameled cast iron, with 8"diameter flue connection. Exhaust manifold shall have a gravity drain for the elimination of condensation with collecting reservoir. Boilers shall not require boiler pumps as minimum system flow shall meet the minimum flow requirements of the boilers. Minimum boiler flow shall be no greater than 25 GPM. Pressure drop through any one unit shall not exceed 4.0 psig under full load. Unit shall be suitable to accept system temperatures at any point along the system design reset schedule without thermal shock or condensation restriction.

C. The flame monitoring system shall incorporate a U/L recognized combustion safeguard system utilizing interrupted spark ignition and a rectification type flame sensor. An electro-hydraulic double seated safety shutoff valve shall be an inherent part of the gas train.

D. Each boiler module shall incorporate electric probe type low water cutoff and dual over temperature protection including a manual reset in accordance with ASME section IV and CSD-1. Remote fault alarm contacts, sensor failure detection, and auxiliary contacts shall be standard equipment. Boilers shall operate on 120 volt 1 phase. Different voltage and phase configurations shall be acceptable however it shall be this sections responsibility to coordinate the change with the CMR and electrical contractor an pay all cost associated with making this change.

E. All aspects of installation of Boiler Plant shall be in strict accordance with manufacturer's instructions. Materials shall conform to all manufacturers' recommendations and shall include a Stainless Steel AL-29-4C Positive Pressure U/L Listed Vent System. Boiler plant piping shall be field constructed of materials as specified. Each boiler shall have individually isolating shutoff valves for service and maintenance.

F. Boiler manufacturer shall supply as part of boiler package a completely integrated microprocessor based Boiler Management System, as furnished by boiler manufacturer, to control all operation and energy input of the multiple boiler plant. The system shall be comprised of a microprocessor based control utilizing pulse width modulation for bumpless transfer of header temperature and sequential firing. The controller shall be PID type for accurate temperature control with excellent frequency response. BMS shall provide contact

closure for automatic adjustable heat start circuit for plant activation and have contact closure for auxiliary equipment such as pumps and combustion air dampers. The controller shall be fully Bacnet or Lon compatible as required by selected EMS system so that the building operator shall be capable of fully monitoring and controlling the boiler plant through the BMS front-end.

G. The BMS will operate on an adjustable inverse ratio in response to outdoor temperature to control the main header temperature outlet to +/-2F. Units shall operate with an Inverse Efficiency Curve, with known Part Load Value Efficiencies. Maximum efficiency shall be achieved at minimum firing input. Reset ratio shall be fully field adjustable from 0.3 to 3.0 in operation. The controller shall have LCD display for monitoring of all sensors and interlocks. Non-volatile backup of all control setpoint shall be internally provided as standard. Control will automatically balance operating time on each module by a first on-first off mode and provide for setback and remote alarm contacts. Connection between central BMS system and individual modules shall be twisted pair low voltage wiring to internal terminal strips for easy installation. System shall be enabled and disabled by the buildings energy management and control system as specified within this specification.

H. The pressure vessel of boiler shall carry an unconditional, non-prorated 10 year warranty against leakage due to defective materials or workmanship. The heat exchanger tubes/ combustion chamber assembly shall be warranted against failure due to thermal stress failure or condensate corrosion for a prorated five year period. All components of the boiler shall be warranted for at least one full year. A Warranty Certificate must be issued to the owner from the manufacturer and a copy of warranty be submitted for engineers approval.

I. Contractor shall provide the services of a local factory authorized representative to supervise all phases of equipment startup. A letter of compliance with all factory recommendations and installation instructions shall be submitted to the engineer with operation and maintenance instructions.

J. Provide ECM variable flow pump for each boiler programmed to be enabled when a respective boiler is called to firing, modulate to optimize temperature drop across boiler and to shutdown after a purge period once a respective boiler is disabled.

K. Provide a serviceable acid neutralizing kit for each boiler. Provide replacement limestone for three (3) full years of operation.

L. Execution:

1. Preliminary requirements: Provide the services of a Company Field Advisor of the Boiler manufacturer for the following:

   a. To assist and review the installing contractor with the assembly and erection of each Boiler. Upon completion of the Boiler assemblies, the Boiler manufacturers Company Field Advisor shall certify the proper assembly and connection of each Boiler prior to startup.

   b. The boiler manufacturers Company Field Advisor shall be Present at time of Start-up to supervise the initial firing of the Boiler(s).

   c. The boiler manufacturers Company Field Advisor shall instruct Boiler Room Operating Personnel.

2. Provide beneath each of the new Boilers, a new poured and reinforced concrete foundation pad at least 4 in. higher than the surrounding floor (4 in. thick), and at least 6 in. wider than the Boiler on all sides. Provide four hold down bolts of at least 5/8-in. diameter into the concrete and fastened through the base channels of the Boiler. The concrete for the foundation pad shall be a mixture of Portland cement, washed aggregate, and potable non-chlorinated water prepared and poured in compliance with Article 15 of the Massachusetts State Building Code and the American Concrete Institute Standard 318. Deliver to the Awarding Authority certification by the concrete supplier that the mixture will attain a 28-day compressive strength of at least 4,000 pounds per square inch. Reinforce this concrete with Number 4 steel reinforcement bars arranged in a 12 inch by 12 inch mesh.

3. Boiler drain valves shall be connected to the lowest water space available and shall be installed with pipe and fittings to connect the bottom Blowoff full size to drain. Furnish and install 3 inch by 1-1/2 inch eccentric reducer in the lower left or right hand tappings of the front section of each Boiler complete with a short nipple and blowoff valve installed. Each blowoff valve shall be Brass, ball type, not less than 1-1/2 inch minimum and rated equal to the pressure stamped on the Boiler and to a temperature rating of not less than 250^{o} F. and all blowdown discharges shall be arranged so as to allow the Operator to view the water that is discharged to drain. Ends of blowdown piping shall be cut at a 45^{o} Degree angle to prevent a cap or plug from being installed.

4. All boiler discharges shall be piped to floor drains or as indicated by the Consulting Engineer. Furnish and install all necessary pipe and fittings to connect the pressure relief valve discharge full size (Minimum Acceptable) to floor drain. Discharge shall be arranged so that there will be no danger of scalding Boiler room personnel in the event of a pressure relief situation. Size and arrangement of discharge piping shall be such that any pressure that may exist or develop will not reduce the relieving capacity of the relief valve below that required to protect the Boiler. All such discharge piping shall be supported by hangar or standoff to prevent the valve body from undue stress or strain.

5. Installing Contractor shall utilize capped tees at all turns in the return piping to the back section of each Boiler for cleaning of the return piping at or near each Boiler. Feedwater, makeup water and/or water treatment shall be introduced into the Boiler water through the return piping only. Provisions shall be made for the expansion and contraction of all hot water mains connected to each Boiler by providing substantial anchorage at suitable points and by providing swing joints so there will be no stress or strain transmitted to either Boiler. Stop valves shall be provided in the supply and return pipe connections to each Boiler permitting draining any Boiler without emptying the entire system.

6. After final assembly and connection, each Boiler shall be thoroughly cleaned internally following the manner described within the Boiler manufacturers installation instructions.

7. All field tests after the Boiler(s) have been installed and connected to the system shall be limited to not more than 80 PSI. Installing Contractor shall furnish all equipment, piping, labor, staging, fittings, valves, hoses and other materials and shall pay all required permits for Inspection as may be required to perform such tests as may be directed by these Contract Documents and as required by the Consulting Engineer and the State Boiler Inspector.

8. An initial Hydrostatic pressure test of 80 PSI shall be conducted on each Boiler for a period of not less than 5 hours. Tests shall be of such duration as necessary and as directed by the Consulting Engineer to ensure that the Boilers have been installed and piped correctly with no leaks or other improper operating conditions.

9. Installing Contractor shall contact and notify the State Boiler Inspector when the installation of the Boiler(s), Burner(s) and controls is substantially complete. Installing Contractor shall request an inspection of the Boilers to be conducted by the State Boiler Inspector and to have a Certificate of Inspection issued upon satisfactory inspection.

10. After receipt of certificate of Inspection, Installing Contractor shall furnish a suitable glass front frame in which to place said certificate. Frame, with Inspection certificate inserted therein, shall then be placed on or posted in a suitable location within the Boiler room in which the new Boilers have been installed.

11. Installing Contractor shall maintain all apparatus in satisfactory operating condition. Perform periodic Burner tune-up and cleaning of the Boiler fireside surfaces when dirty, provide preventative maintenance, perform turndown tests, conduct tests for Flame Safeguard, Combustion Efficiency, Draft tests, Limit Control tests and Safety Valve tests, check the ignition system and adjust, repair or replace any as necessary while the heating system is under his ownership and control and until such time as the Owner accepts the equipment, issues the Final certificate of Payment and assumes the full obligation of Ownership.

12. Installing Contractor shall note that any Warranty Service (Hereinafter specified) as may be absorbed by the authorized Service representative shall in no way absolve the Installing Contractor from any and all responsibility for the Care, Service and Preventative Maintenance for Materials furnished to this Contract, while the Heating System is under his Control, and until final acceptance by the Owner.

13. Installing Contractor shall guarantee the entire installation for a period of One (1) Year from the date of Owner Acceptance and beneficial usage by the Owner and Date of Final Payment.

K. Commissioning:

1. An authorized representative of the Boiler or Burner manufacturer shall perform the initial start-up, final adjusting and testing of the Burners and Controls in the presence of the Owners Operating Personnel.

2. The process of Start-Up and Commissioning shall include Purging of the Boiler(s); Burner Operation Tests, including CO sampling, Stack Temperature(s); CO_2 sampling; Tests for Venting; Ignition Tests; Manifold Pressure Tests; Instruction to the Owner and all other such procedures as may be directed by the Consulting Engineer.

3. The final results of a Combustion Efficiency Test with all pertinent Combustion Data shall be logged onto a check sheet which shall be submitted to the Consulting Engineer to prove compliance with this section of the Specifications and for Record purposes.

4. Combustion efficiency testing shall include no less than the following:

a. Sample and document CO_2 in the flue gas at Low and High rates of fire with recorded Gross and Net Stack Temperatures to establish stack loss value. Each Burner shall be set to operate at the overall best performance and combustion efficiency for which the equipment is designed and capable of.

b. Adjustment and checkout of all aquastat controls, limits, switches, operating controls, low water cutoff devices, low voltage step control relays, combustion controls, and all Lockout conditions.

c. He shall supervise purging of the Boiler(s). All required tests for proper venting which shall include setting and adjusting the Boiler outlet damper to the Boiler manufacturers specifications.

d. Provide instruction to the Owners Operating Personnel in the procedures to resolve a "Lockout" condition. Operating personnel shall also be instructed in the Operation and routine daily maintenance of the Burner, Combustion Controls, Multiple Boiler Reset Control System and controls during the lightoff process. The Owner shall arrange to have the personnel who require training to be present at the Lightoff.

5. Factory Authorized Burner Service representative shall provide the initial Burner lightoff and One (1) Year of Warranty Burner service. This requirement shall not be waived, nor shall the responsibility for the Service Contract be assumed by any other party unless previously approved by the Consulting Engineer in writing.

6. Burner manufacturers service representative shall furnish One (1) Year of Warranty Burner Service on the Burner(s) and Control(s) which shall commence from the Date of Original Lightoff and shall continue Warranty Burner Service coverage up to and including the First Anniversary of Burner Lightoff.

7. Warranty burner service shall include labor and materials to replace any parts or controls, which might fail in service as the result of a defect in materials or manufacture. Normal wear and tear on parts as the result of daily operation will not be included as "no charge" items (nozzles, ignitors, etc.) and other such devices, which may require replacement as the result of operation during the Warranty Service Contract shall not be included. Preventative maintenance, in the form of yearly tune-up and bi-yearly cleanings and adjustments shall be the responsibility of the Installing Contractor throughout the duration of the Warranty Contract while the equipment is under his control. Preventative maintenance, cleaning and routine adjustments shall not be performed by the warranty service Contractor but by the Owners obligated Service Company.

8. Refer to 3 year parts, labor and maintenance warranty requirement for this equipment elsewhere in the spec.

2.18 FLUE VENTING

A. Furnish and install, where shown on the Drawings boiler flue venting as manufactured by Metal Fab, Heat Fab or Pro Tech Systems. Refer to specification section on Boilers for additional flue venting requirements for boilers.

B. For heating and domestic hot water boiler flue vent exhaust venting provide material as shown on the plans, Category IV. Materials shall conform to all manufacturer's

recommendations and shall be constructed of AL-29-4C Stainless Steel Positive Pressure U/L 1738 Listed Vent System. Inner liner shall be AL29-4C and outer wrapper shall be 430 grade Stainless Steel. Mineral fiber insulation shall be provided between inner and outer sections.

C. Provide all components required for complete system. Venting systems including, but not limited to, pipe sections, tees and elbows, drains, cleanouts, supports, variable lengths, ventilates roof thimble assembly, stack caps. All components exposed to the weather shall be constructed of stainless steel.

D. On combustion air intakes for direct vented units double wall type B-vent may be used for the combustion air intake in lieu of insulated round ductwork or other product as approved by the boiler manufacturer.

E. All flue venting shall be installed in accordance with the manufacturer's published installation instructions.

F. All venting work must be done by a Massachusetts licensed plumber or gas fitter.

2.19 SPECIALTIES

A. See also valve and other sections for additional information.

B. Multi-Purpose Valve – At each pump, Taco model MPV (multi-purpose valve) combination non-slam check valve, globe balancing valve and shut-off valve with calibrated pressure taps as manufactured by Taco or Bell & Gossett. Furnish calibrated meter to Owner upon completion of project. Note:
   1. On ECM pumps and VFD pumps, this device shall be fixed in the 100% open position and is only intended to function as a physical balancing check element and non-slam check valve.
   2. MPV is not required on skid mounted pump sets specified with check and isolation valves.
   3. On smaller pumps 10 GPM and below, in lieu of MPV provide a circuit setter balancing valve, non-slam check valve and ball valve shut-off.

C. Swing Check – Bronze body, 125 W.S.P., 200 W.O.G.

D. Strainers – Strainers shall be iron body ‘Y’ type with stainless steel strainers, 250-psig steam and 400 W.O.G. Provide ball valve with hose bib for blow down similar to Watts # B-6000-CC.

E. Dielectric unions – Provide where joining to dissimilar metals, Watts series #3000 or approved equal.

F. Air Separators – Provide Air Separators for the hot water no smaller than the pipe size or larger as shown on the drawings or to insure the peak flow rate is within the products maximum recommended flow rate. Unit shall be of a fully coalescing type.

   1. For system, HX and radiant loop air separators, other than the boiler decoupler, provide Spriotherm Spirovent or approved equal microbubble separator complete with quick air release vent. On sizes allowing such, provide drain port with valve and hose bib.

2. For the central plant provide boiler system decoupler provide a Spirovent Quad VDX series or equal air eliminator, dirt separator, low less header/decoupler with quick air release and drain valve. Unit shall be of the following construction:

   a. Separator shall be fabricated steel, rated for 150 psig working pressure, stamped and registered in accordance with ASME Section VIII, Division 1 for unfired pressure vessels.

   b. Vessel shall include one chamber above the higher nozzle set for air elimination, one below the lower nozzle set for dirt separation, and one between the upper and lower nozzle sets for hydraulic separation. The vessel diameter, height above and below the nozzles, and distance between the nozzles must be equal to the basis of design.

   c. Units shall include an internal medium bundle filling the entire vessel. The bundle shall consist of a copper core tube with continuous wound copper medium permanently affixed to the core.

   d. Each separator shall have a separate venting chamber to prevent system contaminants from interrupting venting operation. The venting chamber shall employ an integral full port float actuated brass venting mechanism.

   e. Air elimination performance shall be capable of removing 100% of the free air, 100% of the entrained air, and up to 99.6% of the dissolved air in the system fluid.

   f. Dirt separation performance shall be capable of removing 80% of particles 30 micron and larger within 100 passes.

   g. The warranty period shall be a non-prorated period of 36 months from date of purchase

G. Air Vents – Provide automatic air vents at all high points within the system and at all coils. Air vents shall be Sparco model #FV 147A. Vents shall be piped to nearest floor drain.

H. Water pressure reducing valves – Provide water pressure reducing valve for each water feed to the heating water systems. Valve shall be similar to Watts #U5 with strainer and pressure gauge.

I. Balancing Valves – Provide calibrated balancing valves where shown on the drawings and as specified herein, Taco model #ACUF circuit setters. Provide one at each location: 1) at each individual boiler return line; 2) at every water coil; 3) at every baseboard branch, unit heater and cabinet heater; 4) at every fan coil unit. In addition, contractor shall furnish to the Owner a Differential Gauge meter Taco model #789 with durable carrying case and hose connections.

J. Expansion Compensators – Provide housed expansion compensators with associated pipe alignment guides and anchors where shown on the drawings or as required where line lengths exceed 100 feet. Compensators shall have double wall stainless steel bellows housed in carbon steel encloure. Provide Metraflex Joints or approved equal at building expansion joints and seismic separation joints within building where shown on plans. In other locations, compensators shall be by Senior Flexonics or approved equal.

K. Refer to System Water Treatment Article for shot feeders.

L. Provide an automatic glycol system feeder pump with 6-gallon tank for each RTU Heat Exchanger loop (type. of 3) system which shall maintain system pressure by pumping 35% propylene glycol into the system automatically as pressure dictates. For system provide Wessels Company #GMP-6 6-gallon mix tank, pump, piping, pressure controller, valves, etc… or approved equal.

2.20 CENTRIFUGAL PUMPS

A. Furnish and install where shown on the plans electric motor driven pumps as scheduled and specified. Pumps shall be end-suction frame mounted type, vertical in-line or in-line type as scheduled and manufactured by Grundfos, Paco or Bell & Gossett.

B. Pumps shall have capacities as scheduled on the drawings. Pumps shall be selected to operate at or near their point of peak efficiency thus allowing for operation at capacities of approximately 25% beyond design capacity. In addition, the design impellar diameter shall be selected so that the design capacity of each pump (GPM and TDH) shall not exceed 90% of the capacity obtainable with maximum impellar diameter at the design speed for that model or as approved.

C. Main System Heating pumps and HX pumps shall be as follows:

1. Furnish and install a pre-fabricated and tested variable speed packaged pumping system to maintain constant water delivery pressure.

2. The packaged pump system shall be a standard product of a single pump manufacturer. The entire pump system including pumps and pump logic controller, shall be designed, built, and tested by the same manufacturer.

3. The complete packaged water booster pump system shall be certified and listed by UL (Category QCZJ – Packaged Pumping Systems) for conformance to U.S. and Canadian Standards.

4. The complete packaged pumping system shall be NSF61 / NSF372 Listed for drinking water and low lead requirements.

5. The packaged pump system shall be ASHRAE 90.1 – 2010 compliant without the need of a remote mounted sensor. The control logic used to simulate a remote mounted sensor shall be proportional pressure control with squared or linear adaptation. An actual flow rate or calculated flow rate based on performance curves (5^{th} order polynomial) loaded into the controller; shall be used to adjust setpoint pressure in proportional pressure control. However each unit shall be able to accept remote sensor and remote signal control.

6. All pumps shall be ANSI NSF 61 / NSF372 Listed for drinking water and low lead requirements.

7. The pumps shall be of the in-line vertical multi-stage design.

8. The head-capacity curve shall have a steady rise in head from maximum to minimum flow within the preferred operating region. The shut-off head shall be a minimum of 20% higher than the head at the best efficiency point.

9. Small Vertical In-Line Multi-Stage Pumps (Nominal flow from 3 to 125 gallons per minute) shall have the following features:

   a. The pump impellers shall be secured directly to the pump shaft by means of a splined shaft arrangement.

   b. The suction/discharge base shall have ANSI Class 250 flange or internal pipe thread (NPT) connections as determined by the pump station manufacturer.

   c. Pump Construction.

      i. Suction/discharge base, pump head, motor stool: Cast iron (Class 30)
      ii. Impellers, diffuser chambers, outer sleeve: 304 Stainless Steel
      iii. Shaft 316 or 431 Stainless Steel
      iv. Impeller wear rings: 304 Stainless Steel
      v. Shaft journals and chamber bearings: Silicon Carbide
      vi. O-rings: EPDM

      Shaft couplings for motor flange sizes 184TC and smaller shall be made of cast iron or sintered steel. Shaft couplings for motor flange sizes larger than 184TC shall be made of ductile iron (ASTM 60-40-18).

      Optional materials for the suction/discharge base and pump head shall be cast 316 stainless steel (ASTM CF-8M) resulting in all wetted parts of stainless steel.

   d. The shaft seal shall be a balanced o-ring cartridge type with the following features:

      i. Collar, Drivers, Spring: 316 Stainless Steel
      ii. Shaft Sleeve, Gland Plate: 316 Stainless Steel
      iii. Stationary Ring: Silicon Carbide
      iv. Rotating Ring: Silicon Carbide
      v. O-rings: EPDM
      vi. The Silicon Carbide shall be imbedded with graphite.

   e. Shaft seal replacement shall be possible without removal of any pump components other than the coupling guard, shaft coupling and motor. The entire cartridge shaft seal shall be removable as a one piece component. Pumps with motors equal to or larger than 15 hp (fifteen horsepower) shall have adequate space within the motor stool so that shaft seal replacement is possible without motor removal.

10. Large In-line Vertical Multi-Stage Pumps (Nominal flows from 130 to 900 gallons per minute) shall have the following features:

    a. The pump impellers shall be secured directly to the smooth pump shaft by means of a split cone and nut design.

    b. The suction/discharge base shall have ANSI Class 125 or Class 250 flange connections in a slip ring (rotating flange) design as indicated in the drawings or pump schedule.

    c. Pump Construction.

I.	Suction/discharge base, pump head	Ductile Iron (ASTM 80-55-06)
II.	Shaft couplings, flange rings:	Ductile Iron (ASTM 80-55-06)
III.	Shaft	431 Stainless Steel
IV.	Motor Stool	Cast Iron (ASTM Class 30)
V.	Impellers, diffuser chambers, outer sleeve:	304 Stainless Steel
VI.	Impeller wear rings:	304 Stainless Steel
VII.	Intermediate Bearing Journals:	Silicon Carbide
VIII.	Intermediate Chamber Bearings:	Leadless Tin Bronze
IX.	Chamber Bushings:	Graphite Filled PTFE
X.	O-rings:	EPDM

d. The shaft seal shall be a balanced o-ring cartridge type with the following features:

I.	Collar, Drivers, Spring:	316 Stainless Steel
II.	Shaft Sleeve, Gland Plate:	316 Stainless Steel
III.	Stationary Ring:	Silicon Carbide
IV.	Rotating Ring:	Silicon Carbide
V.	O-rings:	EPDM

The Silicon Carbide shall be imbedded with graphite.

e. Shaft seal replacement shall be possible without removal of any pump components other than the coupling guard, motor couplings, motor and seal cover. The entire cartridge shaft seal shall be removable as a one-piece component. Pumps with motors equal to or larger than 15 hp (fifteen horsepower) shall have adequate space within the motor stool so that shaft seal replacement is possible without motor removal.

11. Integrated Variable Frequency Drive

a. Each motor shall be of the Integrated Variable Frequency Drive design consisting of a permanent magnet synchronous motor (ECM) and a Variable Frequency Drive (VFD) built and tested as one unit by the same manufacturer.

b. The VFD shall be of the PWM (Pulse Width Modulation) design using IGBT (Insulated Gate Bipolar Transistor) technology.

c. The VFD shall convert incoming fixed frequency three-phase AC power into a variable frequency and voltage for controlling the speed of motor. The motor current shall closely approximate a sine wave. Motor voltage shall be varied with frequency to maintain desired motor current suitable for centrifugal pump control and to eliminate the need for motor de-rating.

d. The VFD shall automatically reduce the switching frequency and/or the output voltage and frequency to the motor during periods of sustained ambient temperatures that are higher than the normal operating range. The switching frequency shall be reduced before motor speed is reduced.

e. An integral RFI filter shall be standard in the VFD.

f. The VFD shall have a minimum of two skip frequency bands which can be field adjustable.

g. The VFD shall have internal solid-state overload protection designed to trip within the range of 105-110% of rated current.

h. The integrated VFD motor shall include protection against input transients, phase imbalance, loss of AC line phase, over-voltage, under-voltage, VFD over-temperature, and motor over-temperature. Three-phase integrated VFD motors shall be capable of providing full output voltage and frequency with a voltage imbalance of up to 10%.

i. The integrated VFD motor shall have, as a minimum, the following input/output capabilities:
   i. Speed Reference Signal: 0-10 VDC, 4-20mA
   ii. Digital remote on/off
   iii. Fault Signal Relay (NC or NO)
   iv. Fieldbus communication port (RS485)

j. The motor shall be Totally Enclosed Fan Cooled (TEFC) with a standard NEMA C-Face, Class F insulation with a temperature rise no higher than Class B.

k. The cooling design of the motor and VFD shall be such that a Class B motor temperature rise is not exceeded at full rated load and speed at a minimum switching frequency of 9.0 kHz.

l. The overall efficiency of the VFD and motor must exceed NEMA Premium Efficiency.

m. Motor drive end bearings shall be adequately sized so that the minimum L10 bearing life is 20,000 hours at the minimum allowable continuous flow rate for the pump at full rated speed.

12. Pump System Controller

a. The pump system controller shall be a standard product developed and supported by the pump manufacturer.

b. The controller shall be microprocessor based capable of having software changes and updates via personal computer (notebook). The controller user interface shall have a color display with a minimum screen size of 3-1/2" x 4-5/8" for easy viewing of system status parameters and for field programming. The display shall have a back light with contrast adjustment. Password protection of system settings shall be standard.

c. The controller shall provide internal galvanic isolation to all digital and analog inputs as well as all fieldbus connections.

d. The controller shall have the ability to be connected to a battery to maintain power on controller during periods of loss of supply power.

e. The controller shall have built in data logging capability. Logged vales shall be graphically displayed on the controller and able to be exported. A minimum of 3600 samples per logged value with the following parameters available for logging:
   - Estimated flow-rate
   - Speed of pumps
   - Inlet pressure

- Process Value (usually discharge pressure of differential pressure depending on application)
- Power consumption
- Controlling parameter (process value)

f. The controller shall display the following as status readings from a single display on the controller (this display shall be the default):
   - Current value of the control parameter, (typically discharge pressure)
   - Most recent existing alarm (if any)
   - System status with current operating mode
   - Status of each pump with current operating mode and rotational speed as a percentage (%)
   - Estimated flow-rate, (not requiring flow meter connection)

g. The controller shall have as a minimum the following hardware inputs and outputs:
   - Three analog inputs (4-20mA or 0-10VDC)
   - Three digital inputs
   - Two digital outputs
   - Ethernet connection
   - Field Service connection to PC for advanced programming and data logging

h. Pump system programming (field adjustable) shall include as a minimum the following:
   - Water shortage protection (analog or digital)
   - Sensor Settings (Suction, Discharge, Differential Pressure analog supply/range)
   - PI Controller (Proportional gain and Integral time) settings
   - High system pressure indication and shut-down
   - Low system pressure indication and shut-down
   - Low suction pressure/level shutdown (via digital contact)
   - Low suction pressure/level warning (via analog signal)
   - Low suction pressure/level shutdown (via analog signal)
   - Flow meter settings (if used, analog signal)

i. The system controller shall be able to accept up to seven programmable set-points via a digital input, (additional input/output module may be required).

j. The controller shall have advanced water shortage protection. When analog sensors (level or pressure) are used for water shortage protection, there shall be two indication levels. One level is for warning indication only (indication that the water level/pressure is getting lower than expected levels) and the other level is for complete system shut-down (water or level is so low that pump damage can occur). System restart after shut-down shall be manual or automatic (user selectable).

k. The system pressure set-point shall be capable of being automatically adjusted by using an external set-point influence. The set-point influence function enables the user to adjust the control parameter (typically pressure) by measuring an additional parameter. (Example: Lower the system pressure set-point based on a flow measurement to compensate for lower friction losses at lower flow rates).

l. The controller shall be capable of receiving a remote analog set-point (4-20mA or 0-10 VDC) as well as a remote system on/off (digital) signal.

m. The controller shall be able to adjust the ramp time of a change in set point on both an increase or decrease change in set point.

n. The pump system controller shall store up to 24 warning and alarms in memory. The time, date and duration of each alarm shall be recorded. A potential-free relay shall be provided for alarm notification to the building management system. The controller shall display the following alarm conditions:

High System Pressure	Low system pressure
Low suction pressure (warning and alarm)	Individual pump failure
VFD trip/failure	Loss of sensor signal (4-20 mA)
Loss of remote set-point signal (4-20mA)	External Fault

o. The pump system controller shall be mounted in a UL Type 3R rated enclosure. A self-certified NEMA enclosure rating shall not be considered equal. The entire control panel shall be UL 508 listed as an assembly. The control panel shall include a main disconnect, circuit breakers for each pump and the control circuit and control relays for alarm functions.

Control panel options shall include, but not be limited to:

Pump Run Lights	System Fault Light
Surge Arrestor	Emergency/Normal Operation Switches
Service Disconnect Switches	

Qty (9) Configurable Digital Outputs available for monitoring
Qty (7) Configurable Digital Inputs available for control

p. The controller shall be capable of receiving a redundant sensor input to function as a backup to the primary sensor (typically discharge pressure).

q. The controller shall have a pump “Test Run” feature such that pumps are switched on during periods of inactivity (system is switched to the “off” position but with electricity supply still connected). The inoperative pumps shall be switched on for a period of two to three (3-4) seconds every 24 hours, 48 hours or once per week and at specific time of day (user selectable).

r. The controller shall be capable of changing the number of pumps available to operate or have the ability limit the maximum power consumption by activation of a digital input for purposes of limited generator supplied power.

s. The controller shall be capable of displaying instantaneous power consumption (Watts or kilowatts) and cumulative energy consumption (kilowatt-hours).

t. The controller shall be capable of displaying instantaneous specific energy use (kW/gpm), (optional flow meter must be connected).

u. The actual pump performance curves (5^{th} order polynomial) shall be loaded (software) into the pump system controller. Pump curve data shall be used for the following:

- Display and data logging of calculated flow rate (not requiring flow measurement)
- Proportional pressure control

- Pump outside of duty range protection
- Pump cascade control based on pump efficiency

v. The controller shall be capable of displaying an estimated flow-rate on the default status screen.

w. The controller shall have proportional pressure control to compensate for pipe friction loss by decreasing pressure set-point at lower flow-rates and increasing pressure set-point at higher flow-rates by using actual flow rate or calculated flow rate. Proportional pressure control that uses pump speed or power consumption only shall not be considered equal to proportional pressure control that uses actual or calculated flow rate.

x. The controller shall have the ability to communicate common field-bus protocols, (Bac-Net, Modbus) via a provided communication expansion card installed inside the controller.

y. The controller shall have Ethernet connection with a built in server allowing for connection to a network with read/write access to controller via web browser and internet.

z. The controller shall have a programmable Service Contact Field that can be populated with service contact information including: contact name, address, phone number(s) and website.

13. Sequence

a. The system controller shall operate equal capacity variable speed pumps to maintain a constant discharge pressure or differential pressure (system set-point), depending on the application. The system controller shall receive an analog signal [4-20mA] from the EMS indicating system pressure/demand. In addition, a factory installed pressure transducer on the discharge manifold shall indicate the actual system pressure.

b. Standard Cascade Control (Pumping Efficiency Based):
The pump system controller shall adjust pump speed as necessary to maintain system set-point pressure as flow demand increases. Utilizing the pump curve information (5^{th} order polynomial), the pump system controller shall stage on additional pumps when pump hydraulic efficiency will be higher with additional pumps in operation. Exception: When the flow and head are outside the operating pump(s) allowable operating range the controller shall switch on an additional pump thus distributing flow and allowing all pump(s) to operate in allowable operating range. When the system pressure is equal to the system set-point, all pumps in operation shall reach equal operating speeds. The pump system controller shall have field adjustable Proportional Gain and Integral time (PI) settings for system optimization.

c. The system controller shall be capable of switching pumps on and off to satisfy system demand without the use of flow switches, motor current monitors or temperature measuring devices.

d. All pumps in the system shall alternate automatically based on demand, time and fault. If flow demand is continuous (no flow shut-down does not occur), the system controller shall have the capability to alternate the pumps every 24 hours, every 48 hours or once

per week. The interval and actual time of the pump change-over shall be field adjustable.

e. The system controller shall be able to control a pressure maintenance pump, (jockey pump), in the system in pressure boosting applications. The set point of the pressure maintenance pump shall be able to be any value above or below the pump system's set point. The pressure maintenance pump shall be able to be staged on as back-up pump when capacity of pump system is exceeded.

f. The system controller shall be capable of stopping pumps during periods of low-flow or zero-flow without wasting water or adding unwanted heat to the liquid. Temperature based no flow shut-down methods that have the potential to waste water and add unwanted temperature rise to the pumping fluid are not acceptable and shall not be used.

g. Standard Low Flow Stop and Energy Saving Mode
If a low or no flow shut-down is required (periods of low or zero demand) a bladder type diaphragm tank shall be installed with a pre-charge pressure of 70% of system set-point. The tank shall be piped to the discharge manifold or system piping downstream of the pump system. When only one pump is in operation the system controller shall be capable of detecting low flow (less than 10% of pump nominal flow) without the use of additional flow sensing devices. When a low flow is detected, the system controller shall increase pump speed until the discharge pressure reaches the stop pressure (system set-point plus 50% of programmed on/off band, adjustable). The pump shall remain off until the discharge pressure reaches the start pressure (system set-point minus 50% of programmed on/off band, adjustable). Upon low flow shut-down a pump shall be restarted in one of the following two ways:

Low Flow Restart: If the low flow condition still exists, the pump shall start and the speed shall again be increased until the stop pressure is reached and the pump shall again be switched off.

Normal Flow Restart: If the pump system controller determines a low flow condition no longer exists the pump shall start and the speed shall be increased until the system pressure reaches the system set-point.

14. System Construction

a. Suction and discharge manifold construction shall be in way that ensures minimal pressure drops, minimize potential for corrosion, and prevents bacteria growth at intersection of piping into the manifold. Manifold construction that includes sharp edge transitions or interconnecting piping protruding into manifold is not acceptable. Manifold construction shall be such that water stagnation cannot exist in manifold during operation to prevent bacteria growth inside manifold.

b. The suction and discharge manifolds material shall be 316 stainless steel. Manifold connection sizes shall be as follows:

- 3 inch and smaller: Male NPT threaded
- 4 inch through 8 inch: ANSI Class 150 rotating flanges
- 10 inch and larger: ANSI Class 150 flanges

c. Pump Isolation valves shall be provided on the suction and discharge of each pump. Isolation valve sizes 2 inch and smaller shall be nickel plated brass full port ball valves. Isolation valve sizes 3 inch and larger shall be a full lug style butterfly valve. The valve disk shall be of stainless steel. The valve seat material shall be EPDM and the body shall be cast iron, coated internally and externally with fusion-bonded epoxy.

d. A spring-loaded non-slam type check valve shall be installed on the discharge of each pump. The valve shall be a wafer style type fitted between two flanges. The head loss through the check valve shall not exceed 5 psi at the pump design capacity. Check valves 1-1/2" and smaller shall have a POM composite body and poppet, a stainless steel spring with EPDM or NBR seats. Check valves 2" and larger shall have a body material of stainless steel or epoxy coated iron (fusion bonded) with an EPDM or NBR resilient seat. Spring material shall be stainless steel. Disk shall be of stainless steel or leadless bronze.

e. For systems that require a diaphragm tank, a connection of no smaller than ¾" shall be provided on the discharge manifold.

f. A pressure transducer shall be factory installed on the discharge manifold (and field installed as specified on plans see EMS). Systems with positive inlet gauge pressure shall have a factory installed pressure transducer on the suction manifold for water shortage protection. Pressure transducers shall be made of 316 stainless steel. Transducer accuracy shall be +/- 1.0% full scale with hysteresis and repeatability of no greater than 0.1% full scale. The output signal shall be 4-20 mA with a supply voltage range of 9-32 VDC.

g. A bourdon tube pressure gauge, 2.5 inch diameter, shall be placed on the suction and discharge manifolds. The gauge shall be liquid filled and have copper alloy internal parts in a stainless steel case. Gauge accuracy shall be 2/1/2 %. The gauge shall be capable of a pressure of 30% above its maximum span without requiring recalibration.

h. Systems with a flooded suction inlet or suction lift configuration shall have a factory installed water shortage protection device on the suction manifold.

i. The base frame shall be constructed of corrosion resistant 304 stainless steel. Rubber vibration dampers shall be fitted between each pumps and baseframe to minimize vibration.

j. Depending on the system size and configuration, the control panel shall be mounted in one of the following ways as shown on the drawings or as required to suit field conditions:
   - On a 304 stainless steel fabricated control cabinet stand attached to the system skid.
   - On a 304 stainless steel fabricated skid, separate from the main system skid
   - On its own base (floor mounted with plinth)

15. Testing

a. The tester used for testing the pump system shall be constructed and calibrated according to the requirements of hydraulic test standard ISO 9906.
b. The entire pump station shall as a minimum be factory tested for functionality and documented results of functionality test supplied with pump station.

Functionality testing shall include the following parameters:

- Complete System Hydrostatic Test – 1.5 times the nameplate maximum pressure
- No-Flow Detection Shutoff Test
- Water Shortage Test
- Two-Point Setpoint Performance Test.

c. Water used for testing shall be treated with three different filtration systems to ensure only clean water is used for testing pump station.
   - 25 micron mechanical filter – removes solid parts from water
   - Activated carbon filter – keeps water clear and eliminates odor
   - Ultraviolet light system – kills all bacteria growth

16. Warranty: The warranty period shall be a non-prorated period of 24 months from date of installation, not to exceed 30 months from date of manufacture.

D. Boiler Pumps

1. Provide split coupled vertical in-line pumps with integrated VFD similar to Grundfoss VLSE. If pumps are to be set on floor slab provide base stand. Pumps shall be capable of communicating directly with the boiler controller for star/stop and speed control. EMS shall wire to pump from boiler controller. EMS shall interface to status output.

E. Radiant Heat Pumps shall be in-line wet rotor liquid cooled type as manufactured by Grundfos, Paco or Bell & Gossett. Pumps shall be multi-speed type adjustable via a knob selector.

F. Vertical and horizontal in-line pumps must be supported with seismically restrained spring vibration isolating hangers between the pump and the pipe vibration isolator.

G. Motors shall be as scheduled and noted herein premium efficiency type capable of qualifying for a utility company rebate. ECM motors shall be provided where scheduled with all packaged skid mount pumps having ECM motors. All other pumps up to an including 2 HP shall have ECM motors.

H. Each motor on a VFD shall be provided with a shaft grounding device to harmlessly bleed potential induced shaft voltages to ground

E. Provide variable speed drives on all pumps where scheduled or specified herein. Note ECM motors need not have VFD's. Refer to article Variable Frequency Drives for additional requirements.

F. Provide H-O-A Nema 1 disconnects on all pumps. Provide combination disconnect and motor starter for each pump not having an ECM motor, variable speed or integral speed drive. Coordinate coil voltage with control requirements.

2.21 UNIT & CABINET UNIT HEATERS

A. Provide hot water cabinet and unit heaters as manufactured by Modine, Rittling, Trane or approved equal. Units shall be U.L. listed. Unit shall have both vertical & horizontal deflection blades.

B. Cabinet unit heaters shall have a fully enclosed cabinet with adjustable frame for full, semi or surface mounting as required by the installation.

C. Provide baked enamel finish on unit. For cabinet unit heaters submit color selection chart for selection by Architect.

D. Furnish disconnect switch for all units. On cabinet unit heaters provide 3-speed fan speed control switch. Cabinet unit heaters shall have tamper proof fan speed switch enclosure.

2.22 SYSTEM WATER TREATMENT

A. Provide two (2) 5-gallon chemical bypass shot feeder for the hot water system (one for each main hot water loop) equal to Neptune model #DBF-5HP with #FBK-5 filter bag kit and leg stands. Bag kit shall have stainless steel filter rack and 20-micron filter bag. Include three (3) spare bag replacements.

B. All systems shall be thoroughly flush with clear water and then filled with clear water and circulated for a period no less than 8 hours. Drain water, clean all strainers and then refill the hot water system with clean water and chemically treat.

C. For glycol systems, after flushing and testing, system shall be filled with a pre-mix of 35% corrosion inhibited propylene glycol.

D. This Contractor shall furnish a one-year system water treatment service by a qualified water treatment and testing agency, including all chemicals required to prevent scaling and corrosion and a minimum of four (4) site visits. Chemicals used shall be approved by the boiler manufacturer. As a minimum, site visits and water testing shall include: initial system fill/start-up, one (1) month after start-up, six (6) months after start-up, and one (1) year after start-up. Provide written report to Architect-Engineer detailing initial system fill/start up test results.

2.23 VIBRATION ISOLATION AND FLEXIBLE CONNECTIONS (See also 2.24 Vibration and Seismic Control for additional information)

A. At duct connections to equipment, provide glass-fabric flexible neoprene connections with a minimum of 6 inch full length and approved by the governmental agencies having jurisdiction.

B. Hot water unit heaters and fan coil units under 2,000 CFM shall be suspended with double deflection neoprene hangers similar to Mason Industries model #HD. Units over this size shall be hung with 1.5” static defection spring hangers with seismic and thrust restraints.

C. Floor mounted pumps shall be set on a continuous rail system comprised of steel channels with double deflection neoprene pads securely mounted to a concrete base pad. Pumps shall be securely attached to the base rail system. System shall be similar to Mason Industries model #RND.

D. At suspended vertical pumps, provide 1-1/2” static deflection spring isolating pipe hangers within 3 feet of each side of pump. Isolators at inlet and outlet of pump shall be located on piping away from pump on opposite side of hangers.

E. At condensing units and condensers provide 6”x6” neoprene vibration pads at all support points as directed by the manufacturer. Pads shall be similar to Mason Industries model

#WMFB composite pad of two neoprene layers sandwiching a steel shim. Paint edges of shim with 2 coats of rustproof primer. Units shall be securely bolted with rubber isolating fastener to the curb or pad.

F. At hydronic pipe connections to pumps provide twin sphere rubber and steel & Kevlar® reinforced flexible pipe connectors as manufactured by Mason Industries model #MFDEJ.

G. At pipe connections to boilers, air handlers, rooftop units, fan coil unitss and hot water unit heaters, provide braided stainless steel flexible pipe connectors as manufactured by Mercer Rubber Co. model #BSS or equal.

2.24 VIBRATION AND SEISMIC CONTROL (See also 2.23 for additional information)

A. Intent:

1. All mechanical equipment, piping and ductwork as noted on the equipment schedule or in the Specification shall be mounted on vibration isolators and with flexible connections to prevent the transmission of vibration and mechanically transmitted sound to the building structure. Vibration isolators shall be selected in accordance with the weight distribution so as to produce reasonably uniform deflections.
2. All isolators and isolation materials shall be of the same manufacturer and shall be certified by the manufacturer.
3. It is the intent of the seismic portion of this Specification to keep all mechanical building system components in place during a seismic event.
4. All such systems must be installed in strict accordance with seismic codes, component manufacturer's and building construction standards. Whenever a conflict occurs between the manufacturer's or construction standards, the most stringent shall apply.
5. This Specification is considered to be minimum requirements for seismic consideration and is not intended as a substitute for legislated, more stringent, national, state or local construction requirements (i.e. MA Codes, IBC Building Code, California Title 24, California OSHPD, or other requirements).
6. Any variance or non-compliance with these Specification requirements shall be corrected by the Contractor in an approved manner.
7. Seismic restraints shall be designed in accordance with seismic force levels as detailed in Section H.

B. The work in this Section includes, but is not limited to, the following:

1. Vibration isolation for piping, ductwork and equipment.
2. Equipment isolation bases.
3. Flexible piping connections.
4. Seismic restraints for isolated equipment.
5. Seismic restraints for non-isolated equipment.
6. Certification of seismic restraint designs and installation supervision.

7. Certification of seismic attachment of housekeeping pads.

8. All mechanical systems. Equipment buried underground is excluded but entry of services through the foundation wall is included. Equipment referred to below is typical. (Equipment not listed is still included in this Specification).

   AC Units
   Air Distrib.
   VAV Boxes
   Ductwork
   Air Handling Units
   Fan Coil Units
   Air Separators
   Fans (all types)
   Boilers
   Heat Exchangers
   Cabinet Heaters
   Piping
   Pumps (all types)
   Rooftop Units and Air Handlers
   Tanks (all types)
   Unit Heaters
   Condensing Units
   Chiller/Heaters (Alternate)

C. Definitions:

1. Life Safety Systems:

   a. All systems involved with fire protection including sprinkler piping, fire pumps, jockey pumps, fire pump control panels, service water supply piping, water tanks, fire dampers and smoke exhaust systems.

   b. All systems involved with and/or connected to emergency power supply including all generators, transfer switches, transformers and all flowpaths to fire protection and/or emergency lighting systems.

   c. All medical and life support systems.

   d. Fresh air relief systems on emergency control sequence including air handlers, conduit, duct, dampers, etc.

   e. All life safety equipment has an asterisk on the equipment schedule.

2. Positive Attachment: A positive attachment is defined as a cast-in anchor, a drill-in wedge anchor, a double sided beam clamp loaded perpendicular to a beam, or a welded or bolted connection to structure. Single sided "C" type beam clamps for support rods of overhead piping, ductwork, or any other equipment are not acceptable on this project as seismic anchor points.

3. Transverse Bracing: Restraint(s) applied to limit motion perpendicular to the centerline of the pipe, duct or conduit.

4. Longitudinal Bracing: Restraint(s) applied to limit motion parallel to the centerline of the pipe, duct or conduit.

D. Manufacturer's Data:

1. The manufacturer of vibration isolation and seismic restraints shall provide submittals for products as follows:

a. Descriptive Data:

(1) Catalog cuts or data sheets on vibration isolators and specific restraints detailing compliance with the Specification.

(2) Detailed schedules of flexible and rigidly mounted equipment, showing vibration isolators and seismic restraints by referencing numbered descriptive Drawings.

b. Shop Drawings:

(1) Submit fabrication details for equipment bases including dimensions, structural member sizes and support point locations.

(2) Provide all details of suspension and support for ceiling hung equipment.

(3) Where walls, floors, slabs or supplementary steel work are used for seismic restraint locations, details of acceptable attachment methods for ducts, conduit and pipe must be included and approved before the condition is accepted for installation. Restraint manufacturers' submittals must include spacing, static loads and seismic loads at all attachment and support points.

(4) Provide specific details of seismic restraints and anchors; include number, size and locations for each piece of equipment.

c. Seismic Certification and Analysis:

(1) Seismic restraint calculations must be provided for all connections of equipment to the structure. Calculations must be stamped by a registered professional engineer with at least five years of seismic design experience, licensed in the state of the job location.

(2) All restraining devices shall have a preapproval number from California OSHPD or some other recognized government agency showing maximum restraint ratings. Preapprovals based on independent testing are preferred to preapprovals based on calculations. Where preapproved devices are not available, submittals based on independent testing are preferred. Calculations (including the combining of tensile and shear loadings) to support seismic restraint designs must be stamped by a registered professional engineer with at least five years of seismic design experience and licensed in the state of the job location. Testing and calculations must include both shear and tensile loads as well as one test or analysis at 45 to the weakest mode.

(3) Analysis must indicate calculated dead loads, static seismic loads and capacity of materials utilized for connections to equipment and

structure. Analysis must detail anchoring methods, bolt diameter, embedment and/or welded length. All seismic restraint devices shall be designed to accept, without failure, the forces detailed in Section H acting through the equipment center of gravity. Overturning moments may exceed forces at ground level.

E. Code and Standards Requirements:

1. Typical Applicable Codes and Standards - most recent or enforced code:

   a. Massachusetts State Building Code.

   b. International Mechanical Code (IMC).

   c. NFPA 90A.

F. Manufacturer's Responsibility:

1. Manufacturer of vibration isolation and seismic control equipment shall have the following responsibilities:

   a. Determine vibration isolation and seismic restraint sizes and locations.

   b. Provide vibration isolation and seismic restraints as scheduled or specified.

   c. Provide calculations and materials if required for restraint of unisolated equipment.

   d. Provide installation instructions, drawings and trained field supervision to insure proper installation and performance.

G. Related Work:

1. Housekeeping Pads:

   a. Housekeeping pad reinforcement and monolithic pad attachment to the structure details and design shall be prepared by the restraint vendor if not already indicated on the Drawings.

   b. Housekeeping pads shall be coordinated with restraint vendor and sized to provide a minimum edge distance of ten (10) bolt diameters all around the outermost anchor bolt to allow development of full drill-in wedge anchor ratings. If cast-in anchors are to be used, the housekeeping pads shall be sized to accommodate the ACI requirements for bolt coverage and embedment.

2. Supplementary Support Steel: Contractor shall supply supplementary support steel for all equipment, piping, ductwork, etc. including roof mounted equipment, as required or specified.

3. Attachments: Contractor shall supply restraint attachment plates cast into housekeeping pads, concrete inserts, double sided beam clamps, etc. in accordance with the requirements of the vibration vendor's calculations.

H. Seismic Force Levels

1. The force levels described in the building code shall be used on this project. Mechanical seismic control exceptions noted in the code for the buildings seismic category shall not apply. For the purposes of seismic design of the mechanical systems, the building shall be considered an emergency shelter.

I. Product Intent:

1. All vibration isolators and seismic restraints described in this section shall be the product of a single manufacturer. Mason Industry's products are the basis of these Specifications; products of other manufacturers are acceptable provided their systems strictly comply with the Specification and have the approval of the specifying engineer. Submittals and certification sheets shall be in accordance with Section D.

2. For the purposes of this project, failure is defined as the discontinuance of any attachment point between equipment or structure, vertical permanent deformation greater than 1/8 in. and/or horizontal permanent deformation greater that 1/4 in.

J. Product Description: Vibration Isolators and Seismic Restraints:

1. Two (2) layers of 3/4 in. thick neoprene pad consisting of 2 in. square waffle modules separated horizontally by a 16 gauge galvanized shim. Load distribution plates shall be used as required. Pads shall be Type Super "W" as manufactured by Mason Industries, Inc.

2. Bridge-bearing neoprene mountings shall have a minimum static deflection of 0.2 in. and all directional seismic capability. The mount shall consist of a ductile iron casting containing two (2) separated and opposing molded neoprene elements. The elements shall prevent the central threaded sleeve and attachment bolt from contacting the casting during normal operation. The shock absorbing neoprene materials shall be compounded to bridge-bearing Specifications. Mountings shall have an Anchorage Preapproval "R" Number from OSHPD in the State of California verifying the maximum certified horizontal and vertical load ratings. Mountings shall be Type BR as manufactured by Mason Industries, Inc.

3. Sheet metal panels shall be bolted to the walls or supporting structure by assemblies consisting of a neoprene bushing cushioned between 2 steel sleeves. The outer sleeve prevents the sheet metal from cutting into the neoprene. Enlarge panel holes as required. Neoprene elements pass over the bushing to cushion the back panel horizontally. A steel disc covers the inside neoprene element and the inner steel sleeve is elongated to act as a stop so tightening the anchor bolts does not interfere with panel isolation in three (3) planes. Bushing assemblies can be applied to the ends of steel cross members where applicable. All neoprene shall be bridge bearing quality. Bushing assemblies shall be Type PB as manufactured by Mason Industries, Inc.

4. A one piece molded bridge bearing neoprene washer/bushing. The bushing shall surround the anchor bolt and have a flat washer face to avoid metal to metal contact. Neoprene bushings shall be Type HG as manufactured by Mason Industries, Inc.

5. Spring isolators shall be free standing and laterally stable without any housing and complete with a molded neoprene cup or 1/4 in. neoprene acoustical friction pad between the baseplate and the support. All mountings shall have leveling bolts that must be rigidly bolted to the equipment. Spring diameters shall be no less than 0.8 of

the compressed height of the spring at rated load. Springs shall have a minimum additional travel to solid equal to 50% of the rated deflection. Submittals shall include spring diameters, deflection, compressed spring height and leveling valves Type LV as manufactured by Mason Industries, Inc.

6. Restrained spring mountings shall have an SLF mounting as described in Specification 5, with a rigid housing that includes vertical limit stops to prevent spring extension when weight is removed. The housing shall serve as blocking during erection. A steel spacer shall be removed after adjustment. Installed and operating heights are equal. A minimum clearance of ½ inch shall be maintained around restraining bolds and between the housing and the spring so as not to interfere with the spring action. Limit stops shall be out of contact during normal operation. Since housings will be bolted or welded in position there must be an internal isolation pad. Housing shall be designed to resist all seismic forces. Mountings shall have Anchorage Preapproval “R” Number from OSHPD in the state of California certifying the maximum certified horizontal and vertical load ratings. Mountings shall be SLR as manufactured by Mason Industries, Inc.

7. Spring mountings as in Specification 5 built into a ductile iron or steel housing to provide all directional seismic snubbing. The snubber shall be adjustable vertically and allow a maximum of ¼ inch travel in all directions before contacting the resilient snubbing collars. Mountings shall have an Anchorage Preapproval “R” Number OSHPD in the State of California verifying the maximum certified horizontal and vertical load ratings. Mountings shall be SSLFH as manufactured by Mason Industries, Inc.

8. Air Springs shall be manufactured with upper and lower steel sections connected by a replaceable flexible nylon reinforced neoprene element. Air spring configuration shall be multiple bellows to achieve a maximum natural frequency of 3 Hz. Air Springs shall be designed for a burst pressure that is a minimum of three times the published maximum operating pressure. All air spring systems shall be connected to either the building control air or a supplementary air supply and equipped with three (3) leveling valves to maintain leveling within plus or minus 1/8 inch. Submittals shall include natural frequency load and damping tests performed by an independent lab or acoustician. Air Springs shall be Type MT and leveling valves Type LV as manufactured by Mason Industries, Inc.

9. Restrained air spring mountings shall have an MT air spring as described in Specification 8, within a rigid housing that includes vertical limit stops to prevent air spring extension when weight is removed. The housing shall serve as blocking during erection. A steel spacer shall be removed after adjustment. Installed and operating heights are equal. A minimum clearance of ½ in. shall be maintained around restraining bolts and between the housing and the air spring so as not to interfere with the air spring action. Limit stops shall be out of contact during normal operation. Housing shall be designed to resist all seismic forces. Mountings shall be SLR-MT as manufactured by Mason Industries, Inc.

10. Hangers shall consist of rigid steel frames containing minimum 1-1/4 in. thick neoprene elements at the top and a steel spring with general characteristics as in Specification 5 seated in a steel washer reinforced neoprene cup on the bottom. The neoprene element and the cup shall have neoprene bushings projecting through the steel box. To maintain stability the boxes shall not be articulated as clevis hangers nor the neoprene element stacked on top of the spring. Spring diameters and hanger box lower hole sizes shall be large enough to permit the hanger rod to swing through a 30 arc from

side to side before contacting the rod bushing and short circuiting the spring. Submittals shall include a hanger Drawing showing the 30 capability. Hangers shall be Type 30N as manufactured by Mason Industries, Inc.

11. Hangers shall be as described in 10, but they shall be precompressed and locked at the rated deflection by means of a resilient seismic upstop to keep the piping or equipment at a fixed elevation during installation. The hangers shall be designed with a release mechanism to free the spring after the installation is complete and the hanger is subjected to its full load. Deflection shall be clearly indicated by means of a scale. Submittals shall include a Drawing of the hanger showing the 30 degree capability. Hangers shall be Type PC30N as manufactured by Mason Industries, Inc.

12. Seismic Cable Restraints shall consist of galvanized steel aircraft cables sized to resist seismic loads with a minimum safety factor of two (2) and arranged to provide all-directional restraint. Cable end connections shall be steel assemblies that swivel to final installation angle and utilize two (2) clamping bolts to provide proper cable engagement. Cables must not be allowed to bend across sharp edges. Cable assemblies shall have an Anchorage Preapproval "R" Number from OSHPD in the State of California verifying the maximum certified load ratings. Cable assemblies shall be Type SCB at the ceiling and at the clevis bolt, SCBH between the hanger rod nut and the clevis or SCBV if clamped to a beam all as manufactured by Mason Industries, Inc.

13. Seismic solid braces shall consist of steel angles or channels to resist seismic loads with a minimum safety factor of 2 and arranged to provide all directional restraint. Seismic solid brace end connectors shall be steel assemblies that swivel to the final installation angle and utilize two through bolts to provide proper attachment. Seismic solid brace assembly shall have anchorage preapproval "R" Number from OSHPD in the state of California verifying the maximum certified load ratings. Solid seismic brace assemblies shall be Type SSB as manufactured by Mason Industries, Inc.

14. Steel angles, sized to prevent buckling, shall be clamped to pipe or equipment rods utilizing a minimum of three ductile iron clamps at each restraint location when required. Welding of support rods is not acceptable. Rod clamp assemblies shall have an Anchorage Preapproval "R" Number from OSHPD in the State of California. Rod clamp assemblies shall be Type SRC as manufactured by Mason Industries, Inc.

15. Pipe clevis cross bolt braces are required in all restraint locations. They shall be special purpose preformed channels deep enough to be held in place by bolts passing over the cross bolt. Clevis cross braces shall have an Anchorage Preapproval "R" Number from OSHPD in the State of California. Clevis cross brace shall be Type CCB as manufactured by Mason Industries, Inc.

16. All-directional seismic snubbers shall consist of interlocking steel members restrained by a one-piece molded neoprene bushing of bridge bearing neoprene. Bushing shall be replaceable and a minimum of 1/4 in. thick. Rated loadings shall not exceed 1000 psi. A minimum air gap of 1/8 in. shall be incorporated in the snubber design in all directions before contact is made between the rigid and resilient surfaces. Snubber end caps shall be removable to allow inspection of internal clearances. Neoprene bushings shall be rotated to insure no short circuits exist before systems are activated. Snubbers shall have an Anchorage Preapproval "R" Number from OSHPD in the State of California verifying the maximum certified horizontal and vertical load ratings. Snubber shall be Type Z-1225 as manufactured by Mason Industries, Inc.

17. All directional seismic snubbers shall consist of interlocking steel members restrained by shock absorbent rubber materials compounded to bridge bearing Specifications. Elastomeric materials shall be replaceable and a minimum of 3/4 in. thick. Rated loadings shall not exceed 1000 psi. Snubbers shall be manufactured with an air gap between hard and resilient material of not less than 1/8 in. nor more that 1/4 in. Snubbers shall be installed with factory set clearances. The capacity of the seismic snubber at 3/8 in. deflection shall be equal or greater than the load assigned to the mounting grouping controlled by the snubber multiplied by the applicable "G" force. Submittals shall include the load deflection curves up to ½ in. deflection in the x, y and z planes. Snubbers shall have an anchorage preapproval "R" Number from OSHPD in the state of California verifying the maximum certified horizontal and vertical load ratings. Snubbers shall be series Z-1011 as manufactured by Mason Industries, Inc.

18. Stud wedge anchors shall be manufactured from full diameter wire, not from undersized wire that is "rolled up" to create the thread. The stud anchor shall also have a safety shoulder which fully supports the wedge ring under load. The stud anchors shall have an evaluation report number from the I.C.B.O Evaluation Service, Inc. verifying its allowable loads. Drill-in stud wedge anchors shall be Type SAS as manufactured by Mason Industries, Inc.

19. Female wedge anchors are preferred in floor locations so isolators or equipment can be slid into place after the anchors are installed. Anchors shall be manufactured from full diameter wire, and shall have a safety shoulder to fully support the wedge ring under load. Female wedge anchors shall have an evaluation report number from the I.C.B.O Evaluation Service, Inc. verifying to its allowable loads. Drill-in female wedge anchors shall be Type SAB as manufactured by Mason Industries, Inc.

20. Vibration isolation manufacturer shall furnish integral structural steel bases. Rectangular bases are preferred for all equipment. Centrifugal refrigeration machines and pump bases may be T or L shaped where space is a problem. Pump bases for split case pump shall include supports for suction and discharge elbows. All perimeter members shall be steel beams with a minimum depth equal to 1/10 of the longest dimension of the base. Base depth need not exceed 14 in. provided that the deflection and misalignment is kept within acceptable limits as determined by the manufacturer. Height saving brackets shall be employed in all mounting locations to provide a base clearance of 1 in. Bases shall be Type WF as manufactured by Mason Industries, Inc.

21. Vibration isolation manufacturer shall furnish rectangular steel concrete pouring forms for floating and inertia foundations. Bases for split case pumps shall be large enough to provide for suction and discharge elbows. Bases shall be a minimum of 1/12 of the longest dimension of the base but not less than 6 in. The base depth need not exceed 12 in. unless specifically recommended by the base manufacturer for mass or rigidity. Forms shall include minimum concrete reinforcing consisting of ½ in. bars welded in place on 6 in. centers running both ways in a layer 1-1/2 in. above the bottom. Forms shall be furnished with steel templates to hold the anchor bolts sleeves and anchors while concrete is being poured. Height saving brackets shall be employed in all mounting locations to maintain a 1 in. clearance below the base. Wooden formed bases leaving a concrete rather then a steel finish are not acceptable. Base shall be Type BMK or K as manufactured by Mason Industries, Inc.

22. Curb mounted rooftop equipment shall be mounted on spring isolation curbs. The lower member shall consist of a sheet metal Z section containing adjustable and removable steel springs that support the upper floating section. The upper frame must provide continuous support for the equipment and must be captive so as to resiliently resist wind and seismic forces. All directional neoprene snubber bushings shall be a minimum of 1/4 in. thick. Steel springs shall be laterally stable and rest on 1/4 in. thick neoprene acoustical pads. Hardware must be plated and the springs provided with a rust resistant finish. The curbs waterproofing shall consist of a continuous galvanized flexible counter flashing nailed over the lower curbs waterproofing and joined at the corners by EPDM bellows. All spring locations shall have access ports with removable waterproof covers. Lower curbs shall have provision for 2 in. of insulation. The roof curbs shall be built to seismically contain the rooftop unit. The unit must be solidly fastened to the top floating rail, and the lower Z section anchored to the roof structure. Curb shall have anchorage preapproval "R" from OSHPD in the state of California attesting to the maximum certified horizontal and vertical load ratings. Curb shall be Type RSC as manufactured by Mason Industries, Inc or approved equal.

23. Flexible spherical piping connectors shall employ peroxide cured EPDM in the covers, liners and Dacron tire cord frictioning. Solid steel rings shall be used within the raised face rubber ends to prevent pullout. Flexible cable bead wire is not acceptable. Sizes 2 in. and larger shall have two spheres reinforced with a ring between spheres to maintain shape and complete with split ductile iron or steel flanges with hooked or similar interlocks. Sizes 16 in. to 24 in. may be single sphere. Sizes 3/4 in. to 1-1/2 in. may have threaded bolted flange assemblies, one sphere and cable retention. 14 in. and smaller connectors shall be rated at 250 psi up to 190 F with a uniform drop in allowable pressure to 190 psi at 250 F. 16 in. and larger connectors are rated 180 psi at 190 F and 135 psi at 250 F. Safety factors to burst and flange pullout shall be a minimum of 3/1. All joints must have permanent markings verifying a 5 minute factory test at twice the rated pressure. Concentric reducers to the above Specifications may be substituted for equal ended expansion joints. Pipe connectors shall be installed in piping gaps equal to the length of the expansion joints under pressure. Control rods need only be used in unanchored piping locations where the manufacturer determines the installation exceeds the pressure requirement without control rods, as control rods are not desirable in seismic work. If control rods are used, they must have 1/2 in. thick Neoprene washer bushings large enough in area to take the thrust at 1000 psi maximum on the washer area. Expansion joints shall be installed on the equipment side of the shut off valves.

    Flexible pump connectors shall be installed at each base mounted pump discharge and suction connection. Connections shall be spool type multi-ply stainless steel bellows with tie rods, rated for 150 psig, Keflex type 150.

    Submittals shall include two (2) test reports by independent consultants showing minimum reductions of 20 DB in vibration accelerations and 10 DB in sound pressure levels at typical blade passage frequencies on this or a similar product by the same manufacturer. All expansion joints shall be installed on the equipment side of the shut off valves. Expansion joints shall be SAFEFLEX SFDEJ, SFEJ, SFDCR or SFU and Control Rods CR as manufactured by Mason Industries, Inc.

24. Flexible stainless steel hose shall have stainless steel braid and carbon steel fittings. Sizes 3 in. and larger shall be flanged. Smaller sizes shall have male nipples. Minimum lengths shall be as tabulated:

Flanged	Male Nipples

3 x 1410 x 26	1/2 x 91-1/2 x 13
4 x 1512 x 28	3/4 x 10 2 x 14
5 x 1914 x 30	1 x 112-1/2 x 18
6 x 2016 x 32	1/4 x 12 8 x 22

Hoses shall be installed on the equipment side of the shut-off valves horizontally and parallel to the equipment shafts wherever possible. Hoses shall be Type BSS as manufactured by Mason Industries, Inc.

25. For vertical riser application more than 3 stories in height, all-directional acoustical pipe anchor, consisting of two sizes of steel tubing separated by a minimum ½ in. thick 60 durometer neoprene. Vertical restraint shall be provided by similar material arranged to prevent vertical travel in either direction. Allowable loads on the isolation material should not exceed 500 psi and the design shall be balanced for equal resistance in any direction. All-directional anchors shall be Type ADA as manufactured by Mason Industries, Inc.

26. For vertical riser application more than 3 stories in height, pipe guides shall consist of a telescopic arrangement of two sizes of steel tubing separated by a minimum ½ in. thickness of 60 durometer neoprene. The height of the guides shall be preset with a shear pin to allow vertical motion due to pipe expansion or contraction. Shear pin shall be removable and reinsertable to allow for selection of pipe movement. Guides shall be capable of $\pm$ 1-5/8 in. motion, or to meet location requirements. Pipe guides shall be Type VSG as manufactured by Mason Industries, Inc.

27. Split Wall Seals consist of two bolted pipe halves with minimum 3/4 in. thick neoprene sponge bonded to the inner faces. The seal shall be tightened around the pipe to eliminate clearance between the inner sponge face and the piping. Concrete may be packed around the seal to make it integral with the floor, wall or ceiling if the seal is not already in place around the pipe prior to the construction of the building member. Seals shall project a minimum of l in. past either face of the wall. Where temperatures exceed 240 deg. F., 10 lb. density fiberglass may be used in lieu of the sponge. Seals shall be Type SWS as manufactured by Mason Industries, Inc.

28. The horizontal thrust restraint shall consist of a spring element in series with a neoprene molded cup as described in Specification 5 with the same deflection as specified for the mountings or hangers. The spring element shall be designed so it can be preset for thrust at the factory and adjusted in the field to allow for a maximum of 1/4 in. movement at start and stop. The assembly shall be furnished with one (1) rod and angle brackets for attachment to both the equipment and the duct work or the equipment and the structure. Horizontal restraints shall be attached at the centerline of thrust and symmetrical on either side of the unit. Horizontal thrust restraints shall be Type WBI/WBD as manufactured by Mason Industries, Inc.

29. At all other platform (no curb) mounted equipment such as condensing units and the like provide 6”x6” neoprene vibration pads at all support points and as shown on the drawings, minimum of six per unit. Pads shall be similar to Mason Industries model #WMFB composite pad of two neoprene layers sandwiching a galvanized steel shim with through hole. Exposed edges of steel shim shall be painted with 2-coats of rustproof primer. Vibration isolators shall be securely bolted to unit and structural support frame with neoprene coated stainless steel bolts, washers and nuts. If required

by the equipment manufacturer, provide continuous rail vibration support systems and submit for review and approval.

K. Execution - General:

1. All vibration isolators and seismic restraint systems must be installed in strict accordance with the manufacturers written instructions and all certified submittal data.

2. Installation of vibration isolators and seismic restraints must not cause any change of position of equipment, piping or duct work resulting in stresses or misalignment.

3. No rigid connections between equipment and the building structure shall be made that degrades the noise and vibration control system herein specified.

4. The Contractor shall not install any equipment, piping, duct or conduit which makes rigid connections with the building unless isolation is not specified. "Building" includes, but is not limited to, slabs, beams, columns, studs and walls.

5. Coordinate work with other trades to avoid rigid contact with the building.

6. Any conflicts with other trades which will result in rigid contact with equipment or piping due to inadequate space or other unforeseen conditions should be brought to the architects/engineers attention prior to installation. Corrective work necessitated by conflicts after installation shall be at the responsible Contractor's expense.

7. Bring to the architects/engineers attention any discrepancies between the Specifications and the field conditions or changes required due to specific equipment selection, prior to installation. Corrective work necessitated by discrepancies after installation shall be at the responsible Contractor's expense.

8. Correct, at no additional cost, all installations which are deemed defective in workmanship and materials at the Contractor's expense.

9. Overstressing of the building structure must not occur because of overhead support of equipment. Contractor must submit loads to the structural engineer of record for approval. Generally bracing may occur from:

   a. Flanges of structural beams.

   b. Upper truss cords in bar joist construction.

   c. Cast in place inserts or wedge type drill-in concrete anchors.

10. Specification 12 cable restraints shall be installed slightly slack to avoid short circuiting the isolated suspended equipment, piping or conduit.

11. Specification 12 cable assemblies are installed taut on non-isolated systems. Specification 13 seismic solid braces may be used in place of cables on rigidly attached systems only.

12. At locations where Specification 12 or 13 restraints are located, the support rods must be braced when necessary to accept compressive loads with Specification 14 braces.

13. At all locations where Specification 12 or 13 restraints are attached to pipe clevis's, the clevis cross bolt must be reinforced with Specification type 15 braces.

14. Drill-in concrete anchors for ceiling and wall installation shall be Specification type 18, and Specification type 19 female wedge type for floor mounted equipment.

15. Vibration isolation manufacturer shall furnish integral structural steel bases as required. Independent steel rails are not permitted on this project.

16. Hand built elastomeric expansion joints may be used when pipe sizes exceed 24 in. or specified movements exceed Specification 23 capabilities.

17. Where piping passes through walls, floors or ceilings the vibration isolation manufacturer shall provide Specification 27 wall seals.

18. Air handling equipment and centrifugal fans shall be protected against excessive displacement which results from high air thrust in relation to the equipment weight. Horizontal thrust restraint shall be Specification type 28 (see selection guide).

19. Locate isolation hangers as near to the overhead support structure as possible.

L. Vibration Isolation of Piping:

1. Horizontal Pipe Isolation: The first three (3) pipe hangers in the main lines near the mechanical equipment shall be as described in Specification 11. Specification 11 hangers must also be used in all transverse braced isolated locations. Brace hanger rods with SRC clamps Specification 14. Horizontal runs in all other locations throughout the building shall be isolated by hangers as described in Specification 10. Floor supported piping shall rest on isolators as described in Specification 6. Heat exchanger's and expansion tanks are considered part of the piping run. The first three (3) isolators from the isolated equipment will have the same static deflection as specified for the mountings under the connected equipment. If piping is connected to equipment located in basements and hangs from ceilings under occupied spaces the first three hangers shall have 0.75 in. deflection for pipe sizes up to and including 3 in., 1-1/2 in. deflection for pipe sizes up to and including 6 in., and 2-1/2 in. deflection thereafter. Hangers shall be located as close to the overhead structure as practical. Where piping connects to mechanical equipment install Specification 23 flexible piping connection or Specification 24 stainless hoses if 23 is not suitable for the service.

2. Riser Isolation: Risers shall be suspended from Specification 10 hangers or supported by Specification 5 mountings, anchored with Specification 25 anchors, and guided with Specification 26 sliding guides. Steel springs shall be a minimum of 0.75 in. except in those expansion locations where additional deflection is required to limit load changes to ± 25% of the initial load. Submittals must include riser diagrams and calculations showing anticipated expansion and contraction at each support point, initial and final loads on the building structure, spring deflection changes and seismic loads. Submittal data shall include certification that the riser system has been examined for excessive stresses and that none will exist in the proposed design.

M. Seismic Restraint of Piping:

1. Seismically restrain all piping listed as a, b or c below. Use Specification 12 cables if isolated. Specification 12 or 13 restraints may be used on unisolated piping.

   a. Gas piping, that is 1 in. I.D. or larger.

   b. Piping located in boiler rooms, mechanical equipment (fan) rooms, and refrigeration equipment rooms that is 1-1/4 in. I.D. and larger.

   c. All other piping 2-1/2 in. diameter and larger.

2. Transverse piping restraints shall be at 40' maximum spacing for all pipe sizes, except where lesser spacing is required to limit anchorage loads.

3. Longitudinal restraints shall be at 80' maximum spacing for all pipe sizes, except where lesser spacing is required to limit anchorage loads.

4. Where thermal expansion is a consideration, guides and anchors may be used as transverse and longitudinal restraints provided they have a capacity equal to or greater than the restraint loads in addition to the loads induced by expansion or contraction.

5. For fuel oil and all gas piping transverse restraints must be at 20 ft. maximum and longitudinal restraints at 40 ft. maximum spacing.

6. Transverse restraint for one (1) pipe section may also act as a longitudinal restraint for a pipe section of the same size connected perpendicular to it if the restraint is installed within 24 in. of the elbow or TEE or combined stresses are within allowable limits at longer distances.

7. Hold down clamps must be used to attach pipe to all trapeze members before applying restraints in a manner similar to clevis supports.

8. Branch lines may not be used to restrain main lines.

9. Cast-iron pipe of all types, glass pipe and any other pipes joined with a four band shield and clamp assembly in Zones 2B, 3 and 4 shall be braced as in sections 3.02.C.2 and 3. For Zones 0, 1 and 2A, 2 band clamps may be used with reduced spacings of ½ of those listed in sections 3.02.C.2 and 3.

N. Vibration Isolation of Ductwork:

1. All discharge runs for a distance of 50' from the connected equipment shall be isolated from the building structure by means of Specification 10 hangers or Specification 5 floor isolators. Spring deflection shall be a minimum of 0.75 in.

2. All duct runs having air velocity of 1000 fpm or more shall be isolated from the building structure by Specification 11 hangers or 5 floor supports. Spring deflection shall be a minimum of 0.75 in.

O. Seismic Restraint of Ductwork:

1. Seismically restrain all duct work with Specification 12 or 13 restraints as listed below:

   a. Restrain rectangular ducts with cross sectional area of 6 sq. ft. or larger.

   b. Restrain round ducts with diameters of 28 in. or larger.

   c. Restrain flat oval ducts the same as rectangular ducts of the same nominal size.

2. Transverse restraints shall occur at 30' intervals or at both ends of the duct run if less than the specified interval. Transverse restraints shall be installed at each duct turn and at each end of a duct run.

3. Longitudinal restraints shall occur at 60' intervals with at least one restraint per duct run. Transverse restraints for one duct section may also act as a longitudinal restraint for a duct section connected perpendicular to it if the restraints are installed within 4' of the intersection of the ducts and if the restraints are sized for the larger duct. Duct joints shall conform to SMACNA duct construction standards.

4. The ductwork must be reinforced at the restraint locations. Reinforcement shall consist of an additional angle on top of the ductwork that is attached to the support hanger rods. Ductwork is to be attached to both upper angle and lower trapeze.

5. A group of ducts may be combined in a larger frame so that the combined weights and dimensions of the ducts are less than or equal to the maximum weight and dimensions of the duct for which bracing details are selected.

6. Walls, including gypsum board non bearing partitions, which have ducts running through them may replace a typical transverse brace. Provide channel framing around ducts and solid blocking between the duct and frame.

P. All mechanical equipment shall be vibration isolated and seismically restrained as per the schedules in paragraph S of this Specification.

Q. Seismic Restraint Exclusions:

1. Piping:

   a. All piping less than 2-1/2 in. in diameter except those listed below.

   b. All gas piping less than 1 in. I.D.

   c. All piping in boiler and mechanical equipment rooms less than 1-1/4 in. I.D.

   d. All clevis or trapeze supported piping suspended from hanger rods where the point of attachment is less than the 12 in. in length from the structure to the structural connection of the clevis or trapeze.

   e. All PVC and fiberglass suspended waste or vent pipe 6 in. in diameter and smaller.

2. Ductwork:

   a. Rectangular, square or oval ducts less than 6 sq. ft. in cross sectional area.

   b. Round duct less than 28 in. in diameter.

   c. Duct supported by hanger rods where the point of attachment is less than 12 in. in length from the structure to the structural connection of the duct work.

R. Suspended Equipment: VAV boxes and fan powered equipment weighing less than 50 lbs. and rigidly connected to the supply side of the duct system and supported with a minimum of 4 hanger rods.

S. Schedules:

1. Equipment Isolator and Seismic Restraint Schedule:

	Vibration Isolation and or Seismic Restraint	
Equipment Schedule	Specification	Static Deflection
Air Handling Unit	1,4,19	Internal1 1-½" Isol.
Fan Coil Unit	4 & 18	
VAV Boxes	10, 12, 19	.75 in.
In-Line Fans	10, 12, 19	.75 in.
Unit Heaters	10, 12, 19	.75 in.
Cabinet Heaters	4 & 18	

Pumps	1, 4, 18, 23	
Boiler	4 & 19	
Condensing Unit	-	-
Suspending Fan Coil	10 & 12	

2.25 DUCTLESS SPLIT AIR CONDITIONING SYSTEM

A. Furnish and install a ductless split commercial in-ceiling cassette fan coil or wall hung as scheduled matched with a roof mounted air cooled condensing unit. Indoor unit shall be wall hung as scheduled. The matched system shall be rated per ARI Standard 210/240 and certified by UL and CSA. The system shall be as manufactured by Daiken, Mitsubishi or Sanyo. A non CFC or HCFC refrigerant must be used such as R-410A or approved equal. Minimum EER=15

B. The combination of the outdoor unit and the indoor-fan coil unit shall have a total net cooling capacity as scheduled on drawings or greater at conditions of entering-air temperature at the evaporator coil of 80 degrees F. dry bulb and 67 degrees F. wet bulb. Outdoor ambient temperature of air entering the condenser of 95 degrees F. The system shall have a minimum listed SEER (seasonal energy efficiency ratio) of 15 at ARI conditions.

C. Indoor Fan Coil Unit:

1. Indoor, direct-expansion, low-profile (11-3/4 in. high) in-ceiling fan coil or wall hung as scheduled. Unit shall come complete with cooling coil, fan, fan motor, piping connectors, electrical controls, condensate pump, and hanging brackets.

2. Cabinet shall be constructed of zinc-coated steel. Fully insulated discharge and inlet grilles shall be attractively styled, high-impact polystryrene. Cabinet shall have filter tracks and cleanable filters which shall be accessible from below with a 1/4-turn fastener. Adjacent room cooling to be provided by a simple knockout in the cabinet side panel, and cabinet shall have provisions to accommodate a limited amount of ductwork, if desired.

3. Fan shall be a centrifugal, direct-drive blower type with air intake in center of the unit and discharge on the perimeter. Air louvers shall be adjustable.

4. Coil shall be copper tube with aluminum fins and galvanized steel tube sheets. Fins will be bonded to the tubes by mechanical expansion. A drip pan under the coil shall have a factory-installed condensate pump and drain connection for hose attachment to remove condensate. External pump shall be provided for wall units as required.

1. Motor shall be totally enclosed and permanently lubricated with inherent protection. Fan motor shall be 3-speed. Unit shall operate on single phase 60- cycle 208 V power.

2. Controls shall be 24 Volt, and shall be easily operated by the user from a wall-mounted control unit. Float control shall be in the condensate sump to shut unit down in case of

pump malfunction. A wall-mounted electro-mechanical thermostat with three (3) fan speed selections, and an auto/manual switch shall be supplied for field installation. The refrigerant is controlled with a piston-type refrigerant metering device, and evaporator coil freeze protection shall be provided.

D. Outdoor Air Cooled Condensing Unit: Furnish and install matching condensing unit. Condensing unit shall have low ambient control for operation down to -10°F, hard start assist kit, winter start package and crankcase heater. Provide 18" high snow stand similar to Quick-Sling product or equal securely fastened to the anchored roof sleepers and the unit. Provide seismic rated vibration isolators.

2.26 CUSTOM ROOFTOP COOLING/HEATING UNITS (MAIN CLASSROOM NW, NE & SE RTU's)

PART 1 - GENERAL

A. SECTION INCLUDES

1. Design, performance criteria, controls, and installation requirements for indoor mounted Custom Air Handling Units.

B. REFERENCES

1. AFBMA 9 – Load Ratings and Fatigue Life for Ball Bearings
2. AMCA Publication 99 – Standards Handbook
3. AMCA Standard 203 – Field Performance Measurement of Fan Systems
4. AMCA Standard 210 – Laboratory Methods of Testing Fans for Performance Rating
5. AMCA Standard 300 – Reverberant Room Method for Sound Testing of Fans
6. AMCA Standard 500 – Laboratory Methods for Testing of Dampers and Louvers
7. ARI Standard 410 – Forced Circulation Air-Cooling and Air-Heating Coils
8. ANSI/ASHRAE Standard 111 – Practices for Measurement, Testing, Adjusting and Balancing of Building HVAC Systems
9. ASHRAE Standard 52.1 – Dust-Spot Procedures for Testing Air-Cleaning Devices
10. ANSI/ASHRAE Standard 52.2 – Method of Testing Air-Cleaning Devices for Removal Efficiency by Particle Size
11. ANSI/ASHRAE 15 – Safety Standard for Refrigeration Systems
12. ANSI/ASHRAE 62.1 – Ventilation for Acceptable Indoor Air Quality
13. ANSI/ASHRAE 90.1 – Energy Standard for Buildings Except Low-Rise Residential
14. ARI 1060 – Performance Rating of Air to Air Energy Recovery Ventilation Equipment
15. ASTM A-653 – Specification for General Requirements for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dipped Process
16. ASTM B117 – Standard Practice for Operating Salt Spray Apparatus
17. IBC 2006-2012 – International Building Code
18. NEMA MG1 – Motors and Generators
19. NFPA 70 – National Electric Code
20. NFPA 90A – Standard for the Installation of Air Conditioning and Ventilating Systems
21. UL 900 – Test Performance of Air Filters

22. UL 1995 – Standard for Heating and Cooling Equipment

C. SUBMITTALS

1. Submit shop drawings and product data in accordance with Division 1
2. Submittals shall include the following:
   a. Dimensioned plan and elevation view drawings, including motor starter and control cabinets, required clearances, and location of all field connections.
   b. Cabinet material, metal thickness, finishes, insulation and accessories.
   c. Ladder-type schematic drawing of the power and auxiliary utility field hookup requirements, indicating all items that are furnished by the manufacturer.
   d. Manufacturer's performance of each unit. Selection shall indicate, as a minimum, the following:
      i. Fan curves with system operating conditions indicated.
      ii. Certified coil performance ratings with system operating conditions.
      iii. Calculations required for base rail heights to satisfy condensate trapping requirements of cooling coil.
      iv. Filters with performance characteristics.
      v. Rated load amp draw.
      vi. Approximate unit shipping weight.

D. OPERATION AND MAINTENANCE DATA

1. Include data on design, inspection and procedures related to preventative maintenance. Operation and maintenance manuals shall be submitted at the time of unit shipment.

E. QUALIFICATIONS

1. Manufacturer shall be a company specializing in the design and manufacture of custom air handling equipment and in business for no less than 15 years.
2. Each unit shall bear an ETL label, conforming to UL Standard 1995.
3. Units shall comply with the requirements of UL 1995 and NFPA 90.
4. Wind Restraint Performance:
   a. Each unit shall have a prominently displayed IBC 2006-2012 (or more current) Seismic Compliance Label issued by an independent third party approval agency which is specific for the size of the component and tested acceleration levels.

F. DELIVERY, STORAGE, AND HANDLING

1. Deliver, store, protect and handle products to site under the supervision of the owner in accordance with the manufacturers Operation and Maintenance Instructions.

G. SEQUENCING AND SCHEDULING

1. Coordinate work performed under this section with work performed under the separate installation contract.

H. WARRANTY

1. The complete unit shall be covered by a part only warranty issued by the manufacturer covering the first year of operation. The warranty period shall start on the date of equipment startup or six months after the date of shipment from factory, whichever occurs first. Contractor shall insure units are shipped so as to be fully installed and started prior to the 6 month warranty from shipping period expires.
2. The installing contractor shall provide labor warranty during the unit's first year of operation.
3. Refer to 3 year parts, labor and maintenance warranty requirement for this equipment elsewhere in the spec.

PART 2 - PRODUCTS

A. MANUFACTURER

1. Basis of design is ClimateCraft. To be approved equal manufacturers of Haakon or Energylabs Inc. shall meet or exceed performance and construction aspects as described and detailed herein. Requests for prior approval must be submitted 10 days prior to bid date. Submittal is to be in sufficient detail to determine equivalency. Substitution requests must originate from a bidder which is a general contractor or mechanical contractor plan record holder.

2. Besides needing to meet all the performance requirements and characteristics specified herein and on the drawings, the specified product as well as any approved equal must be constructed to fit on the existing steel support frames, have supply and return connection that do not impact existing steel framing and cross bracing and must not exceed the weights of the specified units. The units dimensional length (no width) may be allowed to exceed the existing steel frame by no more than 12" in the long dimension and if so the unit base rail must be capable of supporting the overhang of said unit without any added steel framing below.

B. GENERAL

1. Units shall be completely factory assembled and tested with the exception of unit splits as required for shipping or installation requirements as indicated on the schedule and drawings. The equipment's cooling, heating, humidifying, ventilating, exhausting capacity and performance shall meet or exceed that shown on the schedule. Tags and decals to aid in service or to indicate caution areas shall be provided. Electrical wiring diagrams shall be attached to the control panel access doors. Operation and Maintenance manuals shall be furnished with each unit.
2. IBC Seismic Compliance
    1. Complete unit shall be independently certified to meet the seismic compliance standards of the International Building Code, IBC-2000, 2003, 2006, 2009, 2012, 2015
3. Hurricane Resistant Construction

1. Units shall comply with the High Velocity Hurricane Zone requirements of the Florida Building Code and approved to bear a label stating “Miami-Dade County Product Control Approved.” A copy of the Miami-Dade County Notice of Approval (NOA) shall be provided to the user upon request.
    a. NOA shall include a Large and Small Missile Impact rating.
    b. NOA shall include a “Maximum Design Pressure Positive” rating of 110.
    c. NOA shall include a “Maximum Design Pressure Negative” rating of 110.
4. Snow Load
    1. Must be capable of roof snow load of 60 lbs / sq ft.
5. Efficiency
    1. Unit part load and full load EER ratings must meet or exceed those specified in IECC 2015.

C. CABINET CONSTRUCTION

1. Cabinets shall be constructed in a watertight and airtight manner. The manufacturer's standard cabinet construction shall result in an ASHRAE/ANSI Standard 111 Leakage Class 5 rating, or better, as measured in accordance with AMCA Standard 210. A leakage rate as a percent of airflow shall only be submitted following calculation at specific project conditions. Maximum casing leakage (cfm/100 ft^2 of casing surface area) = CL X $P^{0.65.}$ Published leakage rates at generic conditions shall not be submitted.
2. Casing deflection shall not exceed L/200 at +12.0 w.g. in all positive pressure sections and -12.0 w.g. in all negative pressure sections where L is defined as the panel span. Panels shall be designed to deflect no more than 1/200 (.0005” per inch) of span under operating design conditions when measured at the panel span. Casing shall be rated for 1% leakage at 1.5 times the operating pressure with a maximum overall pressure of 12” wc.
3. The unit shall be constructed on a 5” ¼” thick HSS structural steel, welded tubular steel base. Base tubing shall be cold-formed carbon steel, electric resistance welded. Equipment using a die-formed sheet metal base is not acceptable. Formed intermediate cross members shall be constructed of hot rolled 12-gauge galvanized steel. After fabrication, the base frame shall be thoroughly cleaned and coated with high solids, polyamide epoxy paint system for off shore marine standard and enamel painted. Formed steel and bolted bases are NOT acceptable.
4. Units shipped in multiple sections shall be engineered for ease of field assembly. Gasket supplied with the unit shall be a high-quality weather resistant closed-cell EPDM sponge rubber. Each section shall include a permanent label to aid in proper field assembly. All gasket and necessary assembly hardware shall ship loose with unit. Floors shall be designed to deflect no more than 1/200 of span under operating conditions.
5. Floors
    a. Shall be fabricated of 3/16” aluminum tread plate All floor sheets shall be isolated from the base assembly with an EPDM thermal break gasket.
    b. Floors shall be insulated with a two-part polyurethane water impervious foam insulation.
    c. Under liner shall be fabricated of 16-gauge G-90 galvanized steel
    d. Panels shall be 2” thick double wall construction. Panel joints shall be sealed with an industrial EPDM gasket to form a water and airtight seal. Air handling

manufacturers using caulk to seal panels must include an owner witnessed field leakage test. The test shall require the unit to be field design air flow tested and cabinet leak tested for 1% at 1.5 times the operating pressure.

e. Panels shall be individually removable for service without removing the roof or compromising the integrity of the cabinet wall. Panels shall be joined with 5/16" bolts that can be removed and refastened. Panel attachment with screws is not acceptable. All panels shall utilize thermal break construction between the exterior panel and the interior liner and between the panels and the base and roof frames

6. To allow for added protection from ruptured coils or piping, floors in specified section(s) shall include a drain outlet routed through the perimeter base.
7. Wall and roof panels
    a. Panels shall be 2" thick double wall construction. Panel joints shall be sealed with an industrial EPDM gasket to form a water and airtight seal. Air handling manufacturers using caulk to seal panels must include an owner witnessed field leakage test. The test shall require the unit to be field design air flow tested and cabinet leak tested for 1% at 1.5 times the operating pressure.
    b. Panels shall be individually removable for service without removing the roof or compromising the integrity of the cabinet wall. Panels shall be joined with 5/16" bolts that can be removed and refastened. Panel attachment with screws is not acceptable. All panels shall utilize thermal break construction between the exterior panel and the interior liner and between the panels and the base and roof frames.
    c. For long term durability, exterior panels shall be a minimum 16-gauge stucco embossed high strength aluminum.
    d. Interior liners shall be a minimum 16-gauge aluminum. Panel liners shall be of a single piece construction and attached to the exterior panels with a full thermal break. To allow for cleaning, no fasteners shall be used on the exposed liner surface. Single wall units are not acceptable.
8. Insulation
    a. All wall and roof panels shall be insulated with an injected foam insulation with an R value of 13.2 / inch. Panels shall be designed to deflect no more than 1/200 of span under operating design conditions when measured at the panel seam. Insulation shall fill the panel without voids. Panels shall have a minimum.
9. Access doors shall be provided into all sections of the air-handling unit as indicated in the plan documents. Doors shall be sized as shown on plan drawings, shall be a minimum 2" thick with R13 polyurethane foam insulation and shall be double wall construction using the same material type as the corresponding section. Doors shall comply with the requirements of UL 1995 and NFPA 90. The door frame shall be 0.125" extruded 6063-T5 aluminum. Each door shall be mounted with adjustable die cast aluminum hinges. All doors and mounting frames shall incorporate a thermal break design and the doors shall seal to a replaceable extruded EPDM sponge rubber gasket. Doors shall open against static pressure or shall include a pressure relief feature on the door latch.
    a. The door latch assembly shall consist of a roller cam compression arm with a chrome plated steel inner handle and glass fiber / nylon composite outer handle. One tool operated lock shall be provided on each fan section access door. All doors shall have a minimum of two latches. Doors over 72" tall shall have 3 or more latches.

b. A 10”x12” thermal pane viewing window with one wire mesh safety glass pane and one clear pane shall be provided. The frame shall have a no-through-metal thermal break design. Viewing windows shall be on all doors serving a lighted section. Windows on doors exposed to unit mounted UVC light shall use glass that is resistant to UVC transmission.

10. The entire unit shall be painted with a baked epoxy finish with custom color selection by the Architect.
11. The entire unit, including walls, roof, doors, joints, and seams shall include thermal break construction. This construction shall be supported by tested performance producing no condensation on the exterior surface when the air tunnel temperature is 50°F DB under the following exterior conditions:

$$(Th - 50) / (Th - Tdp) < 3.4$$

a. Th = Ambient dry bulb temperature (°F) external to housing
b. Tdp = Ambient dew point temperature (°F) external to housing

D. FAN ASSEMBLIES – DIRECT DRIVE FAN ARRAY

1. Fan Arrays shall be direct-drive, non-overloading SWSI plenum fans designed for industrial duty and suitable for continuous operation.
   i) Fans shall be arranged in an array using one or more welded structural steel assemblies and shall be of the size and quantity specified in the unit schedule. Screwed or riveted frames are unacceptable. Fan assemblies shall be attached directly to base structural members.
   ii) Fan wheels shall have a minimum of 12 airfoil blades for superior sound characteristics and shall be constructed of aluminum to reduce rotational weight and vibration. Fan blades shall be extruded aluminum for uniformity and improved vibration characteristics.
   iii) Each fan and motor assembly shall be independently isolated within the structural assembly using 1 inch deflection spring isolators. Isolators shall be mounted in a three-point arrangement that provides both vertical and horizontal (thrust) isolation and shall not require field adjustment. If hard mounted or rubber in shear is used in place of internal spring isolations, external isolation of the entire unit is required. Isolation system shall be seismic rated to withstand seismic forces in excess of 4G horizontally and vertically to satisfy specified IBC seismic requirements.
   iv) A fan inertia base shall be provided or the fan structure shall exceed an equivalence of 2x mass of the total rotating parts of the fan array. Fan and motor assemblies shall be designed such that no natural frequencies exist within the operating RPM range of the fan, eliminating the need for “lockout” frequency settings in the variable speed drive. The purchasing contractor will be responsible for all costs associated with externally isolating any unit that does not include individual fan isolation.
   v) All fan arrays shall meet the minimum motor efficiency, maximum brake horsepower and total motor horsepower values scheduled. All fans shall be selected to operate at a point no higher than 90% of the peak static pressure rating as defined by the fan performance curve at the selected operating speed. Manufacturer must ensure maximum fan RPM is below the first critical speed. Fans shall be Class 2 construction.
   vi) All fan and motor assemblies shall be dynamically balanced by the manufacturer to a maximum allowable vibration of 0.040 inches per second at

design RPM and a maximum 0.080 inches per second overall vibration limit to bring the fan balance in conformance to a BV-5 Grade G1 per ANSI/AMCA 204. In addition, the manufacturer shall insure that no critical frequencies exist in the fan operating range by varying motor speed in 1Hz increments from design RPM to 50% of design RPM.

2. Unloading
   i) Fans shall be provided with unloading technology to allow fan modulation without surge from 100% to 10%; while maintaining the part load static pressure requirements of the system. There shall be no static pressure or intake plenum losses or any horsepower penalty associated with the system.
   ii) BalanceStream is a self-contained system independent of the building system temperature controls. No powered actuators or control signals are required. Any control points required to operate the unloading sequence shall be wired by the AHU manufacturer to a single point of control for the building automation system to interface. If control points are required, coordination with the BASD manufacturer on control sequence responsibilities shall be required at time of submittal approval.
   iii) They system shall provide a positive shutoff for each fan in case of a fan failure. Each fan shall be provided with an isolation or backdraft damper to prevent bypass in the event of a motor failure. Blank off plates requiring manual installation are not acceptable.
   iv) Fan cycling to allow stable part load operation shall be allowed only if a maximum of 50% of the fans will be cycled off at any time. Each fan is to be cycled in such a manner that all fans operate an equal number of hours in any given 168 hour (1-week) operating period. Control system shall indicate the individual fans operating and not operating. A separate control signal shall be required to indicate fan failure, separate from an indication that a fan is intentionally controlled to be off.
   v) Fan curves shall be submitted; with the system curve indicating the minimum system operating static pressure and the point of fan surge.
3. Motors
   i) Electrical characteristics and horsepower shall be as specified on the project schedule.
   ii) Motors shall be Premium Efficiency per NEMA MG1 Table 12-12 ODP type, shall have NEMA Class F insulation, shall meet NEMA Standard MD-1 Inverter Duty rating and shall be designed to withstand 1600V peak voltage spikes and rise times ≥0.1 microseconds.
   iii) Motors shall have grease lubricated ball bearings designed to deliver a minimum L10 life of 250,000 hours at full load and the maximum operating RPM of the associated fan. Grease zerks and spring loaded grease relief valves shall be provided in each motor to allow easy bearing lubrication without damaging the seals due to over lubrication.
   iv) For efficient operation in a direct drive application, motors shall be capable of operating greater than 60HZ to at least the design operating speed of the fan.
   v) Motors shall be factory wired to a motor control center for connection to a disconnect switch or VFD. The motor control center shall include for each motor circuit a control device providing overload protection, short circuit protection and a manual disconnect means, and all circuits shall be wired to a common main panel terminal block. Each motor shall be factory wired directly to an individual VFD. All motors shall operate at all times and be controlled in unison,

maintaining a consistent and uniform airflow pattern over coils, filters and other devices.

vi) Each motor shall be provided with a shaft grounding device to harmlessly bleed potential induced shaft voltages to ground.

vii) All motors shall be dual nameplated for overspeed purposes in a 4 fan direct drive application.

4. Warranty

i) All fan/motors rotating parts shall be warranted by the unit manufacturer for a full five (5) years from date of unit start-up. Parts warranties provided by third parties are not acceptable.

5. Options

i) In the fan section, provide an overhead motor removal system to facilitate motor replacement.

(1) The assembly shall be either a manually operated winch, capable of being easily moved to any motor location or provide a structural steel I beam for mounting a trolley to assist in fan motor removal. Trolley assembly shall be provided by AHU manufacturer. The beam system shall be mounted overhead of the fan and motor. The beam system shall be supported and mounted to the unit's base support system.

ii) Fans shall be provided with inlet and outlet guards to protect service personnel.

iii) Each array shall be provided with one inlet airflow blank-off plate to be used in case of a motor failure. Plate to include handles and latches for quick installation.

E. FAN ARRAY CONTROLS

1. Fan arrays shall be controlled using a common control signal as provided by the building ATC (such as the duct static control signal), to modulate the fan speed.

2. All fan array controls for unloading and air flow measuring shall be provided by the AHU manufacturer, not by the ATC however, ATC shall command the fans on and off, send them static pressure or airflow volume or fan speed reset commands. The ATC shall monitor all fan airflows, speeds, current, status, etc… thru the factory fan array controller.

3. Each fan array in the air handling unit shall be provided with a factory installed airflow measuring instrument. Every fan in the array will have an airflow measuring device that is guaranteed by the unit manufacturer to have no impact on the fan airflow performance and will not increase the fan sound power. The output of the airflow measurement device on each fan shall be wired by the unit manufacturer back to a central processor mounted on the cabinet exterior that will add the flow from each fan to provide a total airflow for the fan array. Using one air flow measuring device and multiplying by the number of fans provided is not acceptable due to lack of accuracy. The central processor shall be able to detect and report a fan failure. Auxiliary contacts on the motors starters are not acceptable as fans can fail without tripping overloads. Current sensors wired into the central processors can be utilized.

4. Piezometric volume taps with pressure transducers are acceptable. Transducer accuracy shall be 1% of pressure reading from full scale down to 10% of full scale reading to improve accuracy to less than 0.5% of calculated flow from 100%-30% of

flow. The square root linearization and conversion of the pressure signal to flow shall be done at the central processor.

5. The factory fan array control system shall be fully compatible with the Building Automation System via native BACnet, Modbus and N2 communication. Coordinate interface protocol with campus control vendor ESC however, as a minimum, BacNet interface shall be considered basis of design.

F. FAN SPEED CONTROL

1. Each variable air volume supply and return fan shall be provided with an individual variable frequency drive. Drives shall be factory mounted and wired to the motor with adequate ventilation provided. The VFD shall be self-contained, totally enclosed in a NEMA 1 ventilated cabinet and capable of operation between 0 and 40-degree C. The VFD shall be 95% efficient at 100% rated output power, 60 Hz. The VFD shall be UL listed.

   Drives shall be mounted on the exterior of the unit in a NEMA-4 electrical control enclosure {that is shipped loose for field mounting by others}.

   Fans shall modulate to a (CFM) without surge. De-energizing fans shall not be an accepted format. AHU manufacturer must submit proper fan curves demonstrating unloading without fan surge.

2. The factory fan array control system shall be fully compatible with the Building Automation System via native BACnet, Modbus and N2 communication. Coordinate interface protocol with campus control vendor ESC however, as a minimum, BacNet interface shall be considered basis of design

G. UNIT SOUND POWER

1. Fan sound power levels (dB) for the unit shall not exceed values as specified on the equipment schedule.
2. Unit manufacturer shall provide certified inlet, supply and casing radiated, sound power levels based on the final unit configuration.

H. COILS

1. Provide complete coil section(s) with service access door(s) as shown on the plan drawings. Coil connections shall extend through the section casing for ease of installation. Coil connections must be sealed from both the inside and exterior surfaces of the panel with the sleeve of the inner seal covering the pipe within the depth of the panel, all to minimize leakage and condensation. An integral stainless steel air seal which completely seals around the coil casing and extends to the unit pressure bearing surface shall be provided. Air seals / safing materials that are mechanically fastened to the inner liner of the cabinet only shall be constructed of 16 gage materials to match the material type in the appropriate section and shall be gasketed and have fasteners every 3 inches.
2. Multiple, “stacked” coil arrangements must be constructed so as to allow independent removal of any coil without the removal of another within the coil bank.
3. All coils shall meet or exceed the capacities specified on the mechanical schedule and all water coil performances shall be certified in accordance with the AHRI Forced Circulation Air Heating and Air Cooling Coil certification program which is

based on AHRI Standard 410. Face velocities shall not exceed those specified on the mechanical schedule.

4. All cooling coil sections shall include a double sloped drain pan constructed from 304L stainless steel. All corners shall be welded watertight. Coils shall rest on stainless steel supports. The pan shall have a minimum pitch of 2" from high point to the bottom of the drain outlet connection, providing at least a 1/8” per foot slope. The drain pan shall be insulated with a 2-part sprayed on polyurethane, water impervious foam. Insulation shall be applied to the entire under side of the drain pan and coil section base assembly. If multiple stacked coils are used, intermediate drain pans are required. Intermediate pans shall be insulated and drained with 3/4” copper down-comers to the main pan.
5. Hot Water coils shall be of a staggered tube design with high efficiency die formed corrugated plate-type fins for maximum performance. All coils shall be tested with 400 psig compressed air under clear water. Coils shall be designed to operate at 300 psig internal pressure and up to 250ºF. Tubes shall be 5/8" diameter, seamless 0.020" wall copper, mechanically expanded into full drawn fin collars for a continuous compression bond over the full finned length for high efficiency performance. Coil casings shall be a minimum 16-gauge stainless steel. Coil casing reinforcements shall be required for fin lengths over 42". Coil fins shall be 0.0075" thick aluminum. Coils shall be serviceable using 0.25" M.P.T. drain and vent taps on the supply and return headers. Threaded seamless red brass coil connections shall be brazed to copper supply and return headers.
6. Refrigerant coils shall be of a staggered tube design with high efficiency die formed corrugated plate-type fins for maximum performance. All coils shall be tested with 350 psig compressed air under clear water. Coils shall be designed to operate at 250 psig internal pressure. Tubes shall be 5/8" diameter, seamless 0.020" wall copper, mechanically expanded into full drawn fin collars for a continuous compression bond over the full finned length for high efficiency performance. Coil casings shall be a minimum 16-gauge stainless steel. Coil casing reinforcements shall be required for fin lengths over 42". Coil fins shall be 0.0075" thick aluminum. Each coil circuit shall be furnished with a red brass distributor with solder type connections and a copper sweat suction connection.

I. FILTERS

1. Provide complete filter section(s) with filter racks and service access door(s) as shown on the plan drawings. Holding frames provided for medium efficiency applications will be either upstream or downstream accessible. Holding frames provided for high efficiency applications will be upstream accessible, only. Holding frames shall be constructed from heavy gauge galvanized steel and shall be equipped with polyurethane foam gaskets. Frames shall be installed with vertical stiffeners and appropriate frame-to-frame sealant to provide a rigid leak tight assembly. An integral air seal which completely seals around the filter frame assembly and extends to the unit pressure bearing surface shall be provided. Air seals / safing materials that are mechanically fastened to the inner liner of the cabinet only shall be constructed of 16 gage materials to match the material type in the appropriate section and shall be gasketed and have fasteners every 3 inches

   Filter fasteners shall be capable of being installed without the requirement of tools, nuts or bolts. The holding frame shall be designed to accommodate standard size filters with the application of the appropriate type fastener. The filter rack shall be

designed to use standard 24”x24” and 12”x24” filters only. Odd sized filters are not allowed. Holding frame assemblies shall be sized to meet or exceed the face area specified by the mechanical schedule.

2. Gauges
    a. A Magnehelic differential pressure gauge shall be provided factory installed for measuring the pressure drop across the filter bank-single stage. The gauge shall be a diaphragm-actuated dial type, 4¾" O.D., with white dial, black figures and graduations and pointer zero adjustment.
3. MERV 8 filters shall be provided on the main return air stream (upstream of energy wheel exhaust, in the outdoor airstream upstream of the energy wheel intake. High efficiency MERV 13 rigid mini-pleat filters shall be provide upstream of the unit coils and shall be 4” deep, totally rigid and disposable type. Each filter shall consist of water-laid micro fine fiberglass media formed with closely spaced pleats. The enclosing frame shall be double walled water resistant beverage board. The filter media shall have an average efficiency of 95% as rated by ASHRAE Standard 52.1 test methods. Provide filters for start-up and flush out and post flushout. As these units are part of the 3 year warranty and maintenance plan no additional filters are required as all filter changes for 3 years shall be provided by via the maintenance contract.

J. ENERGY RECOVERY SEGMENT

1. Unit shall contain a factory mounted and tested energy recovery wheel(s). The energy recovery wheel(s) shall be mounted in a rigid frame containing the wheel drive motor, drive belt, wheel seals and bearings. Frame shall slide out for service and removal from the cabinet.

2. The energy recovery component shall incorporate a rotary wheel in an insulated cassette frame complete with seals, ECM drive motor and drive belt.

3. Wheels shall be wound continuously with one flat and one structured layer in an ideal parallel plate geometry providing laminar flow and minimum pressure drop-to-efficiency ratios. The layers shall be effectively captured in stainless steel wheel frames or aluminum and stainless steel segment frames that provide a rigid and self-supporting matrix.

4. Wheels shall be provided with removable energy transfer matrix. Wheel frame construction shall be a welded hub, spoke and rim assembly of stainless, plated and/or coated steel and shall be self-supporting without matrix segments in place. Segments shall be removable without the use of tools to facilitate maintenance and cleaning. Wheel bearings shall be selected to provide an L-10 life in excess of 400,000 hours. Rim shall be continuous rolled stainless steel and the wheel shall be connected to the shaft by means of taper locks.

5. All diameter and perimeter seals shall be provided as part of the cassette assembly and shall be factory set. Drive belts of stretch urethane shall be provided for wheel rim drive without the need for external tensioners or adjustment.

6. The energy recovery cassette shall be an Underwriters Laboratories Recognized Component for electrical and fire safety. The wheel drive motor shall be an Underwriters Laboratory Recognized Component and shall be mounted in the

cassette frame and supplied with a service connector or junction box. Thermal performance shall be certified by the manufacturer in accordance with ASHRAE Standard 84, Method of Testing Air-to-Air Heat Exchangers and AHRI Standard 1060, Rating Air-to-Air Energy Recovery Ventilation Equipment. Cassettes shall be listed in the ARI Certified Product. Wheel effectiveness must meet the conditions specified in the schedules but in no case shall sensible effectiveness and total energy effectiveness be less than 70%.

7. Energy recovery wheel cassette shall carry a 5 year non-prorated warranty.

8. Unit shall include 2" MERV 8 pre-filters and 4 inch thick, pleated panel outside air filters with an ASHRAE efficiency of MERV rating of 13, upstream of the wheels. Unit shall include 2 inch thick, pleated panel exhaust air filters with an ASHRAE efficiency of 30% and MERV rating of 8, upstream of the wheels. Provide 4 spare sets in addition to those required during building flush-out period.

9. Hinged service access door shall allow access to the wheel(s).

10. Total energy recovery wheels shall be coated with silica gel desiccant permanently bonded by a process without the use of binders or adhesives, which may degrade desiccant performance. The substrate shall be lightweight polymer and shall not degrade nor require additional coatings for application in marine or coastal environments. Coated segments shall be washable with detergent or alkaline coil cleaner and water. Desiccant shall not dissolve nor deliquesce in the presence of water or high humidity.

11. Unit shall include a variable speed wheel to support both economizer and energy recovery wheel defrost control which includes an adjustable temperature sensor and wheel pressured sensor which, when frost is detected, slows allowing warm exhaust air to defrost the wheel. Wheel bypass dampers shall also be provided to support economizer cooling once the wheel has fully stopped.

12. Unit shall include energy recovery wheel rotation detection sensors and a set of normally open and normally closed contracts for field indication of wheel rotation.

13. Section shall include night bypass recirculation damper as well as wheel OA and EA bypass dampers.

K. DAMPERS

A. Mixing box and economizer outdoor air return air and exhaust air openings shall be airfoil low-leak dampers, Damper shall be {opposed} {parallel} blade type. The frame shall be fabricated from 16-gauge galvanized steel. Damper shall meet the leakage requirements of ASHRAE Std. 90.1 and of the International Energy Conservation Code by leaking less than 3 CFM/sq. ft. at 1" of static pressure, and shall be AMCA licensed as a Class 1A damper.

L. ELECTRICAL POWER AND CONTROLS

1. Unit operating voltage shall be 460V, 3 phase, 60Hz. All wiring and electrical equipment supplied by the manufacturer shall conform to and be installed in accordance with the requirements of UL1995.

Provide copper wires, bus bars, and fittings throughout, except internal wire of the control transformer may be aluminum if copper termination is provided. Identify power supply terminals with permanent markers. The maximum temperature of terminals shall not exceed 167°F (75°C) when the equipment is tested in accordance with its rating. Wiring shall be run in plated flexible metal conduit.

Mount a permanent nameplate on the unit to display the manufacturer, serial number and model number, date of manufacture, horsepower, current rating and voltage.

2. Furnish and install a non-fused disconnect switch for the supply & return fans and condenser sections. Units shall be internally wired in the field to terminate to a single point power connection with disconnect switche(s) mounted on the exterior of the unit in a housed ventilated panel.
3. Each section provided with a service access door, or as indicated on the plan drawings, shall be equipped with a vapor proof mini-fluorescent service light. All lights shall be completely installed and wired to a single toggle with a 60-minute timer switch. All switches shall be wired to the unit control panel. All switch boxes shall include a GFCI convenience receptacle. Lights shall be wired so they are functional whether the main power disconnect is in the on or off position. All exterior electrical boxes shall be metallic NEMA 3R.
4. The AHU manufacturer shall supply and mount all dampers with actuators mounted and wired by EMS control contractor.
5. Although many sensors and devices shall be field mounted and wired by the site control vendor ESC, the fan arrays and condenser section along with associated electronic expansion valves, hot gas reheat valves and such shall be fitted with monitored by and controlled by factory provided controls. The factory control System shall be fully compatible with the Building Automation System via native BACnet, Modbus and N2 communication. Coordinate interface protocol with campus control vendor ESC however, as a minimum, BacNet interface shall be considered basis of design. Factory controller must be capable to flushing hot gas reheat coil as required to prevent oil buil-up.

M. UNIT TESTING AND QUALITY CONTROL

1. The fans shall be factory run tested to insure design integrity and proper RPM. All electrical circuits shall be tested to ensure correct operation before shipment of unit. Units shall pass all quality control checks and be thoroughly cleaned prior to shipment.

N. AIR COOLED CONDENSER

1. Basic Construction: Frame shall consist of heavy gauge galvanized steel with 3 mil powder coat paint, construction baked at 350° for resilience in transport and installation. Color selection shall be custom as selected by the Architect. Condenser must have base with cutouts for forklift or pallet jack.

2. Refrigeration Circuit: Each independent circuit shall consist of a scroll compressor, thermostatic expansion valve for refrigerant metering, sight glass, filter drier, solenoid valve, high and low pressure controls and safety controls.

3. Coils shall include aluminum fins mechanically bonded to enhanced copper tubes with integral sub cooling circuits and rated for 650 psig.

4. Condenser fan(s) shall be direct drive axial type with high efficiency EC motors for head pressure control. Condenser fans shall be ultra-quiet with outlet designed fan blades.

5. Compressors: Unit shall contain no less than four (4) scroll style compressors of varying sizes with at least two (2) being on variable frequency inverters, independently circuited and mounted with rubber isolated compressor mounts to the module base. Compressors shall be configured so as to allow for a minimum of at least six near equally sized staging steps with a minimum turn-down of no greater than 10%. Hot gas bypass shall not be allowed. Unit manufacturer must coordinate required staging scenario with the EMS vendor to insure all required minimum on and off times and compressor rotation are adhered too. Factory controls must include all compressors safeties including compressor oil system flush cycles as required.

6. All suction, hot gas and vapor refrigerant piping shall be fully insulated from the condenser through to the air handler coils including piping running within the air handler in accordance with pipe insulation sections of this specification.

O. AIR COOLED CONDENSER CONTROL SYSTEM

1. Control System shall be fully compatible with the Building Automation System via native BACnet, Modbus and N2 communication. Coordinate interface protocol with campus control vendor ESC however as a minimum BacNet interface shall be considered basis of design.
2. Safety controls shall be provided with unit - High compressor motor temperature, Electrical phase failure, Compressor discharge temperature, Compressor suction temperature.

P. ACCESSORIES

1. Voltage/Phase Monitor – protects against voltage fluctuations, phase loss and phase reversal.
2. Compressor sound blanket

PART 3 - EXECUTION

A. INSTALLATION

1. Install in strict accordance with manufacturer’s requirements, shop drawings, and Contract Documents.
2. Equipment rigging and assembly to be supervised by the manufacturer or a manufacturer certified service organization. Provide for as long a period of time as

is necessary to ensure proper assembly or onsite training but no less than 2 full days.

3. Adjust in alignment on concrete foundations, sole plates or other supporting structure. Level, grout, and bolt in place.
4. Coordinate electrical installation with electrical contractor.
5. Coordinate controls with control contractor. EMS controls contractor shall be given access to the units within the local riggers yard for a minimum of 2-weeks prior to the units being delivered on site to facilitate installation of various controllers, devices, wiring and sensors.
6. Provide all appurtenances required ensuring a fully operational and functional system.
7. Mechanical contractor is responsible for assembly of the units on site and furnishing and installing all materials to make for a complete and fully operational system including but not limited to all interconnecting refrigerant piping, refrigerant, interconnecting power wiring (performed by a licensed electrician), control wiring, etc… It shall be noted that the main power panel, control panel and rain hood are shipped loose and require field installation.

B START-UP

1. Equipment start-up is to be supervised by the unit manufacturer or a manufacturer-certified service organization. Physical connections and start-up are provided by the installing contractor. The start-up engineer shall conduct such operating tests as required to ensure that the unit is operating in accordance with design. Complete testing of all safety and emergency control devices shall be made. The start-up engineer shall submit a written report to the owner and manufacturer containing all test data recorded as required above and a letter certifying that the unit is operating properly.
2. Provide complete Operation & Maintenance Manuals with descriptive literature, model, and serial number of all equipment, performance data, manufacturer's instructions for operating and maintenance, lubrication recommendation and schedule, and winter shutdown procedure.

2.27 PACKAGED ROOFTOP COOLING/HEATING UNITS (RTU's)

A. Unit Certifications: Unit shall be certified in accordance with UL Standard 1995/CSA C22.2 No. 236, Safety Standard for Heating and Cooling Equipment. Unit and refrigeration system shall comply with ASHRAE 15, Safety Standard for Mechanical Refrigeration. Unit Energy Efficiency Ratio (EER) and heating COP shall be equal to or greater than prescribed by ASHRAE 90.1, Energy Efficient Design of New Buildings except Low-Rise Residential Buildings and IECC 2015. Unit shall be safety certified by ETL and be ETL US and ETL Canada listed. Unit nameplate shall include the ETL/ETL Canada label. Unit and components shall be designed, manufactured, and independently analyzed, rated, and certified to meet with the seismic compliance standards of the International Building Code, 2012 edition. If requested, unit shall be provided with Certificate of Compliance from an independent certifying Professional Engineer clearly indicating that the unit and components meet seismic design requirements.

B. Submittals: Product Data: Literature shall be provided that indicates dimensions, operating and shipping weights, capacities, ratings, fan performance, filter information, factory supplied accessories, electrical characteristics and connection requirements. Installation, Operation and Maintenance manual with startup requirements shall be provided. Shop Drawings: Unit drawings shall be provided that indicate assembly, unit dimensions, construction details, clearances, and connection details. Computer generated fan curves for each fan shall be submitted with specific design operation point noted. Wiring diagram shall be provided with details for both power and control systems and differentiate between factory installed and field installed wiring.

C. Warranty: Manufacturer shall provide a “parts only” warranty for a period of 12 months from the date of equipment startup or 18 months from the date of shipment, whichever is less. Contractor shall provide full parts and labor warranty during this time period but no less than 12 months from the point of project substantial completion as determined by the project Architect. Factory warranty shall cover material and workmanship that prove defective, within the specified warranty period, provided manufacturer’s written instructions for installation, operation and maintenance have been followed. Warranty excludes parts associated with routine maintenance, such as belts and air filters. Refer to 3 year parts, labor and maintenance warranty requirement for this equipment elsewhere in the spec.

D. Products shall be provided by the following manufacturers:

1. AAON or approved equal by Daikin or Valent.

2. Substitute equipment may be considered for approval that includes at a minimum:

1. R-410A refrigerant

2. Direct drive supply fans

3. Double wall cabinet construction

4. Insulation with a minimum R-value of 13

5. Stainless steel drain pans

6. Hinged access doors with lockable handles

7. Variable capacity inverter duty scroll compressors and single speed scroll compressors allowing to 10-100% capacity turn-down.

8. Hot gas reheat dehumidification coil.

9. Energy recovery wheel as specified.

10. Airflow measuring stations on the exhaust fan, supply fan and outdoor air intake. Flow stations on outdoor air sections shall be used for monitoring only as OA calculations shall be determined by SA and RA flow stations.

11. All other provisions of the specifications must be satisfactorily addressed

12. Integral smoke detectors compatible with the building fire alarm system.

13. It is the intent of this project that most of the HVAC equipment such as rooftop units shall come with EMS ready controls with most controls and devices provided by the EMS for field installation. Packaged units shall come with refrigeration side condenser controls as well as fan and wheel drives and modulating actuators. Compressor controller shall be furnished by the equipment manufacturer but must be interfaced via terminal strip communication and BacNet for control and monitoring by the EMS.

E. Packaged rooftop unit shall include compressors, evaporator coils, filters, supply fans, dampers, air-cooled condenser coils, condenser fans, hot gas reheat coil, hot water coil, exhaust fans, energy recovery wheels, and unit condenser controls. Unit shall be factory assembled and tested including leak testing of the coils, pressure testing of the refrigeration circuit, and run testing of the completed unit. Run test report shall be supplied with the unit in the controls compartment's literature pocket. Unit shall have decals and tags to indicate lifting and rigging, service areas and caution areas for safety and to assist service personnel. Unit components shall be labeled, including pipe stub outs, refrigeration system components and electrical and controls components. Estimated sound power levels (dB) shall be shown on the unit ratings sheet.

F. Installation, Operation and Maintenance manual shall be supplied within the unit. Laminated color-coded wiring diagram shall match factory installed wiring and shall be affixed to the interior of the control compartment's access door. Unit nameplate shall be provided in two locations on the unit, affixed to the exterior of the unit and affixed to the interior of the control compartment's access door.

G. General Construction:

1. All cabinet walls, access doors, and roof shall be fabricated of double wall, impact resistant, rigid polyurethane foam panels. Unit insulation shall have a minimum thermal resistance R-value of 13. Foam insulation shall have a minimum density of 2 pounds/cubic foot and shall be tested in accordance with ASTM D-1929 for a minimum flash ignition temperature of 610°F. Unit construction shall be double wall with G90 galvanized steel on both sides and a thermal break with no metal path from inside to outside the cabinet. Double wall construction with a thermal break prevents moisture accumulation on the insulation, provides a cleanable interior, prevents heat transfer through the panel, and prevents exterior condensation on the panel.

2. Unit shall be designed to reduce air leakage and infiltration through the cabinet. Cabinet leakage shall not exceed 1% of total airflow when tested at 3 times the minimum external static pressure provided in AHRI Standard 340/360. Panel deflection shall not exceed L/240 ratio at 125% of design static pressure, at a

maximum 8 inches of positive or negative static pressure, to reduce air leakage. Deflection shall be measured at the midpoint of the panel height and width. Continuous sealing shall be included between panels and between access doors and openings to reduce air leakage. Refrigerant piping and electrical conduit through cabinet panels shall include sealing to reduce air leakage.

3. Roof of the air tunnel shall be sloped to provide complete drainage. Cabinet shall have rain break overhangs above access doors.

4. Access to filters, dampers, cooling coils, reheat coil, heaters, supply fans, exhaust fans, return fans, energy recovery wheels, compressors, water-cooled condensers, and electrical and controls components shall be through hinged access doors with quarter turn, zinc cast, lockable handles. Full length stainless steel piano hinges shall be included on the doors.

5. Exterior paint finish shall be capable of withstanding at least 2,500 hours, with no visible corrosive effects, when tested in a salt spray and fog atmosphere in accordance with ASTM B 117-95 test procedure. Unit shall have custom color as selected by the Architect on entire exterior of unit.

6. Units with cooling coils shall include double sloped 304 stainless steel drain pans.

7. Unit shall be provided with base discharge and return air openings. All openings through the base pan of the unit shall have upturned flanges of at least 1/2 inch in height around the opening.

8. Roof curb shall be seismically restrained vibration isolating type with 2” static deflection springs. Curbs shall have an overall height of no greater than 24”.

9. All piping shall rise up within the unit curb and be housed within the insulated unit or within an integral insulated pipe chase. Exposed piping outside the unit shall not be allowed.

H. Electrical

1. Unit shall be provided with standard power block for connecting power to the unit.

2. Unit shall be provided with factory installed and factory wired, non-fused disconnect switch.

3. Unit shall be provided with factory installed and factory wired 115V, 13 amp GFI outlet with outlet disconnect switch in the unit control panel.

4. Unit shall be provided with phase and brown out protection which shuts down all motors in the unit if the electrical phases are more that 10% out of balance on voltage, the voltage is more that 10% under design voltage, or on phase reversal.

5. Unit shall be provided with manual reset low temperature limit controls which shut off the unit when the discharge temperature reaches a field adjustable setpoint.

6. Unit shall be provided with blower auxiliary contacts on the low voltage terminal block which close when the supply fans are energized.

7. Unit shall be provided with remote stop/start terminals which require contact closure for unit operation. When these contacts are open the low voltage circuit is broken and the unit will not operate.

8. For all RTU'S with a scheduled capacity of 2,000 CFM or greater, duct smoke detectors shall be furnished by the Electrical Subcontractor and given to the Mechanical Subcontractor for installation by the factory. The duct smoke detectors shall be wired by the Electrical Subcontractor.

I. Supply Fans

1. Unit shall include direct drive, unhoused, backward curved, plenum supply fans.

2. Blowers and motors shall be dynamically balanced and mounted on rubber isolators.

3. Motors shall be premium efficiency ODP with ball bearings rated for 200,000 hours service with external lubrication points.

4. Variable frequency drives shall be factory wired and mounted in the unit. Fan motors shall be premium efficiency.

5. Each motor shall be provided with a shaft grounding device to harmlessly bleed potential induced shaft voltages to ground.

J. Exhaust Fans

1. Exhaust dampers shall be sized for 100% relief.

2. Fans and motors shall be dynamically balanced.

3. Motors shall be premium efficiency ODP with ball bearings rated for 200,000 hours service with external lubrication points. ECM motor are allowed and preferred as available.

4. Access to exhaust fans shall be through double wall, hinged access doors with quarter turn handles.

5. Unit shall include direct drive or belt driven, unhoused, backward curved, plenum exhaust fans.

6. Variable frequency drives shall be factory wired and mounted in the unit. Fan motors shall be premium efficiency.

7. Each motor shall be provided with a shaft grounding device to harmlessly bleed potential induced shaft voltages to ground

K. Cooling/Heat Pump Heating Coils

1. Evaporator (& heat pump mode) Coils

a. Coils shall be designed for use with R-410A refrigerant and constructed of copper tubes with aluminum fins mechanically bonded to the tubes and galvanized steel end casings. Fin design shall be sine wave rippled.

b. Coils shall have interlaced circuitry and shall be standard (6 row high) capacity.

c. Coils shall be helium leak tested.

d. Coils shall be furnished with a factory installed electronic thermostatic expansion valves (duel for heat pump service see schedule).

L. Refrigeration System

1. Unit shall be factory charged with R-410A refrigerant.

2. Compressors shall be scroll type with thermal overload protection, independently circuited, and carry a 5 year non-prorated warranty.

3. Compressors shall be mounted in an isolated service compartment which can be accessed without affecting unit operation. Lockable hinged compressor access doors shall be fabricated of double wall, rigid polyurethane foam insulated panels to prevent the transmission of noise outside the cabinet.

4. Compressors shall be isolated from the base pan with the compressor manufacturer’s recommended rubber vibration isolators, to reduce any transmission of noise from the compressors into the building area.

5. Each refrigeration circuit shall be equipped with thermostatic expansion valve type refrigerant flow control.

6. Each refrigeration circuit shall be equipped with automatic reset low pressure and manual reset high pressure refrigerant safety controls, Schrader type service fittings on both the high pressure and low pressure sides, and factory installed liquid line filter driers.

7. Unit shall include a variable speed inverter scroll compressor on the lead refrigeration circuit(s) which shall be capable of modulation from 10-100% of its capacity.

8. Refrigeration circuit(s) shall be provided with hot gas reheat coil, modulating valves, electronic controller, supply air temperature sensor and a dehumidification control signal terminal which allow the unit to have a dehumidification mode of operation, which includes supply air temperature control to prevent supply air temperature swings and overcooling of the space.

9. Condenser fans shall all be ECM or inverter variable speed style with adjustable compressor lockout to allow cooling operation down to 35°F.

10. Where scheduled, unit shall have reversing valve(s) for heat pump cycle mode.

M. Condensers

1. Air-Cooled Condenser

a. Condenser fans shall be vertical discharge, axial flow, direct drive fans.

b. Coils shall be designed for use with R-410A refrigerant and constructed of copper tubes with aluminum fins mechanically bonded to the tubes and aluminum end casings. Fin design shall be sine wave rippled.

c. Coils shall be designed for a minimum of 10°F of refrigerant sub-cooling.

d. Coils shall be helium leak tested.

e. Condenser fans shall be inverter controlled for improved performance and low sound.

N. Heating Coils

1. Hot Water Heating Coils

a. Coils shall be certified in accordance with ARI Standard 410 and be leak tested.

b. Coil shall be constructed of copper tubes with aluminum fins mechanically bonded to the tubes and galvanized steel end casings. Fin design shall be sine wave rippled.

c. Coil shall have single (half) serpentine circuitry, 1 (2) rows, and 8 (10) (12) fins per inch. Rows and fins as required to achieve performance specified.

d. Coil shall be located in the reheat position downstream of the supply fans.

e. Control valves shall be field supplied and field installed.

O. Filters

1. MERV 8 filters shall be provided on the exhaust air stream upstream of energy wheel exhaust, in the outdoor airstream upstream of the energy wheel intake. High efficiency MERV 13 rigid mini-pleat filters shall be provide upstream of the unit coils and shall be 4” deep, totally rigid and disposable type. Each filter shall consist of water-laid micro fine fiberglass media formed with closely spaced pleats. The enclosing frame shall be double walled water resistant beverage board. The filter media shall have an average efficiency of 95% as rated by ASHRAE Standard 52.1 test methods. Provide filters for start-up and flush out and post flushout. As these units are part of the 3 year warranty and maintenance plan no additional filters are

required as all filter changes for 3 years shall be provided by via the maintenance contract.

P. Outside Air/Economizer

1. Unit shall include 0-100% economizer consisting of a motor operated outside air damper and return air damper assembly constructed of extruded aluminum, hollow core, airfoil blades with rubber edge seals and aluminum end seals. Damper blades shall be gear driven and designed to meet smoke damper Class-1 leakage specifications in accordance with U.L. 555S at 4 inches w.g. air pressure differential across the damper. Damper assembly shall be controlled by spring return enthalpy activated fully modulating actuator. Unit shall include outside air opening bird screen, outside air hood with rain lip and barometric relief dampers. Provide cleanable and removable moisture eliminators on intake air hoods.

Q. Energy Recovery (see schedules for wheel info. however, all RTU's shall have energy recovery wheels except for the kitchen RTU and make-up air unit)

1. Unit shall contain a factory mounted and tested energy recovery wheel(s). The energy recovery wheel(s) shall be mounted in a rigid frame containing the wheel drive motor, drive belt, wheel seals and bearings. Frame shall slide out for service and removal from the cabinet.

2. The energy recovery component shall incorporate a rotary wheel in an insulated cassette frame complete with seals, ECM drive motor and drive belt.

3. Wheels shall be wound continuously with one flat and one structured layer in an ideal parallel plate geometry providing laminar flow and minimum pressure drop-to-efficiency ratios. The layers shall be effectively captured in stainless steel wheel frames or aluminum and stainless steel segment frames that provide a rigid and self-supporting matrix.

4. Wheels shall be provided with removable energy transfer matrix. Wheel frame construction shall be a welded hub, spoke and rim assembly of stainless, plated and/or coated steel and shall be self-supporting without matrix segments in place. Segments shall be removable without the use of tools to facilitate maintenance and cleaning. Wheel bearings shall be selected to provide an L-10 life in excess of 400,000 hours. Rim shall be continuous rolled stainless steel and the wheel shall be connected to the shaft by means of taper locks.

5. All diameter and perimeter seals shall be provided as part of the cassette assembly and shall be factory set. Drive belts of stretch urethane shall be provided for wheel rim drive without the need for external tensioners or adjustment.

6. The energy recovery cassette shall be an Underwriters Laboratories Recognized Component for electrical and fire safety. The wheel drive motor shall be an Underwriters Laboratory Recognized Component and shall be mounted in the cassette frame and supplied with a service connector or junction box. Thermal performance shall be certified by the manufacturer in accordance with ASHRAE Standard 84, Method of Testing Air-to-Air Heat Exchangers and AHRI Standard 1060, Rating Air-to-Air Energy Recovery Ventilation Equipment. Cassettes shall be

listed in the ARI Certified Product. Wheel effectiveness must meet the conditions specified in the schedules but in no case shall sensible effectiveness and total energy effectiveness be less than 70%.

7. Energy recovery wheel cassette shall carry a 5 year non-prorated warranty.

8. Unit shall include 2" MERV 8 pre-filters and 4 inch thick, pleated panel outside air filters with an ASHRAE efficiency of MERV rating of 13, upstream of the wheels. Unit shall include 2 inch thick, pleated panel exhaust air filters with an ASHRAE efficiency of 30% and MERV rating of 8, upstream of the wheels. Provide 4 spare sets in addition to those required during building flush-out period.

9. Hinged service access door shall allow access to the wheel(s).

10. Total energy recovery wheels shall be coated with silica gel desiccant permanently bonded by a process without the use of binders or adhesives, which may degrade desiccant performance. The substrate shall be lightweight polymer and shall not degrade nor require additional coatings for application in marine or coastal environments. Coated segments shall be washable with detergent or alkaline coil cleaner and water. Desiccant shall not dissolve nor deliquesce in the presence of water or high humidity.

11. Unit shall include a variable speed wheel to support both economizer and energy recovery wheel defrost control which includes an adjustable temperature sensor and wheel pressured sensor which, when frost is detected, slows allowing warm exhaust air to defrost the wheel. Wheel bypass dampers shall also be provided to support economizer cooling once the wheel has fully stopped.

12. Unit shall include energy recovery wheel rotation detection sensors and a set of normally open and normally closed contracts for field indication of wheel rotation.

13. Section shall include bypass recirculation damper as well as wheel OA and EA bypass dampers.

R. Manufacturer must provide grommetted and sealed test ports for temperature and pressure readings between each unit section element, such as filters, coils, energy recovery wheels, dampers and fans

S. Controls

1. Factory Installed and Factory Provided Controller

a. It is the intent of this project that most of the HVAC equipment such as rooftop units shall come stripped of most controls and devices for field installation of sensors. Actuators and devices all provided by the EMS vendor. On rooftop equipment the only exception would be the compressor controller which would be furnished by the equipment manufacturer but must be interfaced with for control by the EMS.

b. Factory controller for condensing section of the unit (i.e. compressors and condenser fans) must be capable to of controlling all features of this section

with external information provided by EMS system such as supply air temperature reset and hot gas control. Controller shall be factory installed in the unit controls compartment and factory tested. Controller must be capable or flushing hot gas reheat coil to prevent oil migration into hot gas coil. Refer to ATC article for points which must come with the units from the factory.

c. Controller shall include non-volatile memory to retain all programmed values, without the use of an external battery, in the event of a power failure.

d. Suction pressure sensors shall be factory installed. Supply air temperature and space humidity setpoints, for the dehumidification mode of operation, shall be adjustable.

e. Units shall be provided with the following minimum control devices or components installed from the factory (or field installed as noted):

- Condenser section controller for full control of the refrigeration side of the unit inclusive but not limited to control of compressors, condenser fans, hot gas reheat valve, reheat coil flush, suction pressure sensors, low and high refrigerant and temperature limits, time on and off delays and voltage and phase protection.

- Fully modulating outdoor air, return air and recirculation damper actuators. Normally closed outdoor air damper.

- 2-position normally close energy wheel OA and EA bypass dampers.

- Supply and exhaust fan(s) ECM or VFD drives.

- Energy recovery wheel drive ECM or VFD drive

- Energy wheel rotation sensor.

- Fan mounted supply and exhaust airflow stations. Airflow stations which require probes to cross the inlet cone of the fan shall not be allowed as they impact the performance of the fan. Airflow station shall be similar to Greenheck Sure-Aire or approved equal by unit fan manufacturer and shall monitor the pressure difference between the fan inlet and the smallest diameter of the fan cone. Low pressure sensor orifices shall be equal spaced at the inlet cone venture and extend to termination plate on fan housing. High pressure flow probe(s) shall be mounted in the low velocity zone near the fan inlet and shall also extend to a termination plate on the fan housing. Flow station shall measure pressure differential to within +/-3%. Furnish field installed electronics package which shall be mounted and wired by EMS and shall include controller in NEMA 4 enclosure with 4 digit 0.6” LCD display configured to read CFM. Unit shall have a 4-20 mA DC analog output signal.

- Provide factory furnished outdoor air flow station. Construction type shall vary by manufacturer but in general shall consist of a multi-point pitot or hot wire array calibrated to the free area of unit intake and

capable of reading with 5% +/- accuracy down to 25% of the schedule minimum outside air volume. As these devices are generally inaccurate at low airflows and/or susceptible to prevailing winds, they shall only be used as a monitoring point with system OA calculated using the units supply airflow station and filed installed return airflow station (i.e. OA = SA-RA). OA flow station shall only be actively used should communication be lost from either the RA or SA flow stations.

- Hot water coil freeze-stat shall be factory furnished, installed at the downstream side of the hot water coil and wired back to a terminal strip. Deice shall be similar in construction to the device specified within the ATC section and shall be of the automatic reset type with manual rest via the EMS front-end.

- Cooling coil leaving air temperature sensor wired to unit condenser controller. This is in addition to the device require to be furnished and installed by the EMS.

- Outdoor air temperature sensor wired to unit condenser controller. This is in addition to the device require to be furnished and installed by the EMS.

2. Field Installed Controls: Refer to control drawings and sequence of operation points list contained with this specification section.

T. Start-Up, Commissioning & Training

1. Provide factory service/start-up technician to check, test and start equipment. Technician shall coordinate mapping of all control points with EMS contractor and commissioning of unit. Technician shall work with project commissioning agent to verify proper operation of unit. In coordination with the mechanical contractor and control contractor the factory technician shall provide Owner training of unit controls, maintenance, etc…

2.28 VARIABLE REFRIGERANT VOLUME AIR CONDITIONING – Three Pipe Heat Recovery and Two Pipe Heat Pump

B. This section includes the design, performance, refrigerant details, controls and installation requirements for Daikin VRV systBMS (variable refrigerant volume) or equal by LG or Mitsubishi.

1. All units shall be listed and rated by ANSI/AHRI Standard 1230-2010 and meet all minimum IEER performance requirements as scheduled.

2. The units shall be ANSI/UL STD 1995 listed and listed by Electrical Testing Labs (ETL) and bear the cETL label.

3. All wiring shall be in accordance with the National Electric Code (NEC).

4. The system will be produced in an ISO 9001 and ISO 14001 facility, which are standards set by the International Standard Organization (ISO). The system shall be factory tested for safety and function.

5. Acceptable manufacturer: Daikin, LG or Mitsubishi.
6. Units must be provided with accessories needed for stable operation down to -13F in heating mode and -4F in cooling mode.

C. SYSTEM DESCRIPTION

i. The variable capacity air conditioning system shall be a Daikin Variable Refrigerant Volume system as specified. The system shall consist of multiple evaporators, branch selector boxes, REFNET™ joints and headers, a two or three pipe refrigeration distribution system using PID control and Daikin VRV condensing unit. The condensing unit shall be a direct expansion (DX), air-cooled or water-cooled, multi-zone air-conditioning system with variable speed inverter driven scroll compressors using R-410A refrigerant. The condensing unit may connect to an indoor evaporator capacity up to 200% of the condensing unit capacity. Each zone shall be capable of operating separately with individual temperature control. Each indoor unit or group of indoor units shall be able to provide independent temperature set points via a local remote controller, a centralized Intelligent touch screen controller, or a BMS interface.

ii. Standard T style joints are not acceptable for a variable refrigerant volume system. Manufacturer specific Y joints shall be supplied by the VRV manufacturer.

iii. Heat Recovery

a. Operation of the system shall permit individual heating and cooling of each indoor unit simultaneously, or of all indoor units associated with each branch selector port.

b. A dedicated hot gas pipe shall be used to ensure optimum heating operation performance. Two-pipe, heat recovery systems utilizing a lower temperature mixed liquid/gas refrigerant to perform heat recovery shall provide system heating capacity at design temperature to the consultant before bidding. Capacity losses from factors such as piping lengths, defrost cycles and lower discharge air temperatures resulting from a 2-pipe only heat recovery system shall be taken into account.

c. Branch selector boxes shall be located as shown on the drawing. Each branch of the branch selector box shall consist of three electronic expansion valves. The branch selector box shall control the operational mode of the subordinate indoor units. The use of three EEV's ensures continuous heating during defrost (multiple condenser systems only), no heating impact during changeover and reduced sound levels. The use of solenoid valves for changeover and pressure equalization shall not be acceptable due to refrigerant noise.

iv. VRV IV FEATURES

a. VRV system shall feature Variable Refrigerant Temperature, where the system automatically varies the target evaporating and condensing temperatures based on building load and weather conditions. The condensing unit shall also feature customizable operating modes which allows for the manual setting of target evaporating and condensing temperatures.

b. Each system shall be available with a configurator software package to allow for remote configuration of operational settings and assessment of operational data and error codes. If this software is not provided by an alternate manufacturer, the contractor shall configure the settings manually for each individual outdoor unit and keep detailed records for future maintenance purposes.

v. START-UP AND WARRANTY

b. The system must be installed by a DXS trained and certified contractor. The bidders shall be required to submit training certification proof with bid documents. Untrained contractors who wish to bid this project may contact DXS (DXS Engineering, 781-258-1002) to arrange training prior to bid day.

c. The manufacturer shall provide a factory trained service technician to start-up each unit. Manufacturer shall provide instruction to the owners' personnel on proper unit operation and maintenance.

d. The warranty period on all parts and compressors shall commence on the date of initial start-up and shall continue for a period of Ten (10) years not to exceed one hundred and twenty six (126) months from date of shipment. Proper maintenance of the equipment, performed by approved technicians as per the manufacturer or manufacturer's representative, shall be conducted. Maintenance logs shall be supplied by the owner upon request.

6. REFRIGERANT PIPING

i. Code Compliance

1. Installation shall conform with ASME B31.5 Mechanical Refrigeration Code.

2. Welding materials and procedures shall conform to ASME SEC 9 and applicable provincial labor regulations.

3. Safety pressure relief valves shall be field supplied and installed in the piping as per

4. Pressure relief valves shall be 600 PSI rated and installed in pairs (two valve per refrigeration circuit), and shall be supplied and installed for both the liquid and suction line as per drawing details. Pressure relief valves shall be individually isolated to allow for maintenance and required replacement.

ii. All systems shall display appropriate Ozone Depletion Prevention (ODP) tags prior to commissioning. VRV manufacturer shall not commission any system not displaying proper ODP tag.

iii. Materials

1. All copper piping shall be air conditioning and refrigerant grade ASTM B280 ACR.

2. Copper piping up to and including 5/8" nominal diameter may be type L copper (and may be soft copper if supported accordingly).

3. Copper piping above 5/8" nominal diameter shall be type K copper.

iv. Brazing rods for all joints shall be 15% silfoss.

v. Approved R-410a flaring block, and approved torque wrenches, both available from VRV manufacturer, shall be used for all flare connections.

vi. Y style piping joints and headers provided by the manufacturer shall be used to ensure proper refrigerant balance and flow for optimum system capacity and performance.

vii. T style joints and/or joints provided by the installing contractor, or Y joints not purchased from the manufacturer shall not be acceptable.

viii. Isolation valves shall be installed where shown on the schematics. Isolation valves shall be bi-flow self seating valves rated for R-410A with operating pressures up to 650 PSI. Valves shall be complete with brass shrader connections located on the valve body only.

ix. Quality Assurance

x. Nitrogen purging shall be used on all brazed joints to minimize oxidization.

xi. Filter dryers, sight glasses, expansion valves, solenoid valves or any other 3rd party components shall NOT be installed in the field piping.

xii. Contractor shall provide VRV manufacturer with all actual pipe lengths installed for calculation of refrigerant charge. Refrigerant piping contractor shall supply and charge VRV system with required quantity of R-410a prior to VRV manufacturer commissioning. Refrigerant charging shall be done in the liquid state.

xiii. High/low pressure gas line, liquid and suction lines shall be individually insulated between the condensing units, branch selector units and indoor units.

1. All indoor refrigerant lines shall be insulated with minimum ½" wall diameter Armaflex.

2. All outdoor refrigerant lines shall be insulated with minimum ¾" wall diameter Armaflex and suitable for outdoor service. Exposed insulation shall be protected by aluminum, sheet metal, painted canvas, plastic cover, or painted with an approved UV coating that is water resistant and provides shielding from solar radiation.

3. Pipe clamps shall fasten around the piping insulation. Pipe clamps that compress the copper directly shall be installed a minimum of 36" away from RefNet joints, and shall be loosely tightened to allow for copper expansion.

4. Pipe supports shall be a maximum of 6' apart.

8. FAN COILS

i. Daikin units shall be designed for R-410A refrigerant and be equipped with an electronic expansion valve.

ii. Computerized PID control shall be used to control superheat to deliver a comfortable room temperature condition. The unit shall be equipped with a programmed drying mechanism that dehumidifies while inhibiting changes in room temperature when used with Daikin remote control BRC1E73.

iii. Indoor units shall be completely factory assembled and tested. Internal unit components shall be factory wired and piped, and complete with electronic proportional expansion valve, control circuit board, fan motor thermal protector, flare connections, condensate drain pan, self-diagnostics, auto-restart function, 3-minute fused time delay, and test run switch.

iv. FXFQ_T – ROUNDFLOW CEILING CASSETTE UNIT

1. Daikin indoor unit model FXFQ_T shall be a round flow ceiling cassette fan coil unit with direct drive DC (ECM) type fan for installation into the ceiling cavity

equipped with an air panel grill. It shall be a round flow 360° air distribution type with a fresh white, impact resistant decoration panel.

2. The supply air is distributed via four individually controlled motorized louvers. The louvers can be manually and individually adjusted for multiple configurations, without requiring blank off plates.
3. The indoor unit shall be equipped with built-in occupancy sensor and surface temperature sensor.
4. The indoor unit's sound pressure shall range from 30 dB(A) to 45 dB(A) at high speed measured at 5 feet below the unit.
5. Return air shall be through the concentric panel, which includes a resin net, mold resistant, antibacterial filter.
6. The indoor units shall be equipped with a condensate pan with antibacterial treatment and condensate pump. The condensate pump shall provide up to 33-1/2" of lift from bottom of unit to top of drain piping and have a built-in safety shutoff and alarm.
7. The fan type shall be direct-drive DC (ECM) with statically and dynamically balanced impeller with three fan speeds available. The DC fan shall be able to automatically adjust between 5 fan speeds based on the space load.
8. The fan motor shall be equipped as standard with adjustable external static pressure (ESP) settings to allow operation with the high efficiency air filter options.
9. Self-Cleaning Filter Panel, which performs automatic filter cleaning up to once a day, with dust collection box that indicates when it should be emptied.
10. Units shall be supplied with an optional fresh air intake kit. The kit shall allow the cassette to pull fresh air directly from outdoors without the need for auxiliary fans. The kit shall then mix the fresh air with the return air before being treated by the coil. Air intake kits that do not have the ability to pull fresh air directly and to introduce it before the coil to allow mixing and conditioning by the unit shall not be acceptable.

v. FXZQ – 4 WAY CEILING CASSETTE UNIT

1. Daikin indoor unit model FXZQ shall be a ceiling cassette fan coil unit for installation into the ceiling cavity equipped with an air panel grill. It shall be a four-way air distribution type, white, impact resistant with a washable decoration panel. The supply air is distributed via motorized louvers which can be horizontally and vertically adjusted from 0° to 90°.
2. The indoor unit's sound pressure shall range from 29 dB(A) to 34 dB(A) at low speed measured at 5 feet below the unit.
3. The 4-way supply air flow shall be capable of field modification to 2-way or 3-way airflow to accommodate various installation configurations including corner installations.
4. Return air shall be through the concentric panel, which includes a resin net mold resistant filter. The indoor units shall be equipped with a condensate pan and condensate pump. The condensate pump shall provide up to 21" of lift and have a built-in safety shutoff and alarm.

5. Three auto-swing positions shall be available to choose from, which include standard, draft prevention and ceiling stain prevention. The airflow of the unit shall have the ability to shut down one or two sides allowing for simpler corner installation.
6. Fresh air intake shall be possible by way of direct duct installation to the side of the indoor unit cabinet.
7. A branch duct knockout shall exist for branch ducting supply air.
8. The fan shall be direct-drive turbo fan type with statically and dynamically balanced impeller with high and low fan speeds available.

vi. FXMQ_PB – CONCEALED CEILING DUCTED UNIT

1. Daikin indoor unit FXMQ_PB shall be a built-in ceiling concealed fan coil unit with direct-drive DC (ECM) type fan with auto CFM adjustment at commissioning for installation into the ceiling cavity. Casing shall be constructed of galvanized steel. Configuration shall be horizontal discharge air with horizontal return air, with a maximum height of 11-13/16" and be designed to fit in tight ceiling plenums.
2. The indoor unit's sound pressure shall range from 29 dB(A) to 43 dB(A) at low speed measured 5 feet below the ducted unit.
3. The indoor units shall be equipped with a condensate pan and condensate pump. The condensate pump shall provide up to 18-3/8" of lift from the center of the drain outlet and have a built-in safety shutoff and alarm.
4. The fan type shall be direct-drive DC (ECM) with statically and dynamically balanced impeller with three fan speeds available, and automatically adjustable external static pressure logic (selectable during commissioning).
5. Field installed filters and filter kits with 2" filter depth option of side or bottom access.
6. Standard, MERV8 filters with 4 sets of filters.

vii. FXAQ – WALL MOUNTED UNIT

1. Daikin indoor unit FXAQ shall be a wall mounted fan coil unit for installation onto a wall within a conditioned space. A mildew-proof, polystyrene condensate drain pan and resin net mold resistant filter shall be included as standard equipment.
2. The indoor unit's sound pressure shall range from 31 dB(A) to 41 dB(A) at low speed measured at 3.3 feet below and 3.3 feet away from the unit.
3. The unit shall have an auto-swing louver which ensures efficient air distribution, which closes automatically when the unit stops. The remote controller shall be able to set five (5) steps of discharge angle. The front grille shall be easily removed for washing. The discharge angle shall automatically set at the same angle as the previous operation upon restart.
4. The cabinet shall be affixed to a factory supplied wall mounting template and located in the conditioned space.
5. The cabinet shall be constructed with sound absorbing foamed polystyrene and polyethylene insulation.

6. The fan type shall be direct-drive cross-flow with statically and dynamically balanced impeller with high and low fan speeds available.
7. Units shall be provided with a loose field installed condensate pump and condensate switch.

viii. FX-LQ – FLOOR CONSOLE UNIT

1. Daikin indoor unit FXLQ shall be a floor mounted console fan coil unit for installation within a conditioned space. The cabinets can be mounted on the floor with refrigerant and condensate lines directed downward or affixed to the wall with horizontal refrigerant and condensate knockouts.
2. FXLQ units shall be suitable for exposed installations with an ivory white finish.
3. The indoor unit's sound pressure shall range from 35 dB(A) to 40 dB(A) at high speed measured at 5 feet away from the unit and 5 feet above floor level.
4. Condensate draining shall be made via gravity or external condensate pump.
5. The cabinet shall be affixed to a factory supplied wall mounting template and located in the conditioned space.
6. The cabinet shall be constructed with sound absorbing fiberglass urethane foam insulation.
7. Maintenance access shall be a minimum of ¾" in the rear, and 4" on the right and left sides.
8. The fan type shall be Sirocco direct-drive with statically and dynamically balanced impeller with high and low fan speeds available.
9. The return air shall be filtered by means of a washable long-life filter with mildew proof resin.
10. Units shall be provided with a loose field installed condensate pump.

ix. FXMQ_M – LARGE SIZE CONCEALED CEILING DUCTED UNIT

1. Daikin indoor unit FXMQ_M shall be a built-in ceiling concealed fan coil unit for installation into the ceiling cavity. Casing shall be constructed of galvanized steel and shall be available in capacities from 72,000 Btu/h to 96,000 Btu/h. The unit configuration shall be horizontal discharge air with horizontal return air.
2. The indoor unit's sound pressure shall be 48 dB(A) or less at low speed measured 5 feet below the ducted unit.
3. The cabinet shall be constructed with sound absorbing foamed polystyrene and polyethylene insulation.
4. Filters are to be field supplied and installed in the ductwork by others.
5. The fan shall be direct-drive Sirocco type fan, statically and dynamically balanced impeller with high and low fan speeds available, and equipped as standard with adjustable external static pressure (ESP) settings.
6. Units shall be provided with a loose field installed condensate pump.
7. Field installed filters and filter kits with 2" filter depth option of side or bottom access.

8. Standard, MERV8 filters, set of 4 filters.

9. CONDENSING UNIT

   i. The condensing unit shall be factory assembled in North America and pre-wired with all necessary electronic and refrigerant controls. The refrigeration circuit of the condensing unit shall consist of Daikin inverter scroll compressors, motors, fans, condenser coil, electronic expansion valves, solenoid valves, 4-way valve, distribution headers, capillaries, filters, shut off valves, oil separators, service ports, liquid receiver and suction accumulator.

   ii. The system will automatically restart operation after a power failure and will not cause any settings to be lost, thus eliminating the need for reprogramming.

   iii. The unit shall incorporate an auto-charging feature and a refrigerant charge check function to ensure proper refrigerant charge.

   iv. The following safety devices shall be included on the condensing unit: high pressure sensor and switch, low pressure sensor, control circuit fuses, crankcase heaters, fusible plug, overload relay, inverter overload protector, thermal protectors for compressor and fan motors, over current protection for the inverter, and anti-recycling timers.

   v. To ensure the liquid refrigerant does not flash when supplying to the various indoor units, the circuit shall be provided with a sub-cooling feature.

   vi. Oil recovery cycle shall automatically occur 2 hours after start of operation and then every 8 hours of operation.

   vii. The Daikin inverter scroll compressors shall be variable speed (PVM inverter) controlled which is capable of changing the speed to follow the variations in total cooling and heating load as determined by the suction gas pressure as measured in the condensing unit. In addition, samplings of evaporator and condenser temperatures shall be made so that the high/low pressures detected are read every 20 seconds and calculated. With each reading, the compressor capacity (INV frequency) shall be controlled to eliminate deviation from target value.

   viii. Non inverter-driven compressors, which may cause starting motor current to exceed the nominal motor current (RLA) and require larger wire sizing, shall not be allowed.

   ix. The inverter driven compressor in each condensing unit shall be high efficiency reluctance DC (digitally commutating), hermetically sealed scroll “G-type” or “J-type”.

   x. Neodymium magnets shall be adopted in the rotor construction to yield a higher torque and efficiency in the compressor instead of the normal ferrite magnet type. Upon complete stop of the compressor, the neodymium magnets will position the rotor into the optimum position for a low torque start.

   xi. The compressors’ motors shall have a cooling system using discharge gas, to avoid sudden changes in temperature resulting in significant stresses on winding and bearings.

   xii. Each compressor shall be equipped with a crankcase heater, high pressure safety switch, and internal thermal overload protector.

   xiii. The compressor shall be internally isolated to avoid the transmission of vibration, eliminating the need for external spring insolation.

xiv. In the event of compressor failure, for condensing units with multiple compressors, the remaining compressors shall continue to operate and provide heating or cooling as required at a proportionally reduced capacity. The microprocessor and associated controls shall be designed to specifically address this condition.

xv. In the case of multiple condenser modules, conjoined operation hours of the compressors shall be balanced by means of the Duty Cycling Function, ensuring sequential starting of each module at each: start/stop cycle, completion of oil return, completion of defrost, or every 8 hours of operation, extending the operating life of the system. When connected to a central control system, sequential start is activated for all systems on each DIII network.

xvi. The unit shall be constructed from rust-proofed mild steel panels coated with a baked enamel finish. The unit shall be modular in design and shall allow for side-by-side installation with minimum spacing requirements.

xvii. Condensing Unit Stand:

Provide 18" high seismic rated snow stand similar to Quick-Sling VRF/VRV Super Stand product or equal securely fastened to the anchored roof sleepers and the unit. Provide neoprene seismic rated vibration isolators.

xviii. Air Cooled

1. The fan motor shall have inherent protection and permanently lubricated bearings. The motor shall be provided with a fan guard to prevent contact with moving parts. The condensing unit shall consist of one or more propeller type, direct-drive 350 or 750 W fan motors that have multiple speed operation via a DC (digitally commutating) inverter. Motors shall be capable of delivering design air at high external static pressures up to 0.32 in WG (factory set as standard at 0.12 in. WG) to accommodate field applied duct for indoor mounting of condensing units.
2. Night setback control of the fan motor for low noise operation by way of automatically limiting the maximum speed shall be a standard feature.
3. The condenser coil shall be manufactured from copper tubes expanded into aluminum fins to form a mechanical bond. The heat exchanger coil shall be of a waffle louver fin and rifled bore tube design to ensure high efficiency performance.
4. The heat exchanger on the condensing units shall be manufactured from Hi-X seamless copper tubes with N-shape internal grooves mechanically bonded on to aluminum fins to an e-Pass Design. The fins are to be covered with an anti-corrosion acrylic resin and type E1 hydrophilic film.
5. The fins are to be covered with an anti-corrosion Ultra Gold coating as standard with a salt spray test rating of 1000hr (ASTM B117 & Blister Rating:10), Acetic acid salt spray test of 500hr (ASTM G85 & Blister Rating:10).
6. The pipe plates shall be treated with powdered polyester resin for corrosion prevention. The thickness of the coating must be between 2.0 to 3.0 microns.
7. The outdoor coil shall have three-circuit heat exchanger design. The lower part of the coil shall be used for inverter cooling and be on or off during heating operation, enhancing the defrost operation.

xix. Heat Pump

1. The outdoor unit shall be capable of heating operation at -4°F ambient temperature. Tested factory data on heating capacity and efficiency shall be available.
2. The outdoor unit shall be capable of cooling operation down to +23°F without any additional low ambient controls.
3. The outdoor unit shall be complete with low ambient controls and low ambient wind baffles for cooling operation down to -4°F

xx. Heat Recovery

1. The outdoor unit shall be capable of heating operation at -13°F ambient temperature. Tested factory data on heating capacity and efficiency shall be available. For multiple module systems, the system shall continue to provide heat to the indoor units in heating operation while in the defrost mode.
2. The outdoor unit shall be capable of cooling operation down to 23°F without any additional low ambient controls.

10. BRANCH SELECTOR BOX

i. Branch selector boxes shall be located as shown on the drawing. Selector box cabinets shall have a galvanized steel plate casing and shall house multiple electronic expansion valve and a sub-cooling loop. The unit shall contain sound absorption thermal insulating material made of flame and heat resistant foamed polyethylene.

ii. Branch selector boxes shall not require drain pan and drain connections. Manufacturers with branch selector boxes requiring drain connections shall bid as an alternate and carry allowances to compensate for the added costs of the drain connections.

iii. Manufacturers with branch selector box sizes, arrangements, or locations that differ from what is specified shall make the necessary arrangements to ensure their alternative branch selector boxes both fit in the space.

11. CONTROLS

i. Fan coil units shall be supplied with Individual Zone Controllers, similar to Daikin model BRC1E73

1. Remote controllers shall be hard wired by installing contractor.
2. Controllers shall be able to function as follows:

1. The controller shall have dual or single Cool and Heat setpoints for occupied periods, and independent setback setpoints for unoccupied periods.
2. The controller shall have the ability to digitally prohibit individual buttons and functions.
3. The controller shall have a self diagnosis function that constantly monitors the system for malfunctions (total of 80 components).
4. An LCD digital display will allow the temperature to be set in 1°F units.

5. The controller shall be equipped with a thermostat sensor.
6. The controller shall have the ability to automatically changeover the mode of operation with dual or single setpoints.
7. Controller shall have built-in 7 day, weekday plus Saturday Sunday (5+1+1), weekday plus weekend (5+2) and everyday (1) scheduler.
8. Controller shall have a simple display mode, displaying only the operation mode, the setpoint(s), and the room temperature.

3. Provide an advanced multi-zone controller for installation in a common area as shown on the plans, equal to Daikin intelligent Touch Manager V2.0. The controller shall have a 10" LCD touch screen display with the following screen views and functionalities :

   1. Central control of set points, schedules, airflow rates, heat/cool mode, and of setback (override) temperature settings during unoccupied periods.
   2. Adjustable temperature limits to restrict local wall mounted thermostat set point ranges.
   3. Visible and audible alarm indication of any system malfunctions with descriptive error code.
   4. External Digital and / or Analog input/output and display of external input values.
   5. Tiered hierarchy allowing for control of fan coil units independently or as a group.
   6. Remotely disable individual functions of the wall mounted controllers.
   7. Web enabled for remote access from PC, tablet or portable device and automatic alert and error emails.
   8. Automatic changeover shall be accomplished using one of the following two algorithms:

      a) Averaging method – the central controller shall sum up the difference between room temperatures and set points for all indoor units in the system. Once this delta reaches the primary changeover deadband of ± 2°F (adjustable), the central controller shall change over the system automatically.

      b) Voting Method – the averaging method shall be used for the first stage of changeover. However, if any fan coil in the system reaches the primary changeover deadband of 3°F away from set point (adjustable), the voting algorithm shall take over and changeover the system to satisfy the diverting fan coil. The voting method limits the maximum amount that a zone can deviate from set point. This maximum amount shall be adjustable.

      - For both automatic change over options, a weight (0-3) can be added to each indoor unit. The automatic changeover algorithm shall use this weighting to prioritize changeover for the more heavily weighted fan coils.
      - Upon any changeover, a guard timer shall prevent another changeover for a period of 15, 30, or 60 (default) minutes.

- The guard timer shall be ignored by a change of setpoint manually from either the central controller or the remote controller, by schedule, or if the secondary deadband is reached with either of the automatic changeover algorithms. The secondary changeover deadband shall be the sum of the primary changeover deadband (adjustable) ± 1°F (adjustable)

9. "3D" Floor plan graphic layout

   - The central controller shall have the capability for site floor plan to be uploaded as a background to create a graphics interface. Background shall be specific project building floor plan rendered in "2D" or "3D".
   - Floor plan layout shall be displayed on building control display as well as accessible from the web.
   - Floor plan will include capability to control indoor unit, and auxiliary inputs / outputs, such as designated lighting control, as follows:
     i. Up to 4 status points to be assigned to the control point icon (room name, room temperature, set point, and mode).
     ii. Status and control points to display on corresponding location of zone served on floor plan.
     iii. Digital input and output icons will display On/Off status.
     iv. Analog input icons will display analog value.
   - Up to 60 floor layout sections shall be possible depending on project scope.

10. Centralized controller shall be complete with power distribution software with the ability to generate .csv files with power consumption data for each fan coil in the system. With proper tenant agreement via a lease or purchase agreement, the distributed power consumption data can be used by the owner or by the billing company to assess how the power consumption of the condensing units shall be distributed to each fan coils. The energy consumption files shall be accessible from the web via a restricted security access.

11. VRV manufacturer shall provide all necessary power meters required for the power distribution software of the centralized controller. Power meters shall be Measurement Canada approved. Power meters shall be installed and wired back to the centralized controller by division 16.

12. Installing contractor shall provide a 24VAC power connection to the central controller.

    a. Power Proportional Distribution (PPD)

       i. The tenant billing option shall be capable of calculating VRV Controls Network equipment energy usage in kWh based on the energy consumption of the outdoor unit(s) divided among the associated indoor units. This software is used in conjunction with the intelligent Touch Manager and a Watt Hour Meter (WHM). A maximum of 3 Watt Hour Meters can be connected to the intelligent Touch Manager. Up to 4 additional Watt Hour Meters can be connected to each iTM Plus Adapter, and up to 7 iTM Plus Adapters can be connected to the intelligent Touch Manager. The Power Proportional Distribution results data can be saved to a USB flash drive, or on a PC with the use of the web access. Data is

saved in the CSV format. Results can be stored up to 13 months in the intelligent Touch Manager.

ii. Provide a control module to allow full integration with a BACnet IP or LonWorks compatible BMS.

1. BACnet module shall be wired, installed and powered (24VAC) by installing contractor. IP connection shall be by BMS contractor.

2. VRV manufacturer shall commission the BACnet panel. BMS contractor shall provide VRV manufacturer with static IP address and instance number for commissioning.

3. All programming for monitoring and control of VRV system via the BACnet panel shall be by BMS contractor, as per the Sequence of Operation.

4. Programmability:

a. The BACnet building management system shall support weekly schedule settings through its programming.

i. The schedule shall support the indoor unit:

1. On/Off

2. Each scheduled event shall specify time and target group

3. Each scheduled event shall include On/Off, Operation Mode, Occupied Cooling Setpoint, Occupied Heating Setpoint, Setup (Cooling) setback setpoint, Setback (Heating) setback setpoint, Remote Controller On/Off Permit/Prohibit, Remote Controller Mode Permit/Prohibit, Remote Controller Setpoint Permit/Prohibit, and Timed Override Enable

4. Setup (Cooling) and Setback (Heating) setpoints when unit is Off (unoccupied) by Group

5. An override shall be provided for use enabling indoor unit operation during the unoccupied period by the BACnet building management system programming.

b. The BACnet building management system shall support auto-changeover through its programming.

i. Auto-change shall provide changeover for both Heat Pump and Heat Recovery systBMS based upon the group configurations. This will allow for the optimal room temperature to be maintained by automatically switching the indoor unit's mode between Cool and Heat in accordance with the room temperature and setpoint temperature.

ii. Changeover shall change the operation mode of the indoor unit that is set as the Changeover Master. The Changeover Master indoor unit shall then change the operation mode of all indoor unit groups daisy chained on the same DIII-Net communication bus to the same outdoor unit in the Heat Pump system or the same branch selector box in the Heat Recovery system.

iii. Changeover to cooling mode shall occur when the room temperature is great than or equal to the cooling setpoint

iv. Differential to be determined by BACnet building management system programming

v. Changeover to heating mode shall occur when room temperature is less than or equal to the heating setpoint.

vi. Differential to be determined by BACnet building management system programming

vii. Guard timer- Upon changeover, guard timer will prevent another changeover during this period. Guard timer should be ignored by a change of setpoint manually from the BMS, Intelligent Touch Controller, Remote Controller, or by schedule. Guard timer to be configured by BACnet building management system programming (30 minute minimum recommended)

c. The Interface for use in BACnet shall support force shutdown of associated indoor unit groups.

12. ELECTRICAL

i. The power supply to the condensing unit shall be as scheduled.

ii. Independent electrical power for fan coils and branch selector boxes shall be 208/230 volts, 1 phase, 60 hertz. The unit shall be capable of operating within the limits of 187 volts to 253 volts.

iii. Unless limited by local local electrical codes and standards, multiple fan coils and branch selector boxes can be connected to the same breaker. Individual disconnect switches for each fan coil are required, and are to be provided and installed by division 16.

iv. Electrical power for condensing units shall be 460 volts, 3 phase, 60 hertz.

v. The control voltage between the indoor and outdoor unit shall be 16VDC non-shielded 2 conductor cable.

vi. The control wiring shall be a two-wire multiplex transmission system, making it possible to connect multiple indoor units to one outdoor unit with one 2-cable wire, thus simplifying the wiring operation.

vii. Control wiring shall be installed in a daisy chain configuration from indoor unit to indoor unit then to the branch selector box and outdoor unit. Control wiring shall run from the indoor unit terminal block to the specific controller for that unit.

13. EXECUTION

a. DELIVERY, STORAGE AND HANDLING

1. Units shall be stored and handled according to the manufacturer's recommendations. Units shall be kept clean and isolated from dust and debris.

ii. INSTALLATION

1. Install condensing units on a flat surface level within 1/8 inch, and elevated a minimum of 18" from ground or roof surface. Provide intermediate supports as recommended by the equipment manufacturer.
2. Provide all necessary control wiring as recommended by the manufacturer.
3. High/low pressure gas line, liquid, and suction lines must be individually insulated between the outdoor and indoor units.
4. Contact DXS (781-258-1002) prior to installation to review and confirm piping layout and lengths.
5. Use refrigeration best practice to allow pipes to expand and contract freely. Review manufacturer installation instructions to ensure expansion joints are properly designed.
6. Pressure test ALL systBMS to 550 PSI after system was vacuumed and held to below 500 microns for at least one hour. Review manufacturer installation instructions for proper pressure test procedures.
7. Design and install all piping as per local code and regulations.

2.29 DUCTLESS SPLIT AIR CONDITIONING SYSTEM (non VRF)

A. Furnish and install a ductless split commercial ceiling mounted fan coil (surface mounted below ceiling) as scheduled mBMShed with a roof mounted air cooled condensing unit. Indoor unit shall be wall hung as scheduled. The mBMShed system shall be rated per ARI Standard 210/240 and certified by UL and CSA. The system shall be as manufactured by Daikin, Mitsubishi, Sanyo or equal. A non CFC or HCFC refrigerant must be used such as R-410A or approved equal. Minimum EER=15

B. The combination of the outdoor unit and the indoor-fan coil unit shall have a total net cooling capacity as scheduled on drawings or greater at conditions of entering-air temperature at the evaporator coil of 80 degrees F. dry bulb and 67 degrees F. wet bulb. Outdoor ambient temperature of air entering the condenser of 95 degrees F. The system shall have a minimum listed SEER (seasonal energy efficiency ratio) of 14 at ARI conditions.

C. Indoor Fan Coil Unit:

1. Indoor, direct-expansion, low-profile (11-3/4 in. high) in-ceiling fan coil or wall hung as scheduled. Unit shall come complete with cooling coil, fan, fan motor, piping connectors, electrical controls, condensate pump, and hanging brackets.

2. Cabinet shall be constructed of zinc-coated steel. Fully insulated discharge and inlet grilles shall be attractively styled, high-impact polystryrene. Cabinet shall have filter tracks and cleanable filters which shall be accessible from below with a 1/4-turn fastener. Adjacent room cooling to be provided by a simple knockout in the cabinet side panel, and cabinet shall have provisions to accommodate a limited amount of ductwork, if desired.

3. Fan shall be a centrifugal, direct-drive blower type with air intake in center of the unit and discharge on the perimeter. Air louvers shall be adjustable.

4. Coil shall be copper tube with aluminum fins and galvanized steel tube sheets. Fins will be bonded to the tubes by mechanical expansion. A drip pan under the coil shall have a factory-installed condensate pump and drain connection for hose attachment to remove condensate. External pump shall be provided for wall units as required.

5. Motor shall be totally enclosed and permanently lubricated with inherent protection. Fan motor shall be 3-speed. Unit shall operate on single phase 60- cycle 208 V power.

6. Controls shall be 24 Volt, and shall be easily operated by the user from a wall-mounted control unit. Float control shall be in the condensate sump to shut unit down in case of pump malfunction. A wall-mounted programmable thermostat with three (3) fan speed selections, and an auto/manual switch shall be supplied for field installation. The refrigerant is controlled with a piston-type refrigerant metering device, and evaporator coil freeze protection shall be provided.

D. Outdoor Air Cooled Condensing Unit: Furnish and install matching condensing unit. Condensing unit shall have low ambient control for operation down to 0°F, hard start assist kit, winter start package and crankcase heater.

E. Condensing Unit Stand: Provide 18” high seismic rated snow stand similar to Quick-Sling VRF/VRV Super Stand product or equal securely fastened to the anchored roof sleepers and the unit. Provide neoprene seismic rated vibration isolators.

2.30 DIRECT FIRED - MAKE-UP AIR UNITS

A. Provide packaged indoor makeup air units, direct fired, as manufactured by Captive Aire, Trane or Reznor. Units shall be AGA certified and ETL listed. Alternate manufacturers that may be considered as acceptable equal units must have the features, dimensions and characteristics of the unit specified herein including an integral variable frequency drive. Any modifications to electrical, structural, etc.. required due to a change from the specified unit must be borne by the mechanical contractor.

B. Casing:
Casing shall be constructed of heavy 18 gauge double wall galvanized steel attached to a 1”x1” tubular frame. Exterior shall be painted with a factory applied primer coat and machine enamel finish with rust inhibitors.
Insulate unit with 1.5 lbs. per cubic foot foil-faced fiberglass insulation. The insulation shall comply with UL standard 181 for erosion and NFPA 90A for fire resistance and will be held in place with adhesive.

C. Fans:
- Provide fan section with forward-curved type, double inlet centrifugal fan designed and suitable for the class of service indicated in the equipment schedule. Shafts shall be properly sized and protectively coated with lubricating oil. Fan shaft shall be designed so as not to pass through the first critical speed as unit comes up to rated RPM. Fans shall be statically and dynamically tested as an assembly.
- Entire fan, motor and drive assembly shall be mounted on an internally isolated neoprene vibration isolator system
- Provide self-aligning grease lubricated ball or roller bearings which shall perform to a minimum of 200,000 hours average life.
- Fan motors shall be premium efficiency inverter duty, open drip proof, service factor 1.15, operable at 208 volts, 3 phase, 60 Hz.

- V-Belt Drive shall be adjustable pitch rated at 1.2 times the motor nameplate.
- Provide variable frequency drive for full control of unit airflow. Provide shaft grounding ring.

D. Filters:
- In addition to intake moisture eliminators, provide four (4) full replacement sets of MERV 8 pre-filters and MERC 13 final filters 2" thick pleated air filters as manufactured by Farr or equal by AAF in addition to the set furnished with the unit.

F. Controls/Burners:
1. Provide gas burner and safety controls to meet ANSI and FM requirements to include flame safeguard, automatic and manual high limits at unit discharge, high temperature safety at burner and a discharge air freezestat (time delay type).
2. Adjustable outside air cut-off shall be provided to disable gas burner when outdoor temperatures exceed an adjustable setpoint or when adequate air across burner is not proved.
3. Discharge air temperature controls shall be electronic with accuracy to +/- 0.2°F. Nominal turndown ratio shall be 30:1 with total control between high and low fire. Provide pre-purge time delay arranged for positive low-fire start-up.
4. Burner shall have non-clogging, stainless steel baffles attached to a cast aluminum gas supply section with no moving parts. The burner shall be capable of a 30-to-1 turndown ratio and be designed for 100% thermal efficiency for the life of the equipment.
5. 100% make-up air system. Constant airflow over the burner shall be maintained via an automatic balancing damper at the burner bypass. Controls shall allow for variable total unit airflow between 25% and 100%.
6. The direct fired burner will consist of a direct spark ignition system, including an ignition module, spark igniter, and flame rod to verify burner low fire (pilot) ignition before allowing the main gas valve to fully open
7. Provide signal conditioner and BacNet card for EMS interface.
8. Main control panel shall be NEMA 3R and contain all standard electrical components, fused disconnect switch, motor starter, 120-volt and/or 24-volt control transformers, control circuit fuses, color coded wires, and an ignition module to lockout the flame in abnormal conditions. The complete control and safety system as well as the burner and gas manifold shall be factory tested prior to shipment.
9. Temperature Controls: shall be a solid-state system located in the main control panel. It shall have a sensor located in the supply air stream which controls the supply air temperature (maximum and minimum) in response to heating requirements with EMS interface for reset/remote control .
10. Remote Control Panel: shall be provided and includes a summer-off-winter (vent-off-heat) switch, a fan on indicator light, a burner on indicator light, a burner alarm light, and a means to reset the burner in the event of flame failure. The unit serial number and customer tag number will be on the panel face. The remote panel shall be interlocked to the EMS as well. The following items shall also be included on the panel: 1)Dirty filter light.
11. High Temperature Limit Switch: turns the burner off when the discharge air temperature exceeds 130° F. This switch must then be manually reset at the heater.
12. Gas manifold: shall be sized for the rated BTU (MBH) capacity as scheduled on the drawings. The gas manifold will be constructed in conformance to ANSI Standards and Factory Mutual (FM) / Industrial Risk Insurers (IRI) insurance requirements.
13. Control & Power Wire Harness: shall be provided to include a 12' long (minimum) pigtail in flexible metal conduit. The harnesses is pre-wired and attached at the unit by

the manufacturer and clearly tagged and marked for field tie-in. Primary motor voltage wires and color coded control voltage wires shall be in separate conduits.

G. Accessories:
1. 100% Outside air intake hood with filters and motorized damper
2. Variable Speed Drive with variable flow controls. Variable volume 100% OA model includes an automatic building pressure and supply duct control, a variable frequency drive (VFD) for supply fan speed control and a burner profile damper with a pressure differential switch to control and maintain the proper burner airflow across the burner profile. VFD to vary fan speed as needed in response to the supply air duct static required by the make-p air system. Provide EMS interface.
3. Low temperature limit switch with 5 minute time delay.
4. High & Low gas pressure switches.
5. Fused disconnect switch.
6. Remote control console with Summer-Off-Winter toggle switch, Blower On light, Burner On light, Dirty Filter Light and Safety Lockout light.
7. Provide a full-perimeter curb, 20" high flat curb, formed of heavy-gauge galvanized or aluminized steel. Installer shall shim the curb so that it is level. Manufacturer to provide 1.5” foil face fiberglass insulation on curb interior, glued and pinned as required. Manufacturer to provide 1” wood-nailer and cant strip. Curb shall be reinforced to comply with seismic requirements.
8. EMS interface kit with signal conditioner & BacNet Card.
9. Refer to plans for additional information.

2.31 FAN COIL UNITS

A. Provide factory fabricated fan coil units as called for on the drawings by McQuay, York, Trane or equal. Units shall be U.L. listed. Fans shall be forward curved statically and dynamically balanced. All control valves and fan relays, shut-off’s, vents and balancing valves shall be furnished by the factory or field furnished for factory or field installation. Vertical fan coil units shall either be filed supplied or come with controls and valves factory or field installed and wired. Ducted fan coil units shall be fitted with field installed controls. Coordinate fully with controls vendor prior to ordering.

B. BASIC UNIT: All fan coils shall be manufactured with heavy gauge galvanized steel to resist corrosion. All models shall be approved for installation with “0” clearance to combustible material. Piping, drain, and wiring connections are readily accessible and mounting holes and/or slots are pre-drilled to save installation time and field labor expense.

C. PLENUMS AND CABINETS: Plenums and cabinets are insulated to increase efficiency and to insure quiet operation. Exposed cabinets and access panels are coated with an attractive baked on finish. Submit color chart for review and selection. All models have throw away MERV 8 filters. Hinged panels are included with some models for easy access and service. Access panels now include “captive” screws.

D. CABINET: Floor models shall be provided with bar grille louver supply, front toe space return and a 1” high dust barrier at the bottom. Top of unit shall be slope style. All models shall have 18-gauge steel cabinet with 16 gauge front panels. All painted surfaces shall be treated with a process which retards corrosion and promotes paint adhesion and finished with a fan, baked on enamel finish, which may be used as a final coat or repainted. All painted steel shall be galvanized. Color selection shall be by Owner and Engineer.

E. Wall models shall have cabinets with bar grille louvers. The entire bottom of the unit must be enclosed. Access to the speed control shall be through the easy access 16-gauge front/top panels.

F. All models shall have two 9” minimum wide piping end pockets. All wall and ceiling units shall have safety hinged access panels that can be easily removed during installation.

G. MOTORS: Standard motors are 120V, variable speed, ECM type with internal thermal overload protection and are mounted with rubber bushings. Blower wheels are centrifugal, forward curved, and dynamically balanced.

H. COILS: Coils have 3/8” O.D. copper tubing expanded to high efficiency aluminum fins. Each coil is factory tested to 350 psig. Manual air vents are standard on all coils. Tube connections are 5/8” O.D. Left and right hand coil connections are available. DX coils where scheduled

I. DRAIN PANS: All drain pans shall constructed of polymer and be coated on the inside surface with a closed cell, fire retardant foam insulation. This insulation shall be UL Listed and provide superior corrosion resistance. All drain pans include both primary and secondary (overflow) drain connections. All drain pans are sloped toward drain connections to facilitate condensate removal.

J. STANDARD FEATURES: Fans coils shall come completely factory assembled with 2 pipe arrangement.

K. APPROVALS: All standard models shall be UL Listed.

L. VALVE & CONTROL PACKAGE: Ducted fan coil units shall have field installed controls furnished and installed by EMS. Cabinet console style fan coil units shall come with a valve package that shall be fully coordinated with the control vendor to match the control manufacturer for the project. If controls are to be sent from the factory matching the projects control vendor, each unit shall come with a factory piping valve and control package If HVAC Trade contractor elects for factory provided option in lieu of field provided, piping package shall include (2) full port ball style isolation valves, (1) balancing circuit setter valve, (1) strainer, (1) 2-way modulating control valve (3-way where noted on drawings), (1) air vent. Each vertical cabinet style fan coil unit and unit ventilator shall include a factory mounted temperature controller matching project control vendors and unit mounted tamper resistant adjustable controls. Ducted fan coil units and air handlers shall come with factory controls and valves for field mounting, piping and wiring. Control valve pressure drop shall not exceed 3 psi at maximum scheduled design flow.

M. Each unit shall be provided with a hot water coil, (DX coil if scheduled), filter rack with 1” MERV 8 disposable filters on console style units and MERV 14 on ducted style units and condensate pan with drain, and ECM motor. ECM motor shall include integral speed adjustment on console style units and remote signal EMS control for ducted units. Provide four (4) spare sets of filters for each unit in addition to those used during start-up and building flush-out.

2.32 HEAT EXCHANGER

A. General

1. Furnish as shown on the plans, a plate & frame style water to water/glycol heat exchanger as manufactured by Alfa Laval, Taco or Bell & Gossett.
2. The heat exchanger manufacturer shall have an established and on-going QA/QC program including manuals available for inspection at plant.
3. The heat exchanger manufacturer shall have extensive background and experience in the design and fabrication of shell & tube style heat exchangers. The manufacturer shall have fabricated shell & tube style heat exchangers for a minimum of twenty (20) years.
4. Heat exchanger shall have 150 psig ASME rated carbon steel shell and #304 stainless steel plates fully serviceable via a removable end.

B. REFERENCES

-ASME Section II - Material Specification
-ASME Section V - Non-Destructive Testing
-ASME Section IX - Welding and Brazing qualifications
-ASME Section VIII - Pressure Vessel Code
-ARI Standard 400 – Liquid to Liquid Heat Exchangers

C. CERTIFICATION

1. ARI Certification
Plate heat exchangers shall be certified according to ARI Standard 400 and listed on the ARI Prime Net site (www.ariprimenet.org). If heat exchanger is not ARI certified, then the manufacturer shall provide an independent third party field performance test using the mapped ratings, limits and tolerances of ARI Standard 400 to verify performance to specification. Any and all cost associated with correcting a non-performing heat exchanger to meet the performance requirements shall be the responsibility of the supplier. Any cost associated with the field performance test shall be included in the price of the heat exchanger.

2. ASME Certification. Heat exchangers shall be designed, constructed, and tested in accordance with Section VIII, Division I of the ASME Pressure Vessel Code, and shall be code stamped.

D. WARRANTY

1. The warranty period shall be 3 years from date of shipment but no less than 1 year from substantial completion.

2.33 FINNED RADIATION

A. Furnish and install, where shown on the Drawings, Slant/Fin Vulcan, Rittling, or Sterling Radiator Co. to be equal to Slant/Fin styles specified below.

B. Enclosures shall be of 16 gauge (14 gauge in restrooms and corridors) cold-rolled steel and shall be furnished with a baked enamel finish, with color selected by the Architect. All baseboard cover in restrooms locker rooms, shower areas and kitchen area shall be constructed of 16 gauge stainless steel. Element shall be copper tube with mechanically bonded corrugated aluminum fins.

C. Fin element shall consist of copper tube with aluminum fins of the number of tiers scheduled on the plans.

D. Support brackets shall be die-formed for rigidity and must be designed to support the elements, piping, and enclosures. Slide cradles shall be provided for movement of elements and piping during expansion and contraction. Supporting brackets with slide cradles shall be furnished and installed at a maximum of 3 ft. 0 in. on centers. Provide brackets for return pipe. Pedestal type baseboard shall come with support feet with matching finish.

E. Provide end covers/caps, access panels, inside/outside corners, columns, splice plates, and trim pieces at each wall as required. Provide accessible valve box at each control valve.

2.34 ACCESS PANELS

A. Furnish and install access panels for access to all parts of the HVAC systems that require accessibility for the proper operation and maintenance of the system.

B. Size shall be sufficient for the purpose, but no less than 12 inches by 18 inches. Particular attention shall be exercised in the selection of doors for masonry walls in order that frame sizes used will match the courses of brick or block. Refer to section 08 31 00 for products.

C. Access doors shall be prime coated of rust inhibitive paint, continuous hinge and manufactured by Inland Steel Products Company “Milcor”, Acudor, Mifab, Miami-Carey or Walsh-Hannon-Galdwin, Incorporated “Way Loctor”. Type shall be based upon “Milcor” as follows:

1. Suspended Drywall Ceilings: Style ATR with 16 gauge frame, 18 gauge panel and flush screwdriver operated cam locks.

2. Plastered Walls and Ceilings: Style K with 16 gauge frame, 14 gauge panel and flush screwdriver operated cam locks.

3. Masonry Non-Rated Walls: Style M with 16 gauge frame, 14 gauge panel and flush screwdriver operated cam locks.

4. Masonry Non-Rated Wall: Fire rated with UL 1-1/2 hour “B” rating, 16 gauge frame, 20 gauge sandwich type insulated panel, self-latching lock having interior release mechanism, and key operated cylinder lock keyed as required to suit requirements of the Architect.

5. Non-Rated Dry Walls: Style DW with 16 gauge frame, 14 gauge panel screwdriver operated cam locks.

2.35 THERMOMETERS AND PRESSURE GUAGES

A. Straight Thermometers:

1. Where indicated on the Drawings, furnish and install 7 in. long die-cast aluminum case, "Adjustable Angle" red appearing mercury tubing thermometers, H.O. Trerice Co., Cat. A001 complete with separable stainless steel Type 304 socket, 30 degrees to 240 degrees F. range, and lagging extensions when installed in insulated pipe.

2. Thermometers to be adjusted to a position for maximum readability from normal operator's position.

3. Thermometers shall be H.O. Trerice Co., Weksler Instruments Corp., Weiss Instruments, or approved equal.

A. Pressure Gauges: Pressure gauges shall be as manufactured by Trerice, or approved equal, Series 600, 4-1/2 in. diameter, range 0 to 100 PSI (or other range as required by application), aluminum case, white face with black figures, with petcocks. Provide fluid filled gauges at pumps.

B. Provide separable stainless steel wells for each thermometer and pressure gauge. Wells for thermometers shall be filled with heat conductive gel prior to installation of thermometer.

2.36 RADIANT HEAT SYSTEM AND COMPONENTS & UNDERSLAB TUBING

A. Provide radiant heating system with products and configuration as shown on the drawings as manufactured by Viega, Wirsbo, Uponor or approved equal. The underslab piping and components in this section shall also apply to underslab tubing/piping shown on the plans convey heating hot water.

B. ViegaPEX™ Barrier Hydronic Radiant Heat Tubing
1. This specification designates the requirements for ViegaPEX Barrier cross-linked polyethylene (PEX) tubing for use in hydronic radiant heating systems. ViegaPEX Barrier includes an oxygen barrier layer that helps restrict the passage of oxygen through the wall of the tubing. All ViegaPEX is manufactured and tested to the requirements of ASTM F876 and F877 and is CTS-OD (copper tube size outer dimension controlled) with an SDR – (standard dimension ratio) 9 wall thickness.
2. ViegaPEX Barriet tubing producg is produced from cross-linkable, high density polyethylene resin. The cross-linkable resin is produced by grafting organo-silane molecules onto a base polyethylene chain. A catalyst that initiates the cross-linking process is blended with the resin before extrusion. Cross-linking is conducted after extrusion by exposing the tubing to heat and moisture (steam). ViegaPEX Barrier includes 4 layers. The first layer is the cross-linked, high density polyethylene. The second layer is an adhesive for the third layer, the ethylene vinyl alcohol layer (EVOH oxygen barrier). The fourth layer is another way then layer of polyethylene, put on the outside to protect the EVOH layer from damage. EVOH is highly resistant to the passage of oxygen.
3. Tubing is marked with manufacturer, ViegaPEX Barrier, nominal size, rating, codes and standards, approvals, date, material code and location of production. Tubing is third party tested to the requirements of the stated ASTM standards. Tubing includes incremental footage markings to assist with loop layout. ViegaPEX Barrier is certified to NSF 61 and 14 for use as part of, or connected to a potable water system.
4. ViegaPEX Barrier tubing is recommended for hydronic radiant heating, cooling and snow melting systems utilizing water or a water/glycol mix as the heat or cold transfer media. Tubing may be installed in concrete, gypsum based lightweight concrete, sand, asphalt (in accordance with special guidelines) in or under wood flooring or behind wallboard or plaster. ViegaPEX Barrier may also be used as transfer lines or baseboard heating systems with a maximum temperature of 200°F @ 80 psi.
5. Install ViegaPEX Barrier in accordance with installation manuals provided by manufacturer and applicable code requirements. Water or air can be used to pressure

test the system. Please follow manufacturer's requirements on pressure and length of time.

C. Stainless Manifolds Shut Off/Balancing/Flow Meters
   1. Stainless manifold is to be used in closed loop hydronic heating systems. These preassembled 1-1/4" diameter stainless supply and return manifolds come attached to two 6-5/8" spacing brackets for compact remote mounting. This stainless manifold provides shut off and balancing valve with flow meters for each circuit. Each flow meter/balancing valve allows graduated flow setting up to 2 gpm. Maximum18 gpm per manifold. The air bleeder and purge valves are connected and factory tested. 1-1/4" union connectors, 1" NPT removable end caps. SVC Circuit connection fittings are sold separately.

D. Basic Heating Control
   1. The radiant heat control shall be by the EMS system. Refer to Automatic Temperature Controls for information on controls. Coordinate location of in-slab sensors prior to pouring of slabs.

E. 2-Way Modualting Injection Valves. Valves shall be provided and controlled by EMS in conjunction with the radiant heat control system to maintain both space and slab temperatures.

F. Entire radiant tubing system shall be installed per manufacturers instructions. In this application the tubing shall be attached to the slab reinforcing mesh with insulation provided under the complete slab. In areas where the tubing is running through areas outside the controlled space to get to the manifolds, the tubing shall be covered with insulation prior to the pouring of the slab. Insulation shall be flexible style to allow concrete to pour onto and around piping and avoid any voids forming within the slab.

2.37 LOUVERS

A. Louvers meeting the following specifications shall be furnished and installed where shown on the plans. Louvers shall be stationary type with drainable blades in a 4" louver frame. Each stationary blade shall incorporate an integral drain gutter and each jamb shall incorporate an integral downspout so water drains to blade end, then down the downspouts and out at the louver sill rather than cascading from blade to blade.

B. Each factory-assembled louver section shall be designed to withstand wind loadings of 25 pounds per square foot (100 mph wind equivalent). Louver frames, mullions, and section joints shall be adequately supported from the building structure to withstand this same wind loading.

C. Louver performance data shall be licensed under the AMCA Certified Ratings Program and shall bear the AMCA Certified Ratings Seal. This certified performance data shall include airflow pressure loss and water penetration, and shall demonstrate performance equal to or better than the Greenheck model specified.

D. Louvers shall be Greenheck model #ESD-403 drainable type fabricated from 60637T5 aluminum extrusions of 0.081" nominal wall thickness. Blades shall be positioned at 37° and 45°angles approximately on 4" centers. Each louver shall be equipped with a framed, removable, rear-mounted screen of ¾" x 0.051" expanded flattened aluminum.

E. Louver shall be supplied with a Kynar finish applied following a thorough cleaning and pretreatment of the metal surface. Dry film thickness of the Kynar shall be approximately 1.2 mils after baking at 450°F. Custom color shall be selected by the architect and shall include metallic color options. Submit color chart.

F. All louvers shall include bird screens. Insect screens shall be required only on intake louvers that serve air make-up directly into a space without going thru an air filter and must include access panels in duct sleeves to allow for cleaning of screens.

G. Manufacturers shall be Greenheck, Ruskin or Airolite

2.38 ELEVATOR PENTHOUSE

A. At the top of each elevator shaft provide the following. The Greenheck model #PEV-400 was designed to meet the elevator shaft ventilation code requirements for the New England States area. The PEV is shipped attached to the curb, available in one size only 30 in. x 30 in. x 18 in.. The penthouse is fabricated from Greenheck model #ESJ-401 extruded aluminum louver blade. The hood is formed aluminum with 0.5 in. insulation. One side of the louvered penthouse is 0.125 in. thick tempered glass. The curb shall be 36 in. high. The curb is fabricated from 12 ga steel with powder-coat paint finish and 1 in. thick insulation. A Smoke Damper is located in the throat of the curb and is operated by a 120-volt actuator that can be wired to the fire control panel. Mill finish on the penthouse is standard.

B. Alternate approved manufacturer is Ruskin

2.39 ELECTRICAL WORK

A. The Heating, Ventilating and Air Conditioning Contractor shall provide all wiring for the Automatic Temperature Controls, air handlers, duct smoke detectors (fan interlock and control loop power), condensers, etc.. except as otherwise specified herein.

B. The HVAC contractor shall hire a licensed electrician to perform all control wiring as required by code. Minimum gauge of all control wiring is 18 AWG and shall be plenum rated.

C. The Electrical Contractor shall install and do all power wiring for all motor starters and unmounted motors, furnished to him at the job site by other trades.

D. For all low voltage motors, temperature control wiring and motor control wiring, including wiring for interlocking, shall be provided by the Section providing the motors, including the installation of all control devices.

E. Furnish all starters and all other motor control devices for motor driven equipment required for the work. The Electrical Contractor shall provide all code required disconnect switches for all motors, except where otherwise noted. The setting of all motors required for mechanical equipment shall be included as part of the mechanical work.

F. Equipment which includes a number of correlated electrical control devices mounted in a single enclosure or on a common base with equipment, shall be supplied for installation completely wired as a unit with terminal boxes and ample leads ready for external wiring.

G. All electrical items called for as part of the mechanical work shall conform to NEMA Standards, to the requirements of the National Fire Protection Association and to the requirements of any local electrical code authority having jurisdiction, any field modifications required to ensure such conformance shall be included as part of the mechanical work.

2.40 ELECTRIC MOTORS

A. This Contractor shall provide all electric motors necessary for driving all motor driven equipment required to be furnished under this section of the Specifications.

B. All motors shall be designed for 3 phase, 60 cycle alternating current operation with 460 volts across the motor terminals, except that, unless otherwise specified herein, all motors 1/3 HP and smaller shall be designed for single phase, 60 cycle alternating current at 120 volts across the terminals.

C. The speed, horsepower, type and other essential data for each motor, if not given under paragraphs describing the various motor driven apparatus, or in schedules on the drawings shall be submitted to the Engineer for his review. All motors shall be premium efficiency type and any connected to a VFD shall have a shaft grounding ring.

D. Contractor shall furnish premium efficient motors eligible for rebate by the local electric utility, when applicable.

2.41 SCAFFOLDS AND STAGING

A. General: Trade Contractors shall obtain required permits for, and provide scaffolds, staging, and other similar raised platforms, required to access their Work as specified in Section 01 50 00 – TEMPORARY FACILITIES AND CONTROLS and herein.

1. Scaffolding and staging required for use by this Trade Contractor pursuant to requirements of Section 01 50 00 – TEMPORARY FACILITIES AND CONTROLS shall be furnished, erected, maintained in a safe condition, and dismantled when no longer required, by this Trade Contract requiring such scaffolding.
2. Each Trade Contractor is responsible to provide, maintain and remove at dismantling, all tarpaulins and similar protective measures necessary to cover scaffolding for inclement weather conditions other than those required to be provided, maintained and removed by the Construction Manager pursuant to MGL (Refer to Section 01 50 00 – TEMPORARY FACILITIES AND CONTROLS and as additionally required for dust control).
    a. Construction Manager is responsible to provide enclosures required for temporary heat from November 1 to March 31; refer to Section 01 50 00 – TEMPORARY FACILITIES AND CONTROLS.
3. Furnishing portable ladders and mobile platforms of all required heights, which may be necessary to perform the work of this trade, are the responsibility of this Trade Contractor.

2.42 HOISTING MACHINERY AND EQUIPMENT

A. All hoisting equipment, rigging equipment, crane services and lift machinery required for the work by this Trade Contractor shall be furnished, installed, operated and maintained in safe conditions by this Trade Contractor, as referenced under Section 01 50 00 - TEMPORARY FACILITIES AND CONTROLS.

2.43 AUTOMATIC TEMPERATURE CONTROLS

A. Furnish and install all control components necessary to obtain a fully functional control system as described herein. The contractor is responsible for providing all controls, relays, etc. necessary to accomplish the Sequence of Operations and performance specified, whether or not the items are specifically identified herein. This shall include all the points shown in the control diagrams and on the drawings. Wherever a setpoint is referred to, this implies that the setting is adjustable by the user. Contractor shall hire the project electrician to provide additional power supplies to support the control devices as required. All controls operating equipment and systems configured to run off emergency power must be wired to the emergency power circuit. This shall include but not be limited to the following systems along with all associated control devices: 1) front-end work station, 2) network controllers and interface, 3) boiler plant (boilers, pumps, ventilation, CO system), 4) domestic water heaters and associated, boiler, tank and recirculation pumps; 5) IDF and MDF cooling systems, 6) fin-tube radiation, 7) cabinet unit heaters & unit heaters, 8) Gymnasium system RTU-20 & 21 (DX cooling and dehum. disabled if on emergency power); 9) Cafeteria system RTU-10 and associated anti-strat. fans (DX cooling and dehum. disabled if on emergency power); 10) Locker Room system RTU-22 (DX cooling and dehum. disabled if on emergency power); 11) Administration & Health Clinic systems RTU-15 and all associated ACHP's and fan coils; 12) Kitchen RTU, MAU and Hood Exhaust Systems and associated VAV's and devices; 13)Locker Room system RTU-22 (DX cooling and dehum. disabled if on emergency power); Provide battery UPS power supplies for the front-end and network interface controls to insure no interruption of the power supply.

B. The specified DDC system shall be based on the most recent generation of products from the Owners current energy management system Alerton by Automated Buildings Systems Inc. Owner's front end graphics must be updated to include this building with link to associated systems. The project graphics and software must be programmed into the existing city wide Alerton server. New controls installed must seamlessly integrate into the existing Alerton system front-end graphics for trending and alarm reporting. The control system shall operate on a central network bus and shall web based access via password protection to any remote computer. This control system shall be referred to as the DDC, EMS or ATC system throughout this specification. EMS system must be Bacnet and Open Protocol compatibility for direct communication with boilers, VFD's & RTU's, etc… to obtain operation status of systems including real time energy consumption. Besides various HVAC systems the EMS shall communicate to other building systems via BacNet ModBus RS-485 connection to monitor and report on status and energy use. The systems shall be as follows:
   - Lighting system (BACNet) – for occupancy/vacancy status of each room.
   - Generator (Modbus RS-485) – for monitoring various generator functions.
   - Submetering (Modbus RS-485) – for monitoring loads for each meter, some of which will have to be manipulated, and then displayed as graph or data.
   - Electrical metering software shall be installed on the EMS work station by the electrical contractor vendor with trending saved to the hard drive. Coordinate with electrical contractor.

   It is the intent of this project that most of the HVAC equipment such as rooftop units shall come stripped of most controls and devices for field installation of sensors. Actuators and devices all provided by the EMS vendor. On rooftop equipment the only exception would be the compressor controller which would be furnished by the equipment manufacturer but must be interfaced with for control by the EMS. Although equipment may come with many

local devices and sensors provided by the equipment manufacturer the EMS contractor must still provide external sensors and devices (i.e. duct smoke detector and damper connections, duct static and space static sensors, return and/or space CO2 sensors, etc…) as required to achieve the sequence of operation and comply with the bid documents. Controls subcontractor must review specifications and clarify with respective mechanical sub-bidders to verify mechanical contractor is proposing to provide the equipment specified with communication interface specified

C. The BMS contractor shall be regularly engaged in the installation and maintenance of BMS systems and shall meet the following qualifications:

i. A minimum of ten (10) years of demonstrated technical expertise and experience in the installation and maintenance of BMS systems similar in size and complexity to this project.
ii. A minimum of ten (10) years experience installing the control system of the manufacturer
that is to be proposed.
iii. Shall be a certified-to-install, direct representative of a control system manufacturer that has a minimum of ten (10) years experience producing control systems similar to that which is to be proposed.
iv. A maintained service organization consisting of at least eight (8) competent servicemen, within 60 miles of the project site, for a period of not less than ten years.
v. Tech support available 24 hrs / per 365 day's per year.
vi. The Bidder shall not be considered qualified to bid this project unless they can provide a list of 10 projects, similar in size and scope to this project, completed within the last four years.
7. The system manufacturer/installer shall provide an experienced project manager for this work from beginning of control installation until final completion. The project manager is responsible for direct supervision of the design, installation, start-up and commissioning of the BMS as well as attending of project meetings whenever directed by the owner, construction manager, and/or mechanical contractor. It shall not be acceptable to change the project manager after the project has begun and before final completion. If the BMS manufacturer wishes to change the project manager, the construction manager and/or owner's representative must be notified immediately and both the new project manager and the previous project manager shall spend 3 consecutive business days together on-site performing a project management switchover. Exceptions may be allowed for small projects as determined by the construction manager and/or owner's representative

D. The entire system, materials & devices as well as installing contractor and associated work shall comply with all current governing codes, ordinances and regulations including UL, NFPA, NEC, IBC, IMC, local AHJ, etc…

E. The system shall have a documented history of compatibility by design for a minimum of 15 years. Future compatibility shall be supported for no less than 10 years. Compatibility shall be defined as the ability for any existing control system component including but not limited to Primary Control Panels, Secondary Control Panels, personal operator workstations, and portable operator's terminals, to be connected and directly communicate with any new BMS system equipment without bridges, routers or protocol converters.

F. All control wiring shall be shielded plenum rated minimum 18 AWG (unless lighter gauge or heavier gauge is required due to impedance or current demands) and shall be run

concealed above ceilings or within walls. When the wiring must run exposed it shall be run in EMT conduit in unfinished service spaces and in Wiremold® or equal conduit system product in finished occupiable spaces.

G. It shall be division 23 00 00 responsibility to provide all personnel as required to fully coordinate with the commissioning agent. The hours of training and instruction outlined in division 23 00 00 and the Testing and Balancing requirements shall be in addition to those tests and requirements outlined in section 01 91 00 and required to fulfill section 01 91 00 commissioning obligations.

H. General

1. The automatic temperature control system shall include, but not be limited to, the following components:
   - Front-end computer with graphic software showing all building HVAC systems. Real-time interface with controlled components.
   - Several stand-alone DDC control unit(s) networked together on a local LAN to control the environment in the entire building
   - Expansion modules for the controllers, if required, shall provide for the capability of additional DDC points.
   - End devices such as sensors, actuators, dampers and valves.
   - Control transformers and relays.
   - Control wiring between duct smoke detectors and the respective fan starters.
2. The failure of any single component shall not interrupt the control strategies of other operational devices.

I. OPERATOR INTERFACE / STATION

1. Provide one main Front-end workstation which shall include the following:
   - Windows operating system compatible computer with Intel 8th Generation Core i5 processor (or equal AMD) 2.8 gigahertz speed.
   - 1 TB Hard Drive
   - 8 GB RAM
   - Dedicated Intel UHD 630 graphics Card (or equal AMD) and 22” flat screen color monitor
   - Keyboard
   - 48X CD-ROM/ REWRITE drive
   - 2 button mouse with scroll wheel
   - 10/100/1000 Ethernet Network Card
   - Wireless Card
   - Windows 10 software (or other as required by EMS)
   - Color Ink Jet Printer
   - 2 cartons of 1000 sheets bright white ink jet paper
   - Software including: dynamic color graphics; database creation and support; password access levels; alarm processing; data collection and trending; etc..
   - Back-up discs of all software and programming.

J. INPUT/OUTPUT INTERFACE

1. Digital Inputs (DI) shall allow the monitoring of on/off signals from remote devices. The digital inputs shall provide a wetting current of 12mA at 12 vdc to be compatible with commonly available control devices.

2. Analog Inputs (AI) shall allow the monitoring of low voltage current or resistance signals and shall have a minimum resolution of 0.1% of the sensing range. Analog inputs shall be compatible with and field configurable to commonly available sensing devices.

3. Digital Outputs (DO) shall provide a continuous low voltage signal for on/off control of remote devices. Where specified in the sequences of operations or indicated on the points list, digital outputs shall have 3-position (on/off/auto) override switches, status lights, and shall be selectable for either normally open or normally closed positions.

4. Analog Outputs (AO) shall provide a modulating signal for the control of end devices. Outputs shall provide either a 0 to 10vdc or a 4 to 20 mA signal as required to provide proper control of the output device.

K. AUXILIARY CONTROL DEVICES

1. Control Valves

   a. Valve bodies shall be 2-way or 3-way mixing as shown on the drawings and as specified herein. Valve bodies 2" and under shall be bronze, screwed type, rated for 125 psig. Valve bodies 2-1/2" and over shall be iron, flanged and rated at 125 psig, except where otherwise noted. Valves shall have stainless steel stems and allow for servicing including packing, stem and disk replacement. Valve shall be sized for a pressure drop equal to 2 psig.

2. Valve Actuators

   a. Valve actuators shall be electronic, spring return, low voltage (24v) and properly selected for the valve body and service. Actuators shall be fully proportioning. Valves for gas-fired make-up air and heating air units shall be obtained from the equipment manufacturer so as to insure that U.L. & AGA listing are maintained. All heating valves including radiation shall be fail open style to open fully upon power loss however during summer months when the heating plant is off, power to the valves shall be disabled as well.

3. Dampers and Actuators

   a. Dampers shall be opposed blade type except where installed in round ductwork where single blade type is acceptable. All damper blades shall be low leakage type with neoprene gasketed edge seals rated for no more than 3CFM/SF leakage at 1" w.g.. Actuators shall be electronic, spring return, low voltage (24v) and properly selected for the required torque and speed. Actuators shall be fully proportioning with the exception of those dampers specified as being 2-position open & closed.
   b. Dampers exposed to the area served shall be double wall insulated ultra-low leakage type.

4. Temperature Sensors

a. Temperature sensors shall be Resistance Temperature Detector (RTD) type or thermistors, as dictated by the requirements of this specification. Final location of all space sensors shall be coordinated with the Owner and Engineer. Space sensors in classrooms, offices, teacher lounges and non-public spaces shall be wall mounted type with a user adjustable access allowing deviation of +/- 3 deg. of computer defined setpoint and push button occupied override. Space sensors in public areas such as in the Gymnasium, Locker Rooms, Cafeteria, Lobby, etc… shall be non-adjustable type with push button occupied override. Sensors in gymnasium and locker room shall be stainless steel plate type with push-button override. Sensors in restrooms shall be stainless steel plate type with no override.

b. Duct sensors shall be rigid or averaging as specified in the sequence of operations. Averaging sensors shall be a minimum of 20 feet in length. Freeze protection sensor shall have a 20 foot sensor crossing back and forth across the air exit face of the water heating coil. Immersion sensors shall be provided with a separable stainless steel well

c. Sensor accuracy's and operating ranges shall be as follows:
- Space temp. +/- 1 deg. F, 0 to 130 deg. F range
- Duct temp. +/- 1 deg. F, 30 to 160 deg. F range
- O.A. Duct temp. +/- 1 deg. F, -30 to 160 deg. F range
- Water +/- 1 deg. F, 0 to 200 deg. F range

5. Relative Humidity Sensors

a. Relative humidity sensors shall be thin film capacitor type with an accuracy of +/- 2% with a range of 10% to 90%. For enthalpy calculations provide on North wall for outdoor air sensing and one in each RTU and AHU main return air duct and elsewhere as shown on the control drawings or indicated herein. Final location of all space sensors shall be coordinated with the Owner and Engineer. Space sensors shall be wall-mounted type.

6. CO2 sensors: Shall be self-calibrating duct or wall-mounting type as specified capable of measuring a CO2 range between 100 and 2000 PPM as manufactured by Mamac or approved equal.

7. Flow Switches

b. Differential pressure switches shall be provided at filters and fans. Paddle type switch shall be provided at boilers unless otherwise noted or if boiler flow turn down is below range of paddle sensor. Current sensing run indicators shall be provided at each fan and pump. Sensor shall be able to differentiate between belt loss and motor failure and report to the workstation as such.

8. Air Flow Measuring Stations: Provide multi-point cross grid hot wire flow measuring station at return air duct main on each RTU and AHU. Devise shall be similar to Ebtron Gold series. Outdoor air intake, exhaust fan and supply air fan airflow stations shall be furnished by the RTU & AHU equipment manufacturer.

9. Water Flow Measuring Stations: Provide ultrasonic water flow measuring stations in the mains of the hot water systems to calculate system GPM flow with +/- 2% accuracy across full range of flow from maximum to a minimum flow rate of 15% of maximum.

10. Duct Smoke Detectors: HVAC contractor shall install duct smoke detectors in ductwork as well as interlock with respective fan circuits and EMS system. Electrical contractor shall furnish duct smoke detector, power wire and wire to fire alarm system.

11. Fire/Smoke Dampers: Coordinate control of fire/smoke fire smoke dampers with electrical contractor. When a fire/smoke damper closes in an area the respective unit serving that area shall shutdown. Electrical contractor shall wire fire/smoke dampers to the fire alarm system.

12. At each fume hood furnish and install fume hood monitoring and control unit with electronic duct damper, sash airflow monitor and alarm as manufactured by Phoenix controls model #FHM631-ENG with #EXV-A-F-14-M series valve with high speed operator or equal by TSI or Johnson Controls. Unit must have a hibernate mode which can be activated by command on the hood monitor and by the EMS to disable the alarm controller and close the valve to minimum position (100+/- CFM) if the sash if closed. Unit shall automatically go out of hibernate mode if the sash is opened.

13. Furnish and install a CO detection and alarm system in boiler plant. The system shall consist of a central control/annuciator panel and a remote CO sensor as shown on the drawings. The system shall communicate with the building EMS. System shall be as manufactured by Toxalert, Viking or MSA. CO sensor shall have solid state sensing element with a 0-400 ppm range, 10-year warranty, automatically calibrating, Toxalert model TOX-CO/ANA with controller model ToxControl. System shall automatically compensate for temperature and send a 0 to 10vdc and digital signal to the building EMS for control of ventilation and monitoring. Provide NEMA 1 enclosure, status lights, 85 dB audible alarm and visual strobe. EMS shall provide all wiring between sensor, panels, alarms, fans, EMS, etc…

14. Furnish and install a refrigerant gas detection system to monitor and alarm in the Condition Prep and Staging Cooler. The system shall consist of a central control/annuciator panel and a remote refrigerant sensor mounted 18” off the floor. The system shall communicate with the building EMS. System shall be as manufactured by Toxalert, Viking or MSA. Sensor shall have solid state sensing element with a 0-400 ppm range, 4-year warranty, automatically calibrating, Toxalert model TOX-REFRIG/ANA with controller model ToxControl. System shall automatically compensate for temperature and send a 0 to 10vdc and signal to the building EMS for status and alarm. Provide (1) NEMA 1 enclosure, status lights, 85 dB audible alarm and visual strobes to alarm. EMS shall provide all wiring between sensor, panels, alarms, EMS, etc…

15. CARBON MONOXIDE / NITROUS OXIDE DETECTION SYSTEM

    A. Provide a Carbon Monoxide & Nitrous Oxide Detection within the Auto Diesel shop area for control of ventilation (via EMS communication) and to provide an alarm signal when a hazardous level of CO or NOx is detected.

    B. The Carbon Monoxide / Nitrous Oxide Detection System shall consist of two (2) central control/annunciator panels with integral horn & strobe light, (4) remote CO sensors, (4) remote NOx sensors and (4) remote volatile fuel sensors (FG).

    C. ACCEPTABLE MANUFACTERS

1. Manufactures shall have local representation experienced with Carbon Monoxide Detection Systems and minimum of ten (10) continuous years of active service. A local supply of spare parts and authorized factory repair service shall be available.

2. List of Manufactures:
   a. Toxalert, Inc.
   b. Vulcain.
   c. Honeywell.
   d. Approved equal.

3. Specification has been based around Toxalert. Local representative is Air Distribution Corporation. Contact: Mark Persechini Telephone number: 508-588-9595

D. CARBON MONOXIDE SENSORS (CO) & NITROGEN OXIDE SENSORS (NOx)

1. The CO and NOx sensors shall output a linear 4 to 20 ma analog signal proportional to the CO or NOx gas levels detected to the controller and shall have a normal operation range of –20 deg. F. to 122 deg. F. and 0 to 95%R.H. non-condensing. The sensor shall have a range of 0 to 250 PPM for CO and 0 to 10 for NOx, with an accuracy of +/- 3% of range. The sensors shall be microprocessor based with twelve (12) bits analog/digital resolution and periodically recalibrate itself.

2. The CO and NOx sensors shall have a solid-state sensing element for life of ten (10) years and shall be microprocessor based and be self-monitoring of proper operation. The temperature thermistor will automatically compensate the output signal for changes in ambient relative humidity and temperature.

3. The CO and NOx sensors shall have indicators for: 1) power on; 2) automatic calibration/operating properly; 3) sensor malfunction; 4) high CO or NOx alarm.

4. The sensor enclosure shall be a NEMA 1 removable hinged cover cabinet, with a keyed lock to prevent tampering. An aluminum splash/dust shield on the face of sensor to protect sensing element.

5. The sensor shall be powered by 24 VAC, 4 wire, 18 gauge shielded.

6. Sensors shall be located as indicated on the drawing(s).

7. Carbon monoxide sensor shall be a model TOX-CO/ANA as manufactured by Toxalert, Inc.

8. Notrogen Oxide/Dioxide sensor shall be a model TOX-NO2/ANA as manufactured by Toxalert, Inc.

E. CONTROLLER/ANNUNCIATOR

1. Provide a controller to monitor carbon monoxide sensors. The controller shall contain power supplies, solid-state control logic, amplifiers, and output to start

and stop the ventilation fans. The controller shall be designed to be wall mounted for visual and audible alarm indication.

2. The controller shall be microprocessor based and utilize battery back-up to ensure system programs are not lost during power interruption.

3. The controller shall be capable of fan start/stop damper open/close operation from a high space temperature.

4. Fan ON delays can be programmed from one (1) to ninety-nine (99) seconds. Power input to control panel should be 120V/1PH/60HZ.

5. The controller and sensors shall be mounted as shown on drawings.

6. Provide labeled indictors on the face of the controller panel for 1) power ON, 2) high CO level, 3) NOx level, 4) fan ON; and 5) power to each sensor.

7. Provide an audible alarm for each sensor with a sound level minimum of 85 db. Also, provide a momentary pushbutton to silence the audible alarm. The visual alarm indicator shall remain lighted as long as the alarm condition persists even though the audible signal has been silenced.

8. The controller shall have all the necessary power supplies and transformers to supply power to CO and NOx sensors.

9. System controller shall be a Toxalert, Inc. Model TOC-CO Series controller.

F. CONDUIT AND WIRE

1. Conduit and wiring shall be as indicated on the plan(s) and meet all local and national codes. Signal wiring shall be a minimum size of #18 AWG for sensors.

2. All wiring shall run in EMT conduit. Provide weatherproof conduit in exterior locations and in the wash bay.

G. INSTALLATION

1. This contractor shall provide all conduit, wiring, and junction and outlet boxes as required for a complete system.

2. Electrical contractor shall provide 120 VAC power to the CO detection system.

H. TESTS AND ADJUSTMENTS

1. A representative of the manufacturer shall be present with the contractor to check out and start up the system per manufacturer recommendations.

2. Perform an actual CO and NOx system test using CO and NOx gas cylinders. The test will be witnessed by the engineer and other interested parties.

16. For each kitchen hood (typical of two hood banks), provide a smoke detection system as manufactured by Intelli-Hood® controls by Melink® or approved equal. Each system

shall include 1)keypad control of hood ventilation system interfaced to EMS, 2) hood optic sensors to fully monitor the area under/within the hood, 3)exhaust duct temperature sensor, 4) space temperature sensor, 5) I/O processor with interface to EMS. For a single fan serving multiple hoods, sensors shall be provided for each hood and the fan speed shall drive off the hood with greatest demand. The MeLink controller for each hood shall be installed per manufacturer's instructions. The hood manufacturer is not providing a utility cabinet and as such the system controller and VFD drives shall be mounted above the ceiling located with adequate service clearance and the touch pad shall be mounted on each respective hood. Controller shall report status, alarms and exhaust CFM to the EMS

L. OPERATOR INTERFACE SOFTWARE

1. Alarms

a. The stand-alone DDC unit shall provide visual notification of equipment failures, program failures, hardware failures or sensor failures. In addition each sensor and point shall be individual alarmed for values in excess of their respective high/low limits or status. When an alarm is detected, it shall be automatically stored and the user notified by displaying a message on the front display panel. The front-end shall be located in the Maintenance Office.

b. In addition to visual notification, an audible alarm shall sound during a high-level alarm condition as follows:
- Duct smoke detector activated
- Fan failure
- Pump failure
- Boiler failure
- Freeze stat protection alarm
- CO and NOx alarm
- Cooler Prep Room CO2 Alarm
- Cooler Prep room Refrigerant alarm
- Low space temperature (lower than 50°F)
- High space alarm (greater than 100°F)
- Freezer and Refrigerator temperature alarms

c. The audible alarm shall be mounted in a location as directed by the Owner. A toggle switch or push button shall be mounted adjacent to the alarm with a laminated plastic tag noting "HVAC Alarm: Silence – Auto". Once alarm condition subsides the alarm shall be automatically reset. This alarm shall be in addition to those local alarms provided for CO & Refrigerant alarms.

2. Scheduling

a. The scheduling program in the stand-alone DDC unit shall provide daily, weekly and calendar scheduling capability. The master schedule shall be capable of being individually edited for each day of the week and holidays.

3. Communications

a. The controller shall communicate on a network bus. In addition, the system shall communicate to the internet via a Ethernet connection. Coordinate with Owner for Ethernet interface port. Contractor shall program system to dial out and email alarms to predefined parties and send alarms to the Owner's security monitoring company.

4. Energy Monitoring

At both the Owner's workstation and the workstation at the Owners Informational Kiosk provide software and graphically trends as required to display system operational status and energy consumption of boilers, chillers, air handlers, system BTU loads, lighting power consumption and solar power Watt energy generation. Graphs shall report energy consumption/generation in BTU, Watts and kW over time.

Energy data from the HVAC equipment and system shall be derived from the applicable fan and pump VFD drive kW information as well as BTU data from the airflow and water flow stations and applicable temperature and humidity sensors (humidity sensors used for airflow BTU energy). In addition, the EMS shall provide monitoring devices to track the natural gas consumed by the domestic hot water heaters and the heating boilers on a real time and totalized basis using pulse metering retrofitted to gas sub meters. The gas meters shall be furnished and installed by the plumbing contractor and the pulse meters shall be installed by the control contractor. Plumbing contractor shall install gas sub meters on the main gas line to the boiler plant and the branch gas line to the domestic water heaters. Heating boiler gas usage shall be determined by subtracting the domestic water heater gas meter reading from the boiler plant gas meter reading. The pulse meters shall be similar to the 'X'-pulser manufactured by IMAC Systems, Inc. compatible with the gas meter furnished by the plumbing contractor

Besides various HVAC systems the EMS shall communicate to other building systems via ModBus RS-485 connection to monitor and report on status and energy use. The systems shall be as follows:

- Lighting system (BACNet) – for occupancy/vacancy status of each room.
- Generator (Modbus RS-485) – for monitoring various generator functions.
- Submetering (Modbus RS-485) – for monitoring loads for each meter, some of which will have to be manipulated, and then displayed as graph or data.

The system shall be fully capable of being programmed to load shed the DX cooling of various systems based on maintaining building kW demand below a preset limit. Unless otherwise directed as a minimum the programming shall prioritize the DX cooling drop as follows: 1st Drop Gym cooling, 2nd Drop kitchen cooling 3rd Drop Café cooling. Further system shedding shall be reviewed with Owner.

5. Generator Monitoring:

a. Integration to Building Management System (BMS):

1) Electrical contractor shall provide Modbus RS-485 communications wiring from the generator to:
   - BMS system.
   - Generator Annunciator.

2) The BMS system shall monitor the following points:
- Overcrank shutdown
- Low coolant temperature warning
- Pre-warning for high engine temperature
- High engine temperature shutdown
- Pre-warning for low lube oil pressure
- Low lube oil pressure shutdown
- Overspeed shutdown
- Low fuel in main tank warning
- Low coolant level warning
- Generator (EPS) supplying load.
- Generator control switch not in auto position warning
- High battery voltage warning
- Low cranking voltage warning
- Low battery voltage warning
- Battery charger failure
- Generator output breaker(s) open warning
- Emergency stop depressed
- Load Bank Connected
- Load Bank Over-Temperature
- Load Bank Load Dump
- Permanent generator Disconnected/Portable Generator (signal from manual transfer switch)
- Spare/Customer alarm
- Spare/Customer alarm

b. The electrical contractor shall provide wiring from the BMS system to the generator for the load bank “transfer of control” contact closure to initiate the load bank and time delay load application circuit.

c. The electrical contractor shall provide wiring from the generator to the BMS for indication, detection and alarm of Load Bank Over-Temperature and Load Dump.

d. Coordinate exact requirements with the electrical vendor.

6. Filter Alarms:

If filter differential static pressure sensor detects a filter pressure drop of greater than a setpoint of 0.7” a dirty filter maintenance alarm shall be reported by the front-end. Typical for all system with filter monitoring as indicated on the control drawings.

M SEQUENCE OF OPERATION – HYDRONIC HEATING BOILERS & BOILER PUMPS

1. The hydronic gas-fired boiler/burner units shall be controlled by a microprocessor based pre-engineered and programmed control system furnished by the boiler

manufacturer. The control system shall be furnished as specified in this specification for Boiler/Burner Units. All boiler/burner control wiring from burner control panels to multiple boiler control system, boiler circulators, primary controls, operating controls, limits, switches, and additional control devices as required shall be furnished and installed by the Automatic Temperature Control Contractor per manufacturer's instructions. The boiler controller shall have system supply and return water sensors and outdoor air sensors wire directly to the factory panel.

2. Boiler controller shall be set to achieve supply water temperature reset indicated below while optimizing the energy consumption of the plant. Boiler controller shall initiate respective boiler primary pump prior to firing respective boiler and shall operate primary pump for a preset duration (initially 30 seconds) after boiler is disabled.

3. The DDC shall monitor the boilers via BacNet or open protocol software but as a minimum interface must allow user to view all operating points, firing rates, energy consumptions, etc….

4. Boilers system shall be enabled when the system pumps are on and the system is in the heating mode. In general, the boiler plant shall be enabled at outdoor temperatures below 65 degrees F. Boilers shall modulate fire on their integral control system resetting HW temperature based on outdoor air temperature HW temp. shall be reset as follows. Boilers shall operate in an energy optimization mode and lead/lag to insure even run time.

O.A.Temp	Supply Temp.
10°F or less	145°F
60°F	110°F

5. When a boiler is called to fire its respective boiler pump shall enable and prove on prior to the boiler firing. When a boiler is disabled the respective pump shall operate 30 seconds to purge the boiler of hot water. Boiler controller shall vary speed of respective boiler pump to maximize boiler efficiency.

6. EMS shall monitor system flow via a flow measuring station and report flow back to front-end for calculation with temperature differentials to achieve BTU energy consumption.

7. Provide two (2) remote shutoff switches for the boiler room. One switch shall be located just outside the interior door to the boiler room. Switch must be located in a break glass or equal tamper resistant enclosure properly labeled. The second switch should be located just inside the boiler room exterior door properly labeled as to its service. Switches must be wired and programmed so that when either switch is placed in the off position a disable signal shall be immediately sent to all of the heating boilers and domestic hot water heaters.

7. DDC Point List - Hydronic Boiler Control

   As a minimum, the following points shall be hard wired monitored and controlled although, the front-end shall be capable of viewing all boiler points through BacNet.

Inputs:	Output

O.A. temperature AI	Boiler system enable/disable DO
Common HW supply temperature AI	Hot water reset AO
Common HW return temperature AI	Boiler Pump AO (3) via boiler controller

Boiler flame failure DI (3)
Boiler status DI (3)
Boiler Pump Status (3) DI
Hot water system flow GPM AI (3)
Main Hot Water Return Temp AI
Main Hot water Supply Temp AI
Boiler Enable/Disable Command DI (3)
Boiler firing rates, temps and Energy data (via BacNet)
Boiler Safety Shut-Off DI (2)

N. SEQUENCE OF OPERATION – SYSTEM PUMPS (P-4A thru P-4D & P-5A thru P-5C)

1. Whenever the system is in heating mode the pumps shall operate. Heating mode shall be enabled when outdoor air temperature drops below 65ºF (adjustable). Heating mode shall also be enabled if any of the classroom displacement ventilation RTU units or Science or Art room RTU requires heating or reheating beyond the capabilities of the RTU's integral reheat (i.e. spaces are overcooling), this enable mode feature can be enabled or disabled per a graphic enable/disable function entitled "Warm Weather Heat Enable/Disable". Once enabled, a start command shall be sent to the respective pump package controller and the controller shall enable the number of pumps required to achieve the flow demand. Whenever the outdoor air temperature is above the heat enable setting, the pumps shall remain off. During summer unoccupied periods the system pumps shall remain off. During winter unoccupied periods, if all the building zones are satisfied and the outdoor air temperature is above 48ºF the pumps may cycle on & off as needed During this mode pumps shall only cycle on if more than 3 zones (adjustable) are calling for heat. If all the heating system pumps are off the boiler plant shall be disabled.

2. If a pump fails as sensed by the factory control package, the standby pump(s) shall be energized and an alarm shall be initiated through the DDC via the pump package BacNet interface

3. The factory pump package controller shall alternate (lead-lag) the pump operation on a run-time bases to provide equal service and wear on the pumps as well as stage and modulate the pumps required to meet the system demand while using the least electrical pump energy required (energy optimization). In general lead/lag pumps shall rotate every 72 run hours.

4. EMS shall monitor system flow via a flow measuring station and report flow back to front-end for calculation with temperature differentials to achieve BTU energy consumption.

5. The pump package controller shall stage pumps and vary the ECM pump speeds as required to maintain constant system differential pressure while optimizing energy consumption. The EMS shall send the pump package a 4-20 mA or 0-10Vdc signal based on maintaining system differential pressure.

6. DDC Point List – Heating System Pumps
   As a minimum, the following points shall be monitored and controlled:

Input	Outputs
	Pump Package P-4A thru D Speed AO
	Pump Package P-5A thru D Speed AO
	Pump Package P-4A thru D Start/Stop DO
	Pump Package P-4A thru D Start/Stop DO
System Diff. Press AI #1	
Flow Station AI #1	
System Diff. Press AI #2	
Flow Station AI #2	
Main Classroom Wing HWR Temp. AI	
Non Classroom Wing HWR Temp AI	
Main Hot Water Supply Temp AI	
Alarms, Status and Energy Data (via BacNet) typ. both pump packages	

O. SEQUENCE OF OPERATION – HEAT EXCHANGERS & PUMPS

1. Whenever the main heating system is active and any of the respective RTU or MAU units require main unit coil heat or whenever outdoor air temperatures drop below a setpoint of 45F the HX system shall be activated.

2. Once the HX system is enabled, a start command shall be sent to the respective pump package controller and the controller shall enable the number of pumps required to achieve the flow demand. Whenever the main system heating pumps are off the pumps shall remain off.

3. If a pump fails as sensed by the factory control package, the standby pump(s) shall be energized and an alarm shall be initiated through the DDC via the pump package BacNet interface

4. The factory pump package controller shall alternate (lead-lag) the pump operation on a run-time bases to provide equal service and wear on the pumps as well as stage and modulate the pumps required to meet the system demand while using the least electrical pump energy required (energy optimization). In general lead/lag pumps shall rotate every 72 run hours.

5. Once the water flow has been proven, the HX water valve shall modulate to maintain hot water setpoint reset off of outdoor air as follows:

Outdoor Air Temp.	Hot Water Supply Temp.
10°F	140°F
60°	105°F

6. EMS shall monitor system flow via a flow measuring station and report flow back to front-end for calculation with temperature differentials to achieve BTU energy consumption.

7. The pump package controller shall stage pumps and vary the ECM pump speeds as required to maintain constant system differential pressure while optimizing energy consumption. The EMS shall send the pump package a 4-20 mA or 0-10Vdc signal based on maintaining system differential pressure.

8. DDC Point List – HX System
   As a minimum, the following points shall be monitored and controlled:

Input	Outputs

Pump Package P-6A thru C Speed AO
Pump Package P-7A thru D Speed AO
Pump Package P-8A thru D Speed AO
Pump Package P-6A thru D Start/Stop DO
Pump Package P-7A thru D Start/Stop DO
Pump Package P-8A thru D Start/Stop DO
HX System Diff. Press AI #1
HX Flow Station AI #1
HX System Diff. Press AI #2
HX Flow Station AI #2
HX HWS Temp. AI (3)
HX HWR Temp AI (3)
Alarms, Status and Energy Data (via BacNet) typ. each pump packages

P. SEQUENCE OF OPERATION – RADIANT FLOOR HEAT

1. The radiant floor heat system supports the Pre-Kindergarten/Early Childhood Ed. rooms. VAV boxes with hot water coils shall also work in conjunction with the slab heat with the VAV heating coil acting as second stage heat. Refer to VAV sequence of operation.
2. Once the boiler plant is enabled and the outdoor air temperature is below 60°F, the respective radiant zone circulator pump shall cycle on and the injection valve modulate to maintain the slab temperature between a minimum of 70°F and maximum of 85°F as required to maintain space heating setpoint initially set for 70°F. If room is at space heating setpoint slab temperature setpoint shall be 70°F if room is 2°F below setpoint slab temperature setpoint shall be 85°F. The injection valve shall modulate to maintain radiant loop hot water temperature between a minimum of 70°F and a maximum of 115°F as required to maintaian the slab and corresponding room temperature setpoint. If room is above space heating setpoint the respective injection valve shall close and the pump shall be disabled. Space temperature setpoints shall be initially set for 62°F during unoccupied periods and 70°F during occupied periods.

   Points List

   a. As a minimum, the following points will be monitored and controlled for each radiant heating zone. See also points indicated on drawings:

Inputs	Outputs
Space temp. AI (mult.)	Hot water valve AO
Space temp. adj AI (mult.)	Radiant heating pump P-9 Start/Stop DO
Push button override DI (mult)	Radiant heating pump P-10 Start/Stop DO
Radiant supply Temp AI	
Radiant return Temp AI	
Pump status current P-9 DI	
Pump status current P-10 DI	

Q. SEQUENCE OF OPERATION - HOT WATER BASEBOARD & PANEL RADIATOR HEAT

1. Space mounted temperature sensors shall enable and disable the radiation valve as required to maintain space temperature setpoint initially set for 62°F during unoccupied periods and 70°F during occupied periods. In areas served by both radiation and air heat, the radiation shall work in conjunction with the air heat with radiation being the first

stage of heat followed by the air heat with no more than an adjustable 0.5F dead-band spread.

Points List

a. As a minimum, the following points will be monitored and controlled for each segment of radiation. See also points indicated on drawings:

Inputs	Outputs
Space temp. AI	Hot water valve DO
Space temp. adj AI	
Push button override DI	

R. SEQUENCE OF OPERATION – BOILER ROOM VENTILATION & MISC.

1. Whenever the boilers are operating and during all periods the room is occupied as determined by a current sensor on the rooms lighting circuit, the boiler room intake damper shall open (this is not required for combustion air) to allow a passive flow of air into the room, the respective fans need not run. OA damper shall close if room is not occupied and boilers are off.
2. If the room temperature exceeds a space cooling setpoint initially set for 85°F and outdoor air temperature is below room temperature. The intake and exhaust air dampers shall open and intake (ILF-4) and exhaust air (ILF-1) fans shall modulate speed from 20% to 100% to achieve space cooling setpoint. Once space drops 5°F below cooling setpoint the fans shall be disabled and the dampers closed (OA shall close if
3. Upon a CO alarm an audible and visual alarm shall sound in the area of the plant and a high level alarm shall be reported by the EMS system at the workstation. The intake and exhaust dampers shall open and the intake and exhaust fans shall start and purge the room for 5 minutes after the alarm condition subsides. If the room temperature falls below a setpoint of 45°F the fans shall be disabled and a high level alarm shall be reported by the EMS.

4. DDC Point List – Boiler Room Ventilation

(1)As a minimum, the following points will be monitored and controlled for the system:

Inputs	Outputs
Exhaust fan status DI	Exhaust fan S/S
Intake fan status DI	Intake fan S/S
Space temp. AI	Fresh Air Damper DO
CO conc. AI (2)	Exhaust damper DO
Lighting current DI	CO Horn/Strobe DO
	Intake Fan Speed AO
	Exhaust Fan Speed AO

S. SEQUENCE OF OPERATION – MAU-1 KITCHEN MAKE-UP AIR UNIT and ASSOC. EXHAUST FANS AND KITCHEN EXHAUST

1. Kitchen Hood Exhaust Fan: Upon a start command from the hood mounted switch, the kitchen hood exhaust fan shall start and run. Proper operation shall be verified by the amperage run indicator.

2. When either kitchen hood is enabled via the respective hood system exhaust controllers start switch the respective KEF fan shall start and initially run at a minimum speed setpoint of 40%.
3. The respective kitchen hood KEF fan shall modulate from 40% minimum speed/airflow to its maximum scheduled speed/airflow based on hood smoke & heat detection and control system output. This system shall send status information to the EMS including exhaust air volume for use by the make-up air system control.
4. Dishwasher Hood Exhaust Fan: Upon a start command from a relay to the dishwasher interlock, the dishwash exhaust fan shall start and run. Proper operation shall be verified by the amperage run indicator.
5. MAU-1 Supply Fan Control – Kitchen Hood On Mode
   a. When either of the main kitchen hood KEF exhaust fans are activated via hood mounted switch, the MAU-1 unit shall be enabled to operate.
   b. OA damper shall open and the supply fan shall modulate as required to maintain supply duct static pressure as set during balancing, initially set for 0.75" w.c.
   c. Custom variable air volume terminals shall modulate make-up to the two (2) kitchen hoods the kitchens shall modulate in response to the exhaust airflow volume as reported by the MeLink or equal hood exhaust system. The custom VAV terminals shall modulate between a minimum airflow of no less than 3,000 CFM and a maximum airflow of 8,000 CFM for the culinary kitchen and 7,000 CFM for the main kitchen tracking the respective hood exhaust air volume – 2,000 CFM. In addition, the space pressure shall be monitored to insure space pressure does not exceed a negative setpoint of -0.01 with respect to the outdoors. If either hood is off the VAV make-up air damper to that kitchen shall close. If both hoods are off the MAU shall be disabled and the VAV dampers shall open.
6. Unoccupied (Kitchen Hood Off) Mode

   If either of the kitchen hoods are off the respective KEF fan shall be disabled and the associated VAV make-up air damper shall close. If both kitchen hood systems are commanded off or, are off due to alarm or the chemical fire agent has discharged, the MAU-1 shall be disabled, its fan and burner disabled, supply fan off and outside air damper closed and VAV dampers shall close. VAV dampers shall open 100% when MAU is off in preparation for the next start cycle.

7. Heating & Cooling Control

   When the MAU system is operating the gas-firing rate shall vary to insure the discharge and air temperature does not drop below 55 deg. F. Supply air temperature shall vary within a 55°F to 70°F reset range based on the lowest space temperature within the kitchens, with supply air being at 55F if kitchen temperature is 75F or above and being at 70F when kitchen temperature is 68 deg. F. or below.
8. Safeties and Status

   a. The supply air sensor, upon sensing low supply air temperature of below 40°F (after a delay of 60 seconds) shall shut down the MAU-1 unit, O.A. dampers shall close, and a freeze alarm shall be generated through the DDC system at the workstation.

b. Amperage switches installed on the supply and exhaust fan motors shall indicate fan status. If the EMS controller is calling for the fan to be on and the flow switch does not prove, the amperage is too low or not existent, a fan failure alarm shall be sent to the workstation. If the exhaust fan fails the gas valve(s) to equipment under the kitchen hood shall close.

c. ATC Contractor shall coordinate with Electrical Contractor on direct fan shutdown for duct smoke detection. Duct smoke detectors shall be furnished by the Electrical Contractor. Supply fan shutdown upon activation of duct smoke detector shall be direct wired to fan control circuits from duct detector contacts by the ATC Contractor.

d. Upon activation of the kitchen hood chemical suppression system, or if the space CO detection system or the natural gas detection system detects a space CO or natural gas level above permissible limit the cooking equipment fuel gas valve shall close. The kitchen hood exhaust fan shall remain operational or if the fan was off it will be enabled on low speed. Coordinate gas valve and control interlock with plumbing contractor and electrical contractor. The kitchen make-up air unit shall be disabled if the kitchen hood suppression system discharges and the outside air damper closed and VAV dampers shall close.

10. DDC Point List

a. Refer to the plans and these sequences of operation and provide all points required and inferred to make for a fully functional and operation system. Being that the unit shall be BacNet compatible several points may be extracted from the interface however this contractor must provide any points and all points needed to achieve the operation and monitoring level specified. The EMS contractor shall provide all points are units are customized in this regard with the exception of those points integral to the MAU as furnished by the manufacturer. Points in **Bold** are devices supplied by the unit manufacturer. As a minimum the following points being monitored and controlled for each unit:

Inputs	Outputs
Filter Diff. Pressure AI	Supply fan S/S DO
Supply/OA air volume AI	MAU Enable/Disable DO
Duct Static AI	Supply fan VFD AO
Dishwasher Interlock DI (2)	**O.A. damper AO**
Discharge air temperature AI	Kitchen MAU VAV AO (2)
Supply fan status amp. switch DI	**MUA-1 Gas Valve AO**
Exhaust fan status/ amp. switch DI (4)	**Internal Gas Burner Damper AO**
	Hood Fan Switch with Pilot Lights DO (1 for main kitchen, 1 for culinary)
Duct Smoke Detector DI	*(Kitchen gas valve(s) (by plumber)*
	Exhaust fan S/S (Hood Fan) DO (2)
Space temperature AI (2)	Exhaust Fan VFD Hood Fan) AO (2)
Suppression System DI (each hood segment)	
Kitchen Hood Switch DI (2)	
Kitchen MAU VAV Airflow AI (2)	
Freezer Temp AI (2)	
Cooler Temp AI (2)	

Hood Smoke Detection/Control AI (2)
HOOD Smoke & Heat Control BacNet Interface
Hood exhaust air volume AI (2)
Space Pressure AI (2)
Carbon Monoxide (CO)(4 sensors and panel by plumber)
Natural gas detector (2 sensors by plumber)
O.A. temperature AI (global)
O.A. humidity AI (global)

T. SEQUENCE OF OPERATION – RTU-1, 2 & 3 (Displacement Systems)

1. General

a. RTU-1, 2 & 3 are custom rooftop units with energy recovery wheels units that are variable air volume (VAV) units which provide year round dehumidification, cooling, heating and ventilation to many classroom areas of the building served thru displacement ventilation systems. The units support the following areas:
   - RTU-1: NW Classroom Wing
   - RTU-2: NE Classroom Wing
   - RTU-3: SE Classroom Wing

b. Some limited control sequences and points related to the DX condenser sections shall be accomplished via the units factory condensing unit controls which must be programmed and interfaced to the EMS. The points required to come with the unit are indicated below (in bold) as well as those points the EMS contractor must provide. EMS contractor must coordinate with RTU vendor to insure all specified sequences and points are provided.

2. Supply & Exhaust Fan Control

a. The EMS system shall compare the outdoor conditions, the space conditions and the buildings historical warm-up/cool-down profile to determine the optimum start time required to achieve space setpoint conditions by the scheduled occupied start time. The fans shall run continuous during the occupied time period. During morning warm-up mode the outdoor air dampers shall remain closed and the system shall supply air reset off the return air temperature to bring the spaces up to space heating setpoint (Refer to Heating Coil Control).

b. The EMS shall index from the occupied mode to the unoccupied mode based on a time schedule furnished by the owner. This schedule may be temporary overridden for a predetermined time period by sensor mounted override switches.

c. For all units with smoke dampers the EMS shall prove that all supply air and return/exhaust air smoke dampers are fully open prior to allowing the fans and unit to operate.

d. Prior to allowing the unit to operate both the DX coil face dampers shall open 100% and prove open prior to allowing the unit to start. Once enabled and after the fans stabilize (120 seconds adjustable), if the total unit airflow is 50% (adj.) or greater of the total rated airflow as determined by the supply fan airflow station both DX coil face dampers shall be open. If the supply airflow is less than 40% (adj), the unit shall only operate either the upper or lower DX coil circuits and the deactivated coil

face damper shall close. Either the lower or upper face damper shall be open and prove open at all times while the unit is in operation. Active upper or lower coil sections shall be rotated in conjunction with the compressor rotation scheme.

3. Occupied Mode

   a. At the commencement of occupied mode, the outdoor air damper and exhaust air damper shall open to their respective position with the return/recirculation air dampers going to their respective positions. The supply fan and exhaust fan shall run continuously throughout the occupied time period (see exhaust fan enable herein). If the high limit discharge air duct static sensor meets or exceeds a setpoint of 3"w.c. or the low limit return air duct static sensor meets or exceeds a setpoint of -3" w.c. the unit shall be disabled, fans shall turn off and an alarm shall be reported. The high limit duct static pressure sensor shall be located upstream (unit side) of the supply smoke dampers. The low limit duct static pressure sensor shall be located upstream (unit side) of the return smoke dampers.

   b. The supply fan variable frequency drive shall modulate to maintain supply air static pressure setpoint initially set for 0.75". Every 5 minutes, the system will check all the VAV damper positions and reset static pressure setpoint as follows: If all the VAV damper positions are below a setpoint of 90% open, then decrease the static pressure setpoint by 5% of the design range (initial range of 0.4" minimum and 0.75" maximum for an increment of 0.05"). Otherwise do not change setpoint. If any VAV damper is open greater than a setpoint of 98% then increase the static pressure setpoint by 5% of the design range. Static pressure setpoint shall never exceed the specified static setpoint

   c. The exhaust damper shall open and the exhaust fan variable frequency drive shall modulate the fan speed to maintain exhaust air levels equal to outdoor air levels minus a 5% offset. The exhaust fan shall not start until the outdoor airflow volume exceeds 20% of the scheduled minimum outside air CFM. Outdoor airflow quantity shall be calculated by using the return duct airflow station and the supply airflow station with outdoor air equal to supply airflow minus return airflow. Space pressure shall be monitored and a low level alarm reported if space pressure exceeds an initial setpoint of +0.01" with respect to outdoors. When enabled, minimum exhaust fan speed shall not be allowed to fall below a setpoint of 10Hz or as otherwise directed by the unit manufacturer.

   d. Outdoor air flow dampers shall maintain outdoor air quantity constant within 10% of the specified outdoor air quantity reset as specified herein.

   e. The outdoor air, return air and exhaust dampers shall modulate to maintain the minimum specified outdoor air level as determined by the flow measuring stations. Outdoor air quantity shall be varied between 25% of the specified minimum outdoor air quantity and the specified minimum outdoor air quantity in response to the multiple space CO2 sensors. Dampers shall modulate to maintain a maximum CO2 level at any space sensor of no greater than 800 ppm (adj.) but in no case shall the outdoor air level exceed the scheduled minimum outdoor air value unless economizer cooling is required. Reduced outdoor air CO2 control shall be overridden in the event economizer cooling is required.

   f. The energy reclaim wheel shall run continuously during occupied periods however, if outdoor air enthalpy is below return air enthalpy and cooling is required the wheel

speed shall modulate to maintain supply air setpoint. Economizer shall be disabled if the OA dry bulb rises above a setpoint of 70F or the OA enthalpy rises above 26 BTU/lb. One the wheel is fully stopped, the wheel bypass dampers shall open.

g. Energy wheel speed shall modulate as frost protection for the wheel insuring that the minimum exhaust air temperature off the wheel does not fall below a setpoint as described below and reset as follows. The final accepted unit and wheel manuf. must be consulted to verify the below values are applicable for their wheel.

RA Humidity	Defrost Enable Outdoor Air Temp	Vary Wheel to Wheel Exhaust Temp
20% RH	-10 F	15 F
30% RH	0 F	20 F
40% RH	10 F	25 F

Pressure drop across wheel in excess of a predefined limit (confirm with factory) shall also indicate a potential frost condition and shall enable defrost mode.

h. If wheel run indicator detects a loss of wheel rotation either due to loss of current or reduced current indicating belt loss an alarm shall be reported by the EMS.

i. Main return air carbon dioxide levels shall be monitored and if levels exceed a maximum CO2 setpoint level of 800 ppm (adj.) or greater a low level alarm shall be reported by the EMS.

4. Unoccupied Mode

a. At the commencement of unoccupied mode the outdoor air dampers shall close and the fans shall cycle off. If required, the fans shall cycle on to maintain unoccupied space cooling and heating setpoints initially set for 88°F and 60°F respectively.

5. Cooling/Dehumidification Control

a. The total enthalpy of the return air and outdoor air streams shall be compared and, if advantageous, outdoor air economizer cycle shall be enabled either partially in conjunction with mechanical cooling or exclusively to maintain supply air temperature setpoint. Economizer shall be disabled if the OA dry bulb rises above a setpoint of 70F or the OA enthalpy rises above 26 BTU/lb. In economizer mode, the outdoor air and return air dampers shall modulate as a first stage to satisfy supply air setpoint. The energy reclaim wheel shall run continuously during occupied periods however, if outdoor air enthalpy is below return air enthalpy and cooling is required the wheel speed shall modulate so as to allow the system to reach supply air setpoint as indicated above and herein. If the wheel is fully stopped the bypass dampers shall open to full bypass.

b. If there is a call for space dehumidification as determined by return air dewpoint rising above a setpoint of 55°F, the DX compressor stages shall stage (inverter or digital compressor shall modulate) to maintain a cooling coil temperature (as measured via refrigerant gas pressure sensor) setpoint of 45 degrees. Stages shall increase as the distance and time from setpoint increase with a minimum of 10 minute delay between compressor stages (coordinate with delays built into

condenser controller. Hot gas reheat shall be modulated as required to maintain supply air setpoint.

c. Hot Gas Reheat Valve (HGRV) Purge Cycle: When the hot gas reheat valve has not been open for at least 2 consecutive minutes within the last hour and a compressor is running in the reheat circuit, the hot gas reheat purge cycle shall be enabled and the HGRV shall be forced 100% open for an adjustable purge duration of 2 minutes. The purge cycle may occur once every 60 minutes (adj.).

d. Supply air discharge setpoint shall be reset between 63°F and 68°F based on the average cooling demand from spaces. If more than 3 zones on the system are above cooling setpoint by greater than a setpoint of 3°F, the supply air reset schedule shall reset down towards the minimum overriding the average demand.

e. Morning Cool-Down: If the average space temperature is above cooling setpoint and it is within 2-hours (adj.) of a scheduled occupied period the EMS shall calculate an optimized start-time to achieve space setpoint and enable the unit into morning cool-down mode. The supply air temperature shall be reset down to 63°F until the average space temperature reaches cooling setpoint or the return air temperature reaches 75°F whichever comes first at which time the unit shall drop out of morning cool-down mode and enter normal occupied operation at the schedule time.

f. If airflow is not proven via a pressure sensor an adjustable differential pressure sensor across either of the DX coil banks, the respective compressors circuits shall be deactivated without regard for minimum compressor run times (coordinate with compressor controller).

6. Heating Control

a. The hot water heat valve (if required) shall modulate to maintain the supply air reset schedule initially 63°F to 68°F or no less than 2°F below general space heating setpoint if no spaces require cooling. Maximum supply air temperature shall be 70°F. If the outdoor air temperature is below a setpoint of 20°F or the total supply airflow of the unit is less than 30% (confirm with unit manuf.), the heat pump cycle shall be disabled and the unit shall rely on hot water heating. Hot water valve shall be closed if DX cooling or dehumidification mode is operational.

b. During morning warm-up or cool down the supply air reset schedule shall be overriden and the coil valve shall modulate to satisfy the reset schedule indicated herein.

c. Morning Warm-up: If the average space temperature is below heating setpoint and it is within 2-hours (adj.) of a scheduled occupied period the units the EMS shall calculate an optimized start-time to achieve space setpoint and enable the unit into morning warm-up mode. The supply air temperature shall be reset up 75°F until the average space temperature reaches heating setpoint or the return air temperature reaches 70°F whichever comes first at which time the unit shall drop out of morning warm-up mode and enter normal occupied operation at the schedule time.

e. During morning warm-up when outdoor air temperatures are above a setpoint of 20°F, the heat pump cycle shall be the first stage of heat for the spaces served by

the respective system followed by the hot water coil. The intent is to minimize reliance on the fossil fuel hot water boiler plant during these conditions.

f. During unoccupied periods when outdoor air temperatures are below a setpoint of 38ºF and the unit is off, the hot water coil valves shall modulate to maintain a hot water leaving coil air temperature of 70°F to insure minimum flow through the heating coils and to prevent nuisance trips of the freeze stats.

7. System Safeties & Misc.:

a. The units have glycol in the hot water coils for freeze protection. If the hot water coil freeze stat detects a leaving air temperature below 38°F for longer than 60 seconds, the unit shall report a low temperature alarm but shall not shutdown. If the system discharge air temperature drops below 40°F for longer than 30 seconds, the ATC shall report a freeze condition to the EMS and the following shall occur:
Disable supply air and exhaust air fans.
Close the outdoor and exhaust air dampers and open the return air damper.
Open hot water coil valve 100%
Annunciate a local alarm

b. Normal damper positions are as follows:
O.A. damper – normally closed
R.A. damper – normally open
E.A. damper – normally closed

c. Smoke Alarm – Upon a smoke detector activation or if any smoke damper in the system is in a position other than fully open, the unit and fans shall shutdown and the dampers shall go to their normal position (i.e. O.A.-Closed). An alarm shall be reported to the EMS system and the building fire alarm system.

g. The factory condensing unit controller shall perform hot gas reheat coil flush cycles as needed to insure no refrigerant oil is tied up in the coils.

h. Coordinate with factory for minimum on & off times, time delays and such for compressors. The condensing section is a VRF system with branch selector boxes refrigerant valves, etc…. EMS must coordinate fully with integration of the VRF controls with the EMS.

8. DDC Point List – RTU-1, 2 & 3 DIPSLACEMENT SYSTEMS

a. Refer to the plans and these sequences of operation and provide all points required and inferred to make for a fully functional and operation system. Being that the units condensing section shall be BacNet compatible several points may be extracted from the interface however this contractor must provide any points and all points needed to achieve the operation and monitoring level specified. The EMS contractor shall provide all points are units are customized in this regard with the exception of those points integral to the RTU condenser section as furnished by the manufacturer. Points in **Bold** are point supplied and/or controlled by the unit manufacturer. Unitary dampers are supplied by the unit manufacturer however, the damper motors and operators are provided by the EMS vendor. As a minimum the following points being monitored and controlled for each unit:

Inputs	Outputs
Filter Diff. Pressure AI	Supply fan S/S DO
Return air volume AI	Exhaust fan S/S DO
Freezestat AI	Supply fan VFD AO
Mixed air temp. AI	O.A. damper AO (mult)
Supply duct static AI	Exhaust damper AO
Supply fan status	Hot Water Coil Valve AO
amp. AI	Exhaust Fan VFD AO
Exhaust fan status/	Wheel Bypass Dampers DO (2)
amp. AI	DX Cooling Stages (multiple) DO & AO
Duct Smoke Det. DI (mult)	Duct Smoke Damper DO (mult) coord. with EC
Discharge air temperature AI	**Hot Gas Reheat Valves AO (multiple)**
R.A. temperature AI	Return Air damper AO (mult)
DX Coil Press./Temp AI (mult)	Wheel Enable and Speed DO & AO
R.A. humidity AI	**Supply Fan Array (Bacnet)**
R.A. CO2 AI	**Exhaust Fan Array (Bacnet)**
Space CO2 AI (multiple)	**Condenser section VRF Bacnet Interface**
Wheel discharge air temp AI	Lower DX Coil Face Damper AO
Wheel rotation DI	Upper DX Coil Face Damper AO
Wheel Pressure Drop AI	
Duct Static Pressure AI	
High Limit Duct Static DI	
Low Limit Duct Static DI	
Wheel Supply Leaving Temp AI	
Duct Smoke Damper DI (mult)	
DX Coil Air DP AI	
Supply Air Volume AI	
Exhaust Air Volume AI	
O.A. temperature AI (global) also integral to unit	
O.A. humidity AI (global) also integral to unit	
Supply Fan Array Data (Bacnet)	
Exhaust Fan Array (Bacnet)	
Condenser section Bacnet Interface	

U. SEQUENCE OF OPERATION – RTU-6, 11, 12, 13, 17 & 19 (VAV Systems)

1. General

a. RTU-6, 11, 12 13, 17 & 19 are packaged rooftop units with energy recovery wheels units that are variable air volume (VAV) units which provide year round dehumidification, cooling, heating and ventilation to various areas of the building. The units support the following areas:
   - RTU-6: Media Center
   - RTU-11: Lobby
   - RTU-12: Life Skills
   - RTU-13: Music
   - RTU-17: Business Ground Floor
   - RTU-19: Pre-K

b. Some limited control sequences and points related to the DX condenser sections shall be accomplished via the units factory condensing unit controls which must be

programmed and interfaced to the EMS. The points required to come with the unit are indicated below (in bold) as well as those points the EMS contractor must provide. EMS contractor must coordinate with RTU vendor to insure all specified sequences and points are provided.

2. Supply & Exhaust Fan Control

   a. The EMS system shall compare the outdoor conditions, the space conditions and the buildings historical warm-up/cool-down profile to determine the optimum start time required to achieve space setpoint conditions by the scheduled occupied start time. The fans shall run continuous during the occupied time period. During morning warm-up mode the outdoor air dampers shall remain closed and the system shall supply air reset off the return air temperature to bring the spaces up to space heating setpoint (Refer to Heating Coil Control).

   b. The EMS shall index from the occupied mode to the unoccupied mode based on a time schedule furnished by the owner. This schedule may be temporary overridden for a predetermined time period by sensor mounted override switches.

   c. For all units with smoke dampers the EMS shall prove that all supply air and return/exhaust air smoke dampers are fully open prior to allowing the fans and unit to operate.

   d. On RTU-11 system, whenever the RTU system or any of the lobby VAV zones are calling for heating the respective anti-stratification fans ASF-# fans shall start and run continuously until all heating demand for the space has ended. ASF fans shall be enabled as a 1st stage call for heat. If the outdoor air temperature is below a setpoint of 40°F the ASF fans shall run continuously regardless of occupancy mode. User shall be able to control the speed of these fans by adjusting at the front-end

3. Occupied Mode

   a. At the commencement of occupied mode, the outdoor air damper shall open to its respective position with the return/recirculation air dampers going to their respective positions. The supply fan and exhaust fan shall run continuously throughout the occupied time period (see exhaust fan enable herein). If the high limit discharge air duct static sensor meets or exceeds a setpoint of 3”w.c. or the low limit return air duct static sensor meets or exceeds a setpoint of -3” w.c. the unit shall be disabled, fans shall turn off and an alarm shall be reported. The high limit duct static pressure sensor shall be located upstream (unit side) of the supply smoke dampers. The low limit duct static pressure sensor shall be located upstream (unit side) of the return smoke dampers.

   b. The supply fan variable frequency drive shall modulate to maintain supply air static pressure setpoint initially set for 0.75”. Every 5 minutes, the system will check all the VAV damper positions and reset static pressure setpoint as follows: If all the VAV damper positions are below a setpoint of 90% open, then decrease the static pressure setpoint by 5% of the design range (initial range of 0.4” minimum and 0.75” maximum for an increment of 0.05”). Otherwise do not change setpoint. If any VAV damper is open greater than a setpoint of 98% then increase the static pressure setpoint by 5% of the design range. Static pressure setpoint shall never exceed the specified static setpoint

c. The exhaust fan variable frequency drive shall modulate the fan speed to maintain exhaust air levels equal to outdoor air levels minus a 5% offset. The exhaust damper shall open (gravity style) when the fan is enabled. The exhaust fan shall not start until the outdoor airflow volume exceeds 25% of the scheduled minimum OA CFM. Outdoor airflow quantity shall be calculated by using the return duct airflow station and the supply airflow station with outdoor air equal to supply airflow minus return airflow. Space pressure shall be monitored and a low level alarm reported if space pressure exceeds an initial setpoint of +0.01" with respect to outdoors. When enabled, minimum exhaust fan speed shall not be allowed to fall below a setpoint of 10Hz or as otherwise directed by the unit manufacturer.

d. Outdoor air flow dampers shall maintain outdoor air quantity constant within 10% of the specified outdoor air quantity reset as specified herein.

e. The outdoor air, return air and exhaust dampers shall modulate to maintain the minimum specified outdoor air level as determined by the flow measuring stations. Outdoor air quantity shall be varied between 20% of the specified minimum outdoor air quantity and the specified minimum outdoor air quantity in response to the multiple space CO2 sensors, where shown on the plans, or the return air sensor, if space sensors are not identified. Dampers shall modulate to maintain a maximum CO2 level at any space sensor of no greater than 800 ppm (adj.) but in no case shall the outdoor air level exceed the scheduled minimum outdoor air value unless economizer cooling is required. Reduced outdoor air CO2 control shall be overridden in the event economizer cooling is required.

f. The energy reclaim wheel shall run continuously during occupied periods however, if outdoor air enthalpy is below return air enthalpy and cooling is required the wheel speed shall modulate to maintain supply air setpoint. Economizer shall be disabled if the OA dry bulb rises above a setpoint of 70F or the OA enthalpy rises above 26 BTU/lb. One the wheel is fully stopped, the wheel bypass dampers shall open.

g. Energy wheel speed shall modulate as frost protection for the wheel insuring that the minimum exhaust air temperature off the wheel does not fall below a setpoint as described below and reset as follows. The final accepted unit and wheel manuf. must be consulted to verify the below values are applicable for their wheel.

RA Humidity	Defrost Enable Outdoor Air Temp	Vary Wheel to Wheel Exhaust Temp
20% RH	-10 F	15 F
30% RH	0 F	20 F
40% RH	10 F	25 F

Pressure drop across wheel in excess of a predefined limit (confirm with factory) shall also indicate a potential frost condition and shall enable defrost mode.

h. If wheel run indicator detects a loss of wheel rotation either due to loss of current or reduced current indicating belt loss an alarm shall be reported by the EMS.

i. Main return air carbon dioxide levels shall be monitored and if levels exceed a maximum CO2 setpoint level of 800 ppm (adj.) or greater a low level alarm shall be reported by the EMS.

4. Unoccupied Mode

a. At the commencement of unoccupied mode the outdoor air dampers shall close and the fans shall cycle off. If required, the fans shall cycle on to maintain unoccupied space cooling and heating setpoints initially set for 88°F and 60°F respectively.

5. Cooling/Dehumidification Control

a. The total enthalpy of the return air and outdoor air streams shall be compared and, if advantageous, outdoor air economizer cycle shall be enabled either partially in conjunction with mechanical cooling or exclusively to maintain supply air temperature setpoint. Economizer shall be disabled if the OA dry bulb rises above a setpoint of 70F or the OA enthalpy rises above 26 BTU/lb. In economizer mode, the outdoor air and return air dampers shall modulate as a first stage to satisfy supply air setpoint. The energy reclaim wheel shall run continuously during occupied periods however, if outdoor air enthalpy is below return air enthalpy and cooling is required the wheel speed shall modulate so as to allow the system to reach supply air setpoint as indicated above and herein. If the wheel is fully stopped the bypass dampers shall open to full bypass.

b. If there is a call for space dehumidification as determined by return air dewpoint rising above a setpoint of 55°F, the DX compressor stages shall stage (inverter or digital compressor shall modulate) to maintain a cooling coil temperature (as measured via refrigerant gas pressure sensor) setpoint of 45 degrees. Stages shall increase as the distance and time from setpoint increase with a minimum of 10 minute delay between compressor stages (coordinate with delays built into condenser controller. Hot gas reheat shall be modulated as required to maintain supply air setpoint.

c. Hot Gas Reheat Valve (HGRV) Purge Cycle: When the hot gas reheat valve has not been open for at least 2 consecutive minutes within the last hour and a compressor is running in the reheat circuit, the hot gas reheat purge cycle shall be enabled and the HGRV shall be forced 100% open for an adjustable purge duration of 2 minutes. The purge cycle may occur once every 60 minutes (adj.).

d. Supply air discharge setpoint shall be reset between 55°F and 65°F based on an average of the cooling demand from spaces. If more than 3 zones on the system are above cooling setpoint by greater than a setpoint of 3°F, the supply air reset schedule shall reset down towards the minimum overriding the average demand.

e. Morning Cool-Down: If the average space temperature is above cooling setpoint and it is within 2-hours (adj.) of a scheduled occupied period the EMS shall calculate an optimized start-time to achieve space setpoint and enable the unit into morning cool-down mode. The supply air temperature shall be reset down to 55°F until the average space temperature reaches cooling setpoint or the return air temperature reaches 75°F whichever comes first at which time the unit shall drop out of morning cool-down mode and enter normal occupied operation at the schedule time.

f. If airflow is not proven via a pressure sensor an adjustable differential pressure sensor across the DX coil, the compressors circuits shall be deactivated without regard for minimum compressor run times (coordinate with compressor controller).

6. Heating Control

   a. The hot water heat valve shall modulate if required to maintain the supply air reset schedule as identified in the cooling sequence initially 55°F to 65°F. Hot water valve shall be closed if DX cooling or dehumidification mode is operational.

   b. During morning warm-up or cool down the supply air reset schedule shall be overriden and the coil valve shall modulate to satisfy the reset schedule indicated herein.

   c. Morning Warm-up: If the average space temperature is below heating setpoint and it is within 2-hours (adj.) of a scheduled occupied period the units the EMS shall calculate an optimized start-time to achieve space setpoint and enable the unit into morning warm-up mode. The supply air temperature shall be reset up 90°F until the average space temperature reaches heating setpoint or the return air temperature reaches 70°F whichever comes first at which time the unit shall drop out of morning warm-up mode and enter normal occupied operation at the schedule time

   d. During morning warm-up or during any unoccupied period when outdoor air temperatures are above a setpoint of 30°F, the heat pump cycle shall be the first stage of heat for the spaces served by the respective system followed by the hot water coils and baseboard radiation. The intent is to minimize reliance on the fossil fuel hot water boiler plant during these conditions.

   e. During unoccupied periods when outdoor air temperatures are below a setpoint of 38ºF and the unit is off, the hot water coil valves shall modulate to maintain a hot water leaving coil air temperature of 70°F to insure minimum flow through the heating coils and to prevent nuisance trips of the freeze stats.

7. System Safeties & Misc.:

   a. The units have glycol in the hot water coils for freeze protection. If the hot water coil freeze stat detects a leaving air temperature below 38°F for longer than 60 seconds, the unit shall report a low temperature alarm but shall not shutdown. If the system discharge air temperature drops below 40°F for longer than 30 seconds, the ATC shall report a freeze condition to the EMS and the following shall occur:
   Disable supply air and exhaust air fans.
   Close the outdoor and exhaust air dampers and open the return air damper.
   Open hot water coil valve 100%
   Annunciate a local alarm

   b. Normal damper positions are as follows:
   O.A. damper – normally closed
   R.A. damper – normally open
   E.A. damper – normally closed

   c. Smoke Alarm – Upon a smoke detector activation or if any smoke damper in the system is in a position other than fully open, the unit and fans shall shutdown and the dampers shall go to their normal position (i.e. O.A.-Closed). An alarm shall be reported to the EMS system and the building fire alarm system.

d. The factory condensing unit controller shall perform hot gas reheat coil flush cycles as needed to insure no refrigerant oil is tied up in the coils.

e. Coordinate with factory for minimum on & off times, time delays and such for compressors.

8. DDC Point List – RTU-6, 11, 12, 13, 17 & 19

a. Refer to the plans and these sequences of operation and provide all points required and inferred to make for a fully functional and operation system. Being that the units condensing section shall be BacNet compatible several points may be extracted from the interface however this contractor must provide any points and all points needed to achieve the operation and monitoring level specified. The EMS contractor shall provide all points are units are customized in this regard with the exception of those points integral to the RTU condenser section as furnished by the manufacturer. Points in **Bold** are point supplied and/or controlled by the unit manufacturer. Refer to respective equipment section in specification for devices being supplied by factory but still required to be controlled by EMS. Unitary dampers are supplied by the unit manufacturer however, the damper motors and operators are provided by the EMS vendor. As a minimum the following points being monitored and controlled for each unit:

Inputs	Outputs
Filter Diff. Pressure AI (3)	Supply fan S/S DO
Return air volume AI	Exhaust fan S/S DO
Freezestat AI	Supply fan VFD AO
Mixed air temp. AI	O.A. damper AO
Supply duct static AI	Return/recirc Air damper AO
Supply fan status	Hot Water Coil Valve AO
amp. AI	Exhaust Fan VFD AO
Exhaust fan status/	Wheel Bypass Dampers DO (2)
amp. AI	DX Cooling Stages (multiple) DO & AO
Duct Smoke Det. DI (mult)	DX Heat Stages (mult) DO&AO
Discharge air temperature AI	**Hot Gas Reheat Valves AO (multiple)**
R.A. temperature AI	Wheel Enable and Speed DO & AO
DX Coil Press./Temp AI (mult)	Duct Smoke Damper DO (mult) coord. with EC
R.A. humidity AI	**Condenser section Bacnet Interface**
R.A. CO2 AI	Anti-Stratification Fans AO
Space CO2 AI (multiple)	
Wheel exhaust leaving air temp AI	
Wheel rotation DI	
Wheel Pressure Drop AI	
Duct Static Pressure AI	
High Limit Duct Static DI (RTU-11 only)	
Low Limit Duct Static DI (RTU-11 only)	
Wheel Supply Leaving Temp AI	
DX Coil Air DP AI	
Duct Smoke Damper DI (RTU-11 only)	
Factory Discharge air Sensor	
Supply Air Volume AI	
Exhaust Air Volume AI	
Outdoor Air Volume AI	

Factory OA temp. sensor
O.A. temperature AI (global) also integral to unit
O.A. humidity AI (global) also integral to unit
Condenser section Bacnet Interface

Note: OA, RA and Bypass damper actuators as well as wheel rotation sensor are furnished with units but must be wired and controlled by EMS. Freezestat is furnished and installed by unit manufacturer but must be wired from terminal strip to EMS.

V. SEQUENCE OF OPERATION – RTU-4, 5, 14 & 22 (VAV Systems with EA VAV)

1. General

a. RTU-4, 5, 14 & 22 are packaged rooftop units with energy recovery wheels units that are variable air volume (VAV) units which provide year round dehumidification, cooling, heating and ventilation to areas in the building. The units support the following areas:
   - RTU-4: SE Science
   - RTU-5: SW Science
   - RTU-14: Art
   - RTU-22: Locker Rooms

b. Some limited control sequences and points related to the DX condenser sections shall be accomplished via the units factory condensing unit controls which must be programmed and interfaced to the EMS. The points required to come with the unit are indicated below (in bold) as well as those points the EMS contractor must provide. EMS contractor must coordinate with RTU vendor to insure all specified sequences and points are provided.

2. Supply & Exhaust Fan Control

a. The EMS system shall compare the outdoor conditions, the space conditions and the buildings historical warm-up/cool-down profile to determine the optimum start time required to achieve space setpoint conditions by the scheduled occupied start time. The fans shall run continuous during the occupied time period. During morning warm-up mode the outdoor air dampers shall remain closed and the system shall supply air reset off the return air temperature to bring the spaces up to space heating setpoint (Refer to Heating Coil Control).

b. The EMS shall index from the occupied mode to the unoccupied mode based on a time schedule furnished by the owner. This schedule may be temporary overridden for a predetermined time period by sensor mounted override switches.

c. For all units with smoke dampers the EMS shall prove that all supply air and return/exhaust air smoke dampers are fully open prior to allowing the fans and unit to operate.

d. RTU-4 & RTU-5 provide make-up air for the science room fume hoods and if the fume hoods are enabled the respective RTU shall be enabled to support the make-up air regardless of occupied schedule.

e. On RTU-14 whenever the RTU system or the Art room zones are calling for heating the respective anti-stratification fans ASF-# fans shall start and run continuously until all heating demand for the space has ended. ASF fans shall be enabled as a 1st stage call for heat. If the outdoor air temperature is below a setpoint of 40°F the ASF fans shall run continuously regardless of occupancy mode. User shall be able to control the speed of these fans by adjusting at the front-end

3. Occupied Mode

a. At the commencement of occupied mode, the outdoor air damper shall open 100% and the return/recirculation air dampers shall close. The supply fan and exhaust fan shall run continuously throughout the occupied time period (see exhaust fan enable herein). If discharge air duct static rises above a setpoint of 3"w.c. the unit shall be disabled and an alarm shall be reported. The high limit duct static pressure sensor shall be located upstream (unit side) of the smoke dampers.

b. The supply fan variable frequency drive shall modulate to maintain supply air static pressure setpoint initially set for 0.75". Every 5 minutes, the system will check all the VAV damper positions and reset static pressure setpoint as follows: If all the VAV damper positions are below a setpoint of 90% open, then decrease the static pressure setpoint by 5% of the design range (initial range of 0.4" minimum and 0.75" maximum for an increment of 0.05"). Otherwise do not change setpoint. If any VAV damper is open greater than a setpoint of 98% then increase the static pressure setpoint by 5% of the design range. Static pressure setpoint shall never exceed the specified static setpoint.

c. The exhaust fan variable frequency drive to maintain return/exhaust air static pressure setpoint initially set for -0.75". The exhaust air damper shall open (gravity style) when the fan is enabled. Refer to VAV Terminal Sequence for additional information. Every 5 minutes, the system will check all the VAV damper positions and reset static pressure setpoint as follows: If all the VAV damper positions are below a setpoint of 90% open, then decrease the static pressure setpoint by 5% of the design range (initial range of -0.4" minimum and -0.75" maximum for an increment of 0.05"). Otherwise do not change setpoint. If any VAV damper is open greater than a setpoint of 98% then increase the static pressure setpoint by 5% of the design range. Static pressure setpoint shall never exceed the specified static setpoint.

d. When enabled, minimum exhaust fan speed shall not be allowed to fall below a setpoint of 10Hz or as otherwise directed by the unit manufacturer.

e. Outdoor air flow as determined by the supply airflow (as unit is 100% OA) shall be monitored.

f. The energy reclaim wheel shall run continuously during occupied periods however, if outdoor air enthalpy is below return air enthalpy and cooling is required the wheel speed shall modulate to maintain supply air setpoint. Economizer shall be disabled if the OA dry bulb rises above a setpoint of 70F or the OA enthalpy rises above 26 BTU/lb. One the wheel is fully stopped, the wheel bypass dampers shall open.

g. Energy wheel speed shall modulate as frost protection for the wheel insuring that the minimum exhaust air temperature off the wheel does not fall below a setpoint as

described below and reset as follows. The final accepted unit and wheel manuf. must be consulted to verify the below values are applicable for their wheel.

RA Humidity	Defrost Enable Outdoor Air Temp	Vary Wheel to Wheel Exhaust Temp
20% RH	-10 F	15 F
30% RH	0 F	20 F
40% RH	10 F	25 F

Pressure drop across wheel in excess of a predefined limit (confirm with factory) shall also indicate a potential frost condition and shall enable defrost mode.

b. On RTU 4 & 5 if the outdoor air is below a setpoint of 25°F, the exhaust air RH is above a setpoint of 20% and the exhaust airflow volume drops below a setpoint of 50% of the supply airflow volume the wheel shall be cycled 5 minutes on and 5 minutes off so as to avoid excessive frosting of the wheel.

h. If wheel run indicator detects a loss of wheel rotation either due to loss of current or reduced current indicating belt loss an alarm shall be reported by the EMS.

i. Main return air carbon dioxide levels shall be monitored and if levels exceed a maximum CO2 setpoint level of 800 ppm (adj.) or greater a low level alarm shall be reported by the EMS.

4. Unoccupied Mode

a. At the commencement of unoccupied mode the outdoor air dampers shall close and the fans shall cycle off. If required, the fans shall cycle on to maintain unoccupied space cooling and heating setpoints initially set for 88°F and 60°F respectively.

5. Cooling/Dehumidification Control

a. The total enthalpy of the return air and outdoor air streams shall be compared and, if advantageous, outdoor air economizer cycle shall be enabled either partially in conjunction with mechanical cooling or exclusively to maintain supply air temperature setpoint. Economizer shall be disabled if the OA dry bulb rises above a setpoint of 70F or the OA enthalpy rises above 26 BTU/lb. In economizer mode, the outdoor air and return air dampers shall modulate as a first stage to satisfy supply air setpoint unless unit is in 100% OA mode. The energy reclaim wheel shall run continuously during occupied periods however, if outdoor air enthalpy is below return air enthalpy and cooling is required the wheel speed shall modulate so as to allow the system to reach supply air setpoint as indicated above and herein. If the wheel is fully stopped the bypass dampers shall open to full bypass.

b. If there is a call for space dehumidification as determined by return air dewpoint rising above a setpoint of 55°F, the DX compressor stages shall stage (inverter or digital compressor shall modulate) to maintain a cooling coil temperature (as measured via refrigerant gas pressure sensor) setpoint of 45 degrees. Stages shall increase as the distance and time from setpoint increase with a minimum of 10 minute delay between compressor stages (coordinate with delays built into condenser controller. Hot gas reheat shall be modulated as required to maintain supply air setpoint.

c. Hot Gas Reheat Valve (HGRV) Purge Cycle: When the hot gas reheat valve has not been open for at least 2 consecutive minutes within the last hour and a compressor is running in the reheat circuit, the hot gas reheat purge cycle shall be enabled and the HGRV shall be forced 100% open for an adjustable purge duration of 2 minutes. The purge cycle may occur once every 60 minutes (adj.).

d. Supply air discharge setpoint shall be reset between 55°F and 70°F based on an average of the cooling demand from spaces. If more than 3 zones on the system are above cooling setpoint by greater than a setpoint of 3°F, the supply air reset schedule shall reset down towards the minimum overriding the average demand.

e. Morning Cool-Down: If the average space temperature is above cooling setpoint and it is within 2-hours (adj.) of a scheduled occupied period the EMS shall calculate an optimized start-time to achieve space setpoint and enable the unit into morning cool-down mode. The supply air temperature shall be reset down to 55°F until the average space temperature reaches cooling setpoint or the return air temperature reaches 75°F whichever comes first at which time the unit shall drop out of morning cool-down mode and enter normal occupied operation at the schedule time.

f. If airflow is not proven via a pressure sensor an adjustable differential pressure sensor across the DX coil, the compressors circuits shall be deactivated without regard for minimum compressor run times (coordinate with compressor controller).

6. Heating Control

a. The hot water heat valve shall modulate if required to maintain the supply air reset schedule as identified in the cooling sequence initially 55°F to 70°F. Hot water valve shall be closed if DX cooling or dehumidification mode is operational.

b. During morning warm-up or cool down the supply air reset schedule shall be overriden and the coil valve shall modulate to satisfy the reset schedule indicated herein.

c. Morning Warm-up: If the average space temperature is below heating setpoint and it is within 2-hours (adj.) of a scheduled occupied period the units the EMS shall calculate an optimized start-time to achieve space setpoint and enable the unit into morning warm-up mode. The supply air temperature shall be reset up 90°F until the average space temperature reaches heating setpoint or the return air temperature reaches 70°F whichever comes first at which time the unit shall drop out of morning warm-up mode and enter normal occupied operation at the schedule time

d. During morning warm-up or during any unoccupied period when outdoor air temperatures are above a setpoint of 30°F, the heat pump cycle shall be the first stage of heat for the spaces served by the respective system followed by the hot water coils and baseboard radiation. The intent is to minimize reliance on the fossil fuel hot water boiler plant during these conditions.

e. During unoccupied periods when outdoor air temperatures are below a setpoint of 38ºF and the unit is off, the hot water coil valves shall modulate to maintain a hot water leaving coil air temperature of 70°F to insure minimum flow through the heating coils and to prevent nuisance trips of the freeze stats.

7. System Safeties & Misc.:

   a. The units have glycol in the hot water coils for freeze protection. If the hot water coil freeze stat detects a leaving air temperature below 38°F for longer than 60 seconds, the unit shall report a low temperature alarm but shall not shutdown. If the system discharge air temperature drops below 40°F for longer than 30 seconds, the ATC shall report a freeze condition to the EMS and the following shall occur:
   Disable supply air and exhaust air fans.
   Close the outdoor and exhaust air dampers and open the return air damper.
   Open hot water coil valve 100%
   Annunciate a local alarm

   b. Normal damper positions are as follows:
   O.A. damper – normally closed
   R.A. damper – normally open
   E.A. damper – normally closed

   c. Smoke Alarm – Upon a smoke detector activation or if any smoke damper in the system is in a position other than fully open, the unit and fans shall shutdown and the dampers shall go to their normal position (i.e. O.A.-Closed). An alarm shall be reported to the EMS system and the building fire alarm system.

   d. The factory condensing unit controller shall perform hot gas reheat coil flush cycles as needed to insure no refrigerant oil is tied up in the coils.

   e. Coordinate with factory for minimum on & off times, time delays and such for compressors.

8. DDC Point List – RTU-4, 5, 14 & 22

   a. Refer to the plans and these sequences of operation and provide all points required and inferred to make for a fully functional and operation system. Being that the units condensing section shall be BacNet compatible several points may be extracted from the interface however this contractor must provide any points and all points needed to achieve the operation and monitoring level specified. The EMS contractor shall provide all points are units are customized in this regard with the exception of those points integral to the RTU condenser section as furnished by the manufacturer. Points in **Bold** are point supplied and/or controlled by the unit manufacturer. Unitary dampers are supplied by the unit manufacturer however, the damper motors and operators are provided by the EMS vendor. As a minimum the following points being monitored and controlled for each unit:

Inputs	Outputs
Filter Diff. Pressure AI (3)	Supply fan S/S DO
Return air volume AI	Exhaust fan S/S DO
Freezestat AI	Supply fan VFD AO
Mixed air temp. AI	O.A. damper AO
Supply duct static AI	Return Air damper AO
Supply fan status	Hot Water Coil Valve AO
amp. AI	Exhaust Fan VFD AO
Exhaust fan status/	Wheel Bypass Dampers DO (2)
amp. AI	DX Cooling Stages (multiple) DO & AO

Duct Smoke Det. DI (mult)
Discharge air temperature AI
R.A. temperature AI
DX Coil Press./Temp AI (mult)
R.A. humidity AI
R.A. CO2 AI
Space CO2 AI (multiple)
Wheel discharge air temp AI
Wheel rotation DI
Wheel Pressure Drop AI
Supply Duct Static Pressure AI
Return/Exhaust Duct Static Pressure AI
Low Limit Duct Static Pressure AI
High Limit Duct Static DI
Wheel Supply Leaving Temp AI
DX Coil Air DP AI
Duct Smoke Damper DI (mult)
Outdoor air volume (monitoring)
Supply Air Volume AI
Exhaust Air Volume AI
Factory Discharge Air sensor
Factory OA Temp sensor AI
O.A. temperature AI (global) also integral to unit
O.A. humidity AI (global) also integral to unit
Condenser section Bacnet Interface

DX Heat Stages (mult) DO&AO
Hot Gas Reheat Valves AO (multiple)
Wheel Enable and Speed DO & AO
Duct Smoke Damper DO (mult) coord. with EC
Condenser section Bacnet Interface
Anti-Stratification Fans AO (multiple spaces)

Note: OA, RA and Bypass damper actuators as well as wheel rotation sensor are furnished with units but must be wired and controlled by EMS. Freezestat is furnished and installed by unit manufacturer but must be wired from terminal strip to EMS.

W. SEQUENCE OF OPERATION – RTU-7 (VAV Systems with EA VAV)

1. General

   a. RTU-7 is a packaged rooftop units that is a variable air volume (VAV) units which provide year round cooling, heating, dehumidification and ventilation to the main kitchen and culinary kitchen.

   b. Some limited control sequences and points related to the DX condenser sections shall be accomplished via the units factory condensing unit controls which must be programmed and interfaced to the EMS. The points required to come with the unit are indicated below (in bold) as well as those points the EMS contractor must provide. EMS contractor must coordinate with RTU vendor to insure all specified sequences and points are provided.

2. Supply & Exhaust Fan Control

   a. The EMS system shall compare the outdoor conditions, the space conditions and the buildings historical warm-up/cool-down profile to determine the optimum start time required to achieve space setpoint conditions by the scheduled occupied start time. The fans shall run continuous during the occupied time period. During

morning warm-up mode the outdoor air dampers shall remain closed and the system shall supply air reset off the return air temperature to bring the spaces up to space heating setpoint (Refer to Heating Coil Control).

b. The EMS shall index from the occupied mode to the unoccupied mode based on a time schedule furnished by the owner. This schedule may be temporary overridden for a predetermined time period by sensor mounted override switches.

c. For all units with smoke dampers the EMS shall prove that all supply air and return/exhaust air smoke dampers are fully open prior to allowing the fans and unit to operate.

d. RTU-7 provides some level of make-up air for the kitchens so if either of the kitchen hoods are enabled the RTU-7 shall be enabled along with MAU-1 to support the make-up air regardless of occupied schedule as the hood being enabled indicates an occupied condition.

3. Occupied Mode

a. At the commencement of occupied mode, the outdoor air damper shall open to deliver 25% OA and the return air damper shall go to its respective positon. The supply fan shall run continuously throughout the occupied time period (see exhaust fan enable herein).

b. The supply fan variable frequency drive shall modulate to maintain supply air static pressure setpoint initially set for 0.75".

c. The branch duct return air dampers shall control between an adjustable positon of 50% to 100% as required to maintain the respective areas at no less than -0.01" with respect to outdoors. The exhaust fan shall not start unless either of the kitchen spaces become positive with respect to outdoors. When enabled, minimum exhaust fan speed shall not be allowed to fall below a setpoint of 10Hz or as otherwise directed by the unit manufacturer.

d. Outdoor airflow quantity shall modulate between 25% and 100% as required to insure both kitchens spaces do not fall below a maximum negative static setpoint of -0.01"w.g with respect to outdoors. RTU outdoor air shall be calculated by using the return duct airflow station and the supply airflow station with outdoor air equal to supply airflow minus return airflow. Space pressure shall be monitored and a low level alarm reported if space pressure exceeds an initial setpoint of +0.01" with respect to outdoors.

e. Main return air carbon dioxide levels shall be monitored and if levels exceed a maximum CO2 setpoint level of 800 ppm (adj.) or greater a low level alarm shall be reported by the EMS.

4. Unoccupied Mode

a. At the commencement of unoccupied mode the outdoor air dampers shall close and the fans shall cycle off. If required, the fans shall cycle on to maintain unoccupied space cooling and heating setpoints initially set for 88°F and 60°F respectively.

5. Cooling/Dehumidification Control

   a. The total enthalpy of the return air and outdoor air streams shall be compared and, if advantageous, outdoor air economizer cycle shall be enabled either partially in conjunction with mechanical cooling or exclusively to maintain supply air temperature setpoint. Economizer shall be disabled if the OA dry bulb rises above a setpoint of 70F or the OA enthalpy rises above 26 BTU/lb. In economizer mode, the outdoor air and return air dampers shall modulate as a first stage to satisfy supply air setpoint unless unit is in 100% OA mode. The energy reclaim wheel shall run continuously during occupied periods however, if outdoor air enthalpy is below return air enthalpy and cooling is required the wheel speed shall modulate so as to allow the system to reach supply air setpoint as indicated above and herein. If the wheel is fully stopped the bypass dampers shall open to full bypass.

   b. If there is a call for space dehumidification as determined by return air dewpoint rising above a setpoint of 55°F, the DX compressor stages shall stage (inverter or digital compressor shall modulate) to maintain a cooling coil temperature (as measured via refrigerant gas pressure sensor) setpoint of 45 degrees. Stages shall increase as the distance and time from setpoint increase with a minimum of 10 minute delay between compressor stages (coordinate with delays built into condenser controller. Hot gas reheat shall be modulated as required to maintain supply air setpoint.

   c. Hot Gas Reheat Valve (HGRV) Purge Cycle: When the hot gas reheat valve has not been open for at least 2 consecutive minutes within the last hour and a compressor is running in the reheat circuit, the hot gas reheat purge cycle shall be enabled and the HGRV shall be forced 100% open for an adjustable purge duration of 2 minutes. The purge cycle may occur once every 60 minutes (adj.).

   d. Supply air discharge setpoint shall be reset between 55°F and 65°F based on an average of the cooling demand from spaces. If more than 3 zones on the system are above cooling setpoint by greater than a setpoint of 3°F, the supply air reset schedule shall reset down towards the minimum overriding the average demand.

   e. Morning Cool-Down: If the average space temperature is above cooling setpoint and it is within 2-hours (adj.) of a scheduled occupied period the EMS shall calculate an optimized start-time to achieve space setpoint and enable the unit into morning cool-down mode. The supply air temperature shall be reset down to 55°F until the average space temperature reaches cooling setpoint or the return air temperature reaches 75°F whichever comes first at which time the unit shall drop out of morning cool-down mode and enter normal occupied operation at the schedule time.

   f. If airflow is not proven via a pressure sensor an adjustable differential pressure sensor across the DX coil, the compressors circuits shall be deactivated without regard for minimum compressor run times (coordinate with compressor controller).

6. Heating Control

   a. The hot water heat valve shall modulate if required to maintain the supply air reset schedule as identified in the cooling sequence initially 55°F to 70°F. Hot water valve shall be closed if DX cooling or dehumidification mode is operational.

b. During morning warm-up or cool down the supply air reset schedule shall be overriden and the coil valve shall modulate to satisfy the reset schedule indicated herein.

c. Morning Warm-up: If the average space temperature is below heating setpoint and it is within 2-hours (adj.) of a scheduled occupied period the units the EMS shall calculate an optimized start-time to achieve space setpoint and enable the unit into morning warm-up mode. The supply air temperature shall be reset up 90°F until the average space temperature reaches heating setpoint or the return air temperature reaches 70°F whichever comes first at which time the unit shall drop out of morning warm-up mode and enter normal occupied operation at the schedule time

f. During morning warm-up or during any unoccupied period when outdoor air temperatures are above a setpoint of 30°F, the heat pump cycle shall be the first stage of heat for the spaces served by the respective system followed by the hot water coils and baseboard radiation. The intent is to minimize reliance on the fossil fuel hot water boiler plant during these conditions.

g. During unoccupied periods when outdoor air temperatures are below a setpoint of 38ºF and the unit is off, the hot water coil valves shall modulate to maintain a hot water leaving coil air temperature of 70°F to insure minimum flow through the heating coils and to prevent nuisance trips of the freeze stats.

7. System Safeties & Misc.:

a. The units have glycol in the hot water coils for freeze protection. If the hot water coil freeze stat detects a leaving air temperature below 38°F for longer than 60 seconds, the unit shall report a low temperature alarm but shall not shutdown. If the system discharge air temperature drops below 40°F for longer than 30 seconds, the ATC shall report a freeze condition to the EMS and the following shall occur:
Disable supply air and exhaust air fans.
Close the outdoor and exhaust air dampers and open the return air damper.
Open hot water coil valve 100%
Annunciate a local alarm

b. Normal damper positions are as follows:
O.A. damper – normally closed
R.A. damper – normally open
E.A. damper – normally closed

c. Smoke Alarm – Upon a smoke detector activation or if any smoke damper in the system is in a position other than fully open, the unit and fans shall shutdown and the dampers shall go to their normal position (i.e. O.A.-Closed). An alarm shall be reported to the EMS system and the building fire alarm system.

f. The factory condensing unit controller shall perform hot gas reheat coil flush cycles as needed to insure no refrigerant oil is tied up in the coils.

g. Coordinate with factory for minimum on & off times, time delays and such for compressors.

8. DDC Point List – RTU- 7

a. Refer to the plans and these sequences of operation and provide all points required and inferred to make for a fully functional and operation system. Being that the units condensing section shall be BacNet compatible several points may be extracted from the interface however this contractor must provide any points and all points needed to achieve the operation and monitoring level specified. The EMS contractor shall provide all points are units are customized in this regard with the exception of those points integral to the RTU condenser section as furnished by the manufacturer. Points in **Bold** are point supplied and/or controlled by the unit manufacturer. Unitary dampers are supplied by the unit manufacturer however, the damper motors and operators are provided by the EMS vendor. As a minimum the following points being monitored and controlled for each unit:

Inputs	Outputs
Filter Diff. Pressure AI (3)	Supply fan S/S DO
Return air volume AI	Exhaust fan S/S DO
Freezestat AI	Supply fan VFD AO
Mixed air temp. AI	O.A. damper AO
Supply duct static AI	Return Air damper AO
Supply fan status	Hot Water Coil Valve AO
amp. AI	Exhaust Fan VFD AO
Exhaust fan status/	
amp. AI	DX Cooling Stages (multiple) DO & AO
Duct Smoke Det. DI (mult)	DX Heat Stages (mult) DO&AO
Discharge air temperature AI	**Hot Gas Reheat Valves AO (multiple)**
R.A. temperature AI	
DX Coil Press./Temp AI (mult)	
R.A. humidity AI	**Condenser section Bacnet Interface**
R.A. CO2 AI	Anti-Stratification Fans AO (multiple spaces)
Space CO2 AI (multiple)	
Supply Duct Static Pressure AI	
Return/Exhaust Duct Static Pressure AI	
Low Limit Duct Static Pressure AI	
High Limit Duct Static DI	
DX Coil Air DP AI	
Duct Smoke Damper DI (mult)	
Outdoor air volume (monitoring)	
Supply Air Volume AI	
Exhaust Air Volume AI	
Factory Discharge Air sensor	
Factory OA Temp sensor AI	
O.A. temperature AI (global) also integral to unit	
O.A. humidity AI (global) also integral to unit	
Condenser section Bacnet Interface	

Note: OA, RA and Bypass damper actuators as well as wheel rotation sensor are furnished with units but must be wired and controlled by EMS. Freezestat is furnished and installed by unit manufacturer but must be wired from terminal strip to EMS.

X. SEQUENCE OF OPERATION – RTU-8, 9, 10, 18, 20, 21 & 23 (Single Zone VAV Systems)

1. General

   a. RTU-8, 9, 10, 20, 21 & 23 are packaged rooftop units with energy recovery wheels units that are single zone style variable air volume (VAV) units which provide year round dehumidification, cooling, heating and ventilation to various areas of the building. The units support the following areas:
      - RTU-8: Auditorium
      - RTU-9: Auditorium
      - RTU-10: Cafeteria
      - RTU-20: Gym Small Court
      - RTU-21: Gym Large Court
      - RTU-23: Wellness

   b. Some limited control sequences and points related to the DX condenser sections shall be accomplished via the units factory condensing unit controls which must be programmed and interfaced to the EMS. The points required to come with the unit are indicated below (in bold) as well as those points the EMS contractor must provide. EMS contractor must coordinate with RTU vendor to insure all specified sequences and points are provided.

2. Supply & Exhaust Fan Control

   a. The EMS system shall compare the outdoor conditions, the space conditions and the buildings historical warm-up/cool-down profile to determine the optimum start time required to achieve space setpoint conditions by the scheduled occupied start time. The fans shall run continuous during the occupied time period. During morning warm-up mode the outdoor air dampers shall remain closed and the system shall supply air reset off the return air temperature to bring the spaces up to space heating setpoint (Refer to Heating Coil Control).

   b. The EMS shall index from the occupied mode to the unoccupied mode based on a time schedule furnished by the owner. This schedule may be temporary overridden for a predetermined time period by sensor mounted override switches.

   c. For all units with smoke dampers the EMS shall prove that all supply air and return/exhaust air smoke dampers are fully open prior to allowing the fans and unit to operate.

   d. On RTU-10, 20 & 21 systems, whenever the RTU system is calling for heating the respective anti-stratification fans ASF-# fans shall start and run continuously until all heating demand for the space has ended. ASF fans shall be enabled as a 1st stage call for heat. If the outdoor air temperature is below a setpoint of 40°F the ASF fans shall run continuously regardless of occupancy mode. User shall be able to control the speed of these fans by adjusting at the front-end.

3. Occupied Mode

   a. At the commencement of occupied mode, the outdoor air damper shall open to its respective position with the return/recirculation air dampers going to their respective positions. The supply fan and exhaust fan shall run continuously throughout the occupied time period (see exhaust fan enable herein). If the high limit discharge air duct static sensor meets or exceeds a setpoint of 3”w.c. or the low limit return air

duct static sensor meets or exceeds a setpoint of -3" w.c. the unit shall be disabled, fans shall turn off and an alarm shall be reported. The high limit duct static pressure sensor shall be located upstream (unit side) of the supply smoke dampers. The low limit duct static pressure sensor shall be located upstream (unit side) of the return smoke dampers.

b. The supply fans shall initially operate at 40% speed (40% supply airflow) and shall speed up or down as needed to support space cooling, economizer, CO2 ventilation control or heating demands. For space temperature control the supply air temperature shall reset to minimum (for cooling) or maximum (for heating) setpoint first prior to increasing fan speed to achieve space setpoint.

c. The exhaust fan variable frequency drive shall modulate the fan speed to maintain exhaust air levels equal to outdoor air levels minus a 5% offset. The exhaust damper shall open (gravity style) when the fan is enabled. The exhaust fan shall not start until the outdoor airflow volume exceeds 20% (adj.) of the scheduled minimum OA CFM. Outdoor airflow quantity shall be calculated by using the return duct airflow station and the supply airflow station with outdoor air equal to supply airflow minus return airflow. Space pressure shall be monitored and a low level alarm reported if space pressure exceeds an initial setpoint of +0.01" with respect to outdoors. When enabled, minimum exhaust fan speed shall not be allowed to fall below a setpoint of 10Hz or as otherwise directed by the unit manufacturer.

d. Outdoor air flow dampers shall maintain outdoor air quantity constant within 10% of the specified outdoor air quantity reset as specified herein.

e. The outdoor air, return air and exhaust dampers shall modulate to maintain the minimum specified outdoor air level as determined by the flow measuring stations. Outdoor air quantity shall be varied between 25% of the specified minimum outdoor air quantity and the specified minimum outdoor air quantity in response to the space CO2 sensors, where shown on the plans, or the return air sensor, if space sensors are not identified. Dampers shall modulate to maintain a maximum CO2 level at any space sensor of no greater than 800 ppm (adj.) but in no case shall the outdoor air level exceed the scheduled minimum outdoor air value unless economizer cooling is required. Reduced outdoor air CO2 control shall be overridden in the event economizer cooling is required.

f. The energy reclaim wheel shall run continuously during occupied periods however, if outdoor air enthalpy is below return air enthalpy and cooling is required the wheel speed shall modulate to maintain supply air setpoint. Economizer shall be disabled if the OA dry bulb rises above a setpoint of 70F or the OA enthalpy rises above 26 BTU/lb. One the wheel is fully stopped, the wheel bypass dampers shall open.

g. Energy wheel speed shall modulate as frost protection for the wheel insuring that the minimum exhaust air temperature off the wheel does not fall below a setpoint as described below and reset as follows. The final accepted unit and wheel manuf. must be consulted to verify the below values are applicable for their wheel.

RA Humidity	Defrost Enable Outdoor Air Temp	Vary Wheel to Wheel Exhaust Temp
20% RH	-10 F	15 F
30% RH	0 F	20 F
40% RH	10 F	25 F

Pressure drop across wheel in excess of a predefined limit (confirm with factory) shall also indicate a potential frost condition and shall enable defrost mode.

h. If wheel run indicator detects a loss of wheel rotation either due to loss of current or reduced current indicating belt loss an alarm shall be reported by the EMS.

i. Main return air carbon dioxide levels shall be monitored and if levels exceed a maximum CO2 setpoint level of 800 ppm (adj.) or greater a low level alarm shall be reported by the EMS.

4. Unoccupied Mode

a. At the commencement of unoccupied mode the outdoor air dampers shall close and the fans shall cycle off. If required, the fans shall cycle on to maintain unoccupied space cooling and heating setpoints initially set for 88°F and 60°F respectively.

5. Cooling/Dehumidification Control

a. The total enthalpy of the return air and outdoor air streams shall be compared and, if advantageous, outdoor air economizer cycle shall be enabled either partially in conjunction with mechanical cooling or exclusively to maintain supply air temperature setpoint. Economizer shall be disabled if the OA dry bulb rises above a setpoint of 70F or the OA enthalpy rises above 26 BTU/lb. In economizer mode, the outdoor air and return air dampers shall modulate as a first stage to satisfy supply air setpoint. The energy reclaim wheel shall run continuously during occupied periods however, if outdoor air enthalpy is below return air enthalpy and cooling is required the wheel speed shall modulate so as to allow the system to reach supply air setpoint as indicated above and herein. If the wheel is fully stopped the bypass dampers shall open to full bypass.

b. If there is a call for space dehumidification as determined by return air dewpoint rising above a setpoint of 55°F, the DX compressor stages shall stage (inverter or digital compressor shall modulate) to maintain a cooling coil temperature (as measured via refrigerant gas pressure sensor) setpoint of 45 degrees. Stages shall increase as the distance and time from setpoint increase with a minimum of 10 minute delay between compressor stages (coordinate with delays built into condenser controller. Hot gas reheat shall be modulated as required to maintain supply air setpoint.

c. Hot Gas Reheat Valve (HGRV) Purge Cycle: When the hot gas reheat valve has not been open for at least 2 consecutive minutes within the last hour and a compressor is running in the reheat circuit, the hot gas reheat purge cycle shall be enabled and the HGRV shall be forced 100% open for an adjustable purge duration of 2 minutes. The purge cycle may occur once every 60 minutes (adj.).

d. Supply air discharge setpoint shall be reset between 55°F and 90°F based on the space temperature demand.

e. Morning Cool-Down: If the space temperature is above cooling setpoint and it is within 2-hours (adj.) of a scheduled occupied period the EMS shall calculate an optimized start-time to achieve space setpoint and enable the unit into morning

cool-down mode. The supply air temperature shall be reset down to 55°F until the space temperature reaches cooling setpoint or the return air temperature reaches 75°F whichever comes first at which time the unit shall drop out of morning cool-down mode and enter normal occupied operation at the schedule time.

f. If airflow is not proven via a pressure sensor an adjustable differential pressure sensor across the DX coil, the compressors circuits shall be deactivated without regard for minimum compressor run times (coordinate with compressor controller).

6. Heating Control

a. The hot water heat valve shall modulate if required to maintain the supply air reset schedule as identified in the cooling sequence initially 55°F to 90°F. Hot water valve shall be closed if DX cooling or dehumidification mode is operational.

b. During morning warm-up or cool down the supply air reset schedule shall be overriden and the coil valve shall modulate to satisfy the reset schedule indicated herein.

c. Morning Warm-up: If the space temperature is below heating setpoint and it is within 2-hours (adj.) of a scheduled occupied period the units the EMS shall calculate an optimized start-time to achieve space setpoint and enable the unit into morning warm-up mode. The supply air temperature shall be reset up 90°F until the space temperature reaches heating setpoint or the return air temperature reaches 70°F whichever comes first at which time the unit shall drop out of morning warm-up mode and enter normal occupied operation at the schedule time

d. During morning warm-up or during any unoccupied period when outdoor air temperatures are above a setpoint of 30°F, the heat pump cycle shall be the first stage of heat for the spaces served by the respective system followed by the hot water coils and baseboard radiation. The intent is to minimize reliance on the fossil fuel hot water boiler plant during these conditions.

e. During unoccupied periods when outdoor air temperatures are below a setpoint of 38ºF and the unit is off, the hot water coil valves shall modulate to maintain a hot water leaving coil air temperature of 70°F to insure minimum flow through the heating coils and to prevent nuisance trips of the freeze stats.

7. System Safeties & Misc.:

a. The units have glycol in the hot water coils for freeze protection. If the hot water coil freeze stat detects a leaving air temperature below 38°F for longer than 60 seconds, the unit shall report a low temperature alarm but shall not shutdown. If the system discharge air temperature drops below 40°F for longer than 30 seconds, the ATC shall report a freeze condition to the EMS and the following shall occur:
Disable supply air and exhaust air fans.
Close the outdoor and exhaust air dampers and open the return air damper.
Open hot water coil valve 100%
Annunciate a local alarm

b. Normal damper positions are as follows:
O.A. damper – normally closed

R.A. damper – normally open
E.A. damper – normally closed

c. Smoke Alarm – Upon a smoke detector activation or if any smoke damper in the system is in a position other than fully open, the unit and fans shall shutdown and the dampers shall go to their normal position (i.e. O.A.-Closed). An alarm shall be reported to the EMS system and the building fire alarm system.

d. The factory condensing unit controller shall perform hot gas reheat coil flush cycles as needed to insure no refrigerant oil is tied up in the coils.

e. Coordinate with factory for minimum on & off times, time delays and such for compressors.

8. DDC Point List – RTU-8, 9, 10, 20, 21 & 23

a. Refer to the plans and these sequences of operation and provide all points required and inferred to make for a fully functional and operation system. Being that the units condensing section shall be BacNet compatible several points may be extracted from the interface however this contractor must provide any points and all points needed to achieve the operation and monitoring level specified. The EMS contractor shall provide all points are units are customized in this regard with the exception of those points integral to the RTU condenser section as furnished by the manufacturer. Points in **Bold** are point supplied and/or controlled by the unit manufacturer. Unitary dampers are supplied by the unit manufacturer however, the damper motors and operators are provided by the EMS vendor. As a minimum the following points being monitored and controlled for each unit:

Inputs	Outputs
Filter Diff. Pressure AI (3)	Supply fan S/S DO
Return air volume AI	Exhaust fan S/S DO
Freezestat AI	Supply fan VFD AO
Mixed air temp. AI	O.A. damper AO
Supply duct static AI	Return/recirc Air damper AO
Supply fan status	Hot Water Coil Valve AO
amp. AI	Exhaust Fan VFD AO
Exhaust fan status/	Wheel Bypass Dampers DO (2)
amp. AI	DX Cooling Stages (multiple) DO & AO
Duct Smoke Det. DI (mult)	DX Heat Stages (mult) DO&AO
Discharge air temperature AI	**Hot Gas Reheat Valves AO (multiple)**
R.A. temperature AI	Wheel Enable and Speed DO & AO
DX Coil Press./Temp AI (mult)	Duct Smoke Damper DO (mult) coord. with EC
R.A. humidity AI	**Condenser section Bacnet Interface**
R.A. CO2 AI	Anti-Stratification Fans AO
Space CO2 AI (multiple)	
DX Coil Air DP AI	
Wheel discharge air temp AI	
Wheel rotation DI	
Wheel Pressure Drop AI	
Duct Static Pressure AI	
High Limit Duct Static DI	
Low Limit Duct Static DI	

Wheel Supply Leaving Temp AI
Duct Smoke Damper DI (mult)
Outdoor air volume AI (monitoring)
Supply Air Volume AI
Exhaust Air Volume AI
Factory Discharge Air sensor
Factory OA Temp sensor AI
O.A. temperature AI (global) also integral to unit
O.A. humidity AI (global) also integral to unit
Condenser section Bacnet Interface

Note: OA, RA and Bypass damper actuators as well as wheel rotation sensor are furnished with units but must be wired and controlled by EMS. Freezestat is furnished and installed by unit manufacturer but must be wired from terminal strip to EMS.

Y. SEQUENCE OF OPERATION – RTU-16 & Auto Diesel Area

1. General

a. RTU-16 is a packaged rooftop units with energy recovery wheels units that is a single zone style variable air volume (VAV) units which provide year round dehumidification, cooling, heating and ventilation to the Auto Diesel area.

b. Some limited control sequences and points related to the DX condenser sections shall be accomplished via the units factory condensing unit controls which must be programmed and interfaced to the EMS. The points required to come with the unit are indicated below (in bold) as well as those points the EMS contractor must provide. EMS contractor must coordinate with RTU vendor to insure all specified sequences and points are provided.

2. Supply & Exhaust Fan Control

a. The EMS system shall compare the outdoor conditions, the space conditions and the buildings historical warm-up/cool-down profile to determine the optimum start time required to achieve space setpoint conditions by the scheduled occupied start time. The fans shall run continuous during the occupied time period. During morning warm-up mode the outdoor air dampers shall remain closed and the system shall supply air reset off the return air temperature to bring the spaces up to space heating setpoint (Refer to Heating Coil Control).

b. The EMS shall index from the occupied mode to the unoccupied mode based on a time schedule furnished by the owner. This schedule may be temporary overridden for a predetermined time period by sensor mounted override switches.

c. For all units with smoke dampers the EMS shall prove that all supply air and return/exhaust air smoke dampers are fully open prior to allowing the fans and unit to operate.

d. Whenever the RTU system is calling for heating the respective anti-stratification fans ASF-# fans shall start and run continuously until all heating demand for the space has ended. ASF fans shall be enabled as a 1st stage call for heat. If the

outdoor air temperature is below a setpoint of 40°F the ASF fans shall run continuously regardless of occupancy mode. User shall be able to control the speed of these fans by adjusting at the front-end.

3. Occupied Mode

   a. At the commencement of occupied mode, the outdoor air damper shall open to its 100% open positon with the return/recirculation air dampers going to their respective positions. The supply fan and exhaust fan shall run continuously throughout the occupied time period (see exhaust fan enable herein). If the high limit discharge air duct static sensor meets or exceeds a setpoint of 3"w.c. or the low limit return air duct static sensor meets or exceeds a setpoint of -3" w.c. the unit shall be disabled, fans shall turn off and an alarm shall be reported. The high limit duct static pressure sensor shall be located upstream (unit side) of the supply smoke dampers. The low limit duct static pressure sensor shall be located upstream (unit side) of the return smoke dampers.

   c. The supply fans shall initially operate at 40% speed (40% supply airflow) and shall speed up or down as needed to support space cooling, economizer, CO, or NO ventilation control or heating demands. For space temperature control the supply air temperature shall reset to minimum (for cooling) or maximum (for heating) setpoint first prior to increasing fan speed to achieve space setpoint.

   d. The exhaust fan variable frequency drive shall modulate the fan speed to maintain exhaust air levels equal to outdoor air levels plus a 5% offset. As the unit is 100% outdoor air the outdoor airflow quantity is equal to the supply airflow station when the unit is in occupied mode. In addition, the exhaust airflow shall be reset to insure the space does not become overly negative due to the operation of vehicle exhaust systems and/or welding hoods. When either of these systems is enabled the 5% offset control shall be overridden and the EF fan shall run to maintain space pressure at -0.01" with respect to outdoors. When enabled, minimum exhaust fan speed shall not be allowed to fall below a setpoint of 10Hz or as otherwise directed by the unit manufacturer.

   e. In addition space temperature demand the unit supply air fan volume shall increase to maintain space CO levels at no higher than 10 ppm and space NO2 levels no higher than 3 ppm.

   f. The energy reclaim wheel shall run continuously during occupied periods however, if outdoor air enthalpy is below return air enthalpy and cooling is required the wheel speed shall modulate to maintain supply air setpoint. Economizer shall be disabled if the OA dry bulb rises above a setpoint of 70F or the OA enthalpy rises above 26 BTU/lb One the wheel is fully stopped, the wheel bypass dampers shall open.

   g. Energy wheel speed shall modulate as frost protection for the wheel insuring that the minimum exhaust air temperature off the wheel does not fall below a setpoint as described below and reset as follows. The final accepted unit and wheel manuf. must be consulted to verify the below values are applicable for their wheel.

RA Humidity	Defrost Enable Outdoor Air Temp	Vary Wheel to Wheel Exhaust Temp
20% RH	-10 F	15 F
30% RH	0 F	20 F

40% RH	10 F	25 F

Pressure drop across wheel in excess of a predefined limit (confirm with factory) shall also indicate a potential frost condition and shall enable defrost mode.

h. If the outdoor air is below a setpoint of 25°F, the exhaust air RH is above a setpoint of 20% and the exhaust airflow volume drops below a setpoint of 50% of the supply airflow volume the wheel shall be cycled 5 minutes on and 5 minutes off so as avoid excessive frosting of the wheel.

i. If wheel run indicator detects a loss of wheel rotation either due to loss of current or reduced current indicating belt loss an alarm shall be reported by the EMS.

j. Main return air carbon dioxide levels shall be monitored and if levels exceed a maximum CO2 setpoint level of 800 ppm (adj.) or greater a low level alarm shall be reported by the EMS.

4. Unoccupied Mode

a. At the commencement of unoccupied mode the outdoor air dampers shall close and the fans shall cycle off. If required, the fans shall cycle on to maintain unoccupied space cooling and heating setpoints initially set for 88°F and 60°F respectively.

5. Cooling/Dehumidification Control

a. The total enthalpy of the return air and outdoor air streams shall be compared and, if advantageous, outdoor air economizer cycle shall be enabled either partially in conjunction with mechanical cooling or exclusively to maintain supply air temperature setpoint. Economizer shall be disabled if the OA dry bulb rises above a setpoint of 70F or the OA enthalpy rises above 26 BTU/lb. In economizer mode, the outdoor air and return air dampers shall modulate as a first stage to satisfy supply air setpoint. The energy reclaim wheel shall run continuously during occupied periods however, if outdoor air enthalpy is below return air enthalpy and cooling is required the wheel speed shall modulate so as to allow the system to reach supply air setpoint as indicated above and herein. If the wheel is fully stopped the bypass dampers shall open to full bypass.

b. If there is a call for space dehumidification as determined by return air dewpoint rising above a setpoint of 55°F, the DX compressor stages shall stage (inverter or digital compressor shall modulate) to maintain a cooling coil temperature (as measured via refrigerant gas pressure sensor) setpoint of 45 degrees. Stages shall increase as the distance and time from setpoint increase with a minimum of 10 minute delay between compressor stages (coordinate with delays built into condenser controller. Hot gas reheat shall be modulated as required to maintain supply air setpoint.

c. Hot Gas Reheat Valve (HGRV) Purge Cycle: When the hot gas reheat valve has not been open for at least 2 consecutive minutes within the last hour and a compressor is running in the reheat circuit, the hot gas reheat purge cycle shall be enabled and the HGRV shall be forced 100% open for an adjustable purge duration of 2 minutes. The purge cycle may occur once every 60 minutes (adj.).

d. Supply air discharge setpoint shall be reset between 55°F and 90°F based on the space temperature demand.

e. Morning Cool-Down: If the space temperature is above cooling setpoint and it is within 2-hours (adj.) of a scheduled occupied period the EMS shall calculate an optimized start-time to achieve space setpoint and enable the unit into morning cool-down mode. The supply air temperature shall be reset down to 55°F until the space temperature reaches cooling setpoint or the return air temperature reaches 75°F whichever comes first at which time the unit shall drop out of morning cool-down mode and enter normal occupied operation at the schedule time.

f. If airflow is not proven via a pressure sensor an adjustable differential pressure sensor across the DX coil, the compressors circuits shall be deactivated without regard for minimum compressor run times (coordinate with compressor controller).

6. Heating Control

a. The hot water heat valve shall modulate if required to maintain the supply air reset schedule as identified in the cooling sequence initially 55°F to 90°F. Hot water valve shall be closed if DX cooling or dehumidification mode is operational.

b. During morning warm-up or cool down the supply air reset schedule shall be overriden and the coil valve shall modulate to satisfy the reset schedule indicated herein.

c. Morning Warm-up: If the space temperature is below heating setpoint and it is within 2-hours (adj.) of a scheduled occupied period the units the EMS shall calculate an optimized start-time to achieve space setpoint and enable the unit into morning warm-up mode. The supply air temperature shall be reset up 90°F until the space temperature reaches heating setpoint or the return air temperature reaches 70°F whichever comes first at which time the unit shall drop out of morning warm-up mode and enter normal occupied operation at the schedule time

f. During unoccupied periods when outdoor air temperatures are below a setpoint of 38ºF and the unit is off, the hot water coil valves shall modulate to maintain a hot water leaving coil air temperature of 70°F to insure minimum flow through the heating coils and to prevent nuisance trips of the freeze stats.

7. System Safeties & Misc.:

a. The units have glycol in the hot water coils for freeze protection. If the hot water coil freeze stat detects a leaving air temperature below 38°F for longer than 60 seconds, the unit shall report a low temperature alarm but shall not shutdown. If the system discharge air temperature drops below 40°F for longer than 30 seconds, the ATC shall report a freeze condition to the EMS and the following shall occur:
Disable supply air and exhaust air fans.
Close the outdoor and exhaust air dampers and open the return air damper.
Open hot water coil valve 100%
Annunciate a local alarm

b. Normal damper positions are as follows:
O.A. damper – normally closed

R.A. damper – normally open
E.A. damper – normally closed

c. Smoke Alarm – Upon a smoke detector activation or if any smoke damper in the system is in a position other than fully open, the unit and fans shall shutdown and the dampers shall go to their normal position (i.e. O.A.-Closed). An alarm shall be reported to the EMS system and the building fire alarm system.

d. The factory condensing unit controller shall perform hot gas reheat coil flush cycles as needed to insure no refrigerant oil is tied up in the coils.

e. Coordinate with factory for minimum on & off times, time delays and such for compressors.

f. A high level alarm shall be reported at the front-end as well as an audible alarm and strobe shall report in the garage area if space CO levels rise above 30 ppm or space NO2 levels rise higher than 8 ppm. Alarm shall automatically reset once levels fall below alarm limits.

8. DDC Point List – RTU-16

a. Refer to the plans and these sequences of operation and provide all points required and inferred to make for a fully functional and operation system. Being that the units condensing section shall be BacNet compatible several points may be extracted from the interface however this contractor must provide any points and all points needed to achieve the operation and monitoring level specified. The EMS contractor shall provide all points are units are customized in this regard with the exception of those points integral to the RTU condenser section as furnished by the manufacturer. Points in **Bold** are point supplied and/or controlled by the unit manufacturer. Unitary dampers are supplied by the unit manufacturer however, the damper motors and operators are provided by the EMS vendor. As a minimum the following points being monitored and controlled for each unit:

Inputs	Outputs
Filter Diff. Pressure AI (3)	Supply fan S/S DO
Return air volume AI	Exhaust fan S/S DO
Freezestat AI	Supply fan VFD AO
Mixed air temp. AI	O.A. damper AO
Supply duct static AI	Return/recirc Air damper AO
Supply fan status	Hot Water Coil Valve AO
amp. AI	Exhaust Fan VFD AO
Exhaust fan status/	Wheel Bypass Dampers DO (2)
amp. AI	DX Cooling Stages (multiple) DO & AO
Duct Smoke Det. DI (mult)	DX Heat Stages (mult) DO&AO
Discharge air temperature AI	**Hot Gas Reheat Valves AO (multiple)**
R.A. temperature AI	Wheel Enable and Speed DO & AO
DX Coil Press./Temp AI (mult)	Duct Smoke Damper DO (mult) coord. with EC
R.A. humidity AI	**Condenser section Bacnet Interface**
R.A. CO2 AI	Anti-Stratification Fans AO
Space CO2 AI	CO & NO Horn Strobes DO (multiple)
DX Coil Air DP AI	
Space CO (multiple)	

Space NO2 (multiple)
Wheel discharge air temp AI
Wheel rotation DI
Wheel Pressure Drop AI
Duct Static Pressure AI
High Limit Duct Static DI
Low Limit Duct Static DI
Wheel Supply Leaving Temp AI
Duct Smoke Damper DI (mult)
Outdoor air Volume AI (monitoring)
Supply Air Volume AI
Exhaust Air Volume AI
Factory Discharge Air sensor
Factory OA Temp sensor AI
O.A. temperature AI (global) also integral to unit
O.A. humidity AI (global) also integral to unit
Condenser section Bacnet Interface

Note: OA, RA and Bypass damper actuators as well as wheel rotation sensor are furnished with units but must be wired and controlled by EMS. Freezestat is furnished and installed by unit manufacturer but must be wired from terminal strip to EMS.

Z. SEQUENCE OF OPERATION – RTU-15 & 24 (DOAS Systems)

1. General

   a. RTU-15 & 24 are packaged rooftop units with energy recovery wheels units that provide tempered and dehumidified air to various VRF systems. The units support the following areas:
      - RTU-15: Administration
      - RTU-24: Kitchen & Culinary Support Areas

   b. Some limited control sequences and points related to the DX condenser sections shall be accomplished via the units factory condensing unit controls which must be programmed and interfaced to the EMS. The points required to come with the unit are indicated below (in bold) as well as those points the EMS contractor must provide. EMS contractor must coordinate with RTU vendor to insure all specified sequences and points are provided.

2. Supply & Exhaust Fan Control

   a. The EMS shall index from the occupied mode to the unoccupied mode based on a time schedule furnished by the owner. This schedule may be temporary overridden for a predetermined time period by sensor mounted override switches.

   b. Once enabled, both the supply and exhaust fan shall run at a fixed speed set during balancing.

3. Occupied Mode

a. At the commencement of occupied mode, the outdoor air damper shall open 100% with the return/recirculation air dampers going to their respective positions. The supply fan and exhaust fan shall run continuously throughout the occupied time period.

b. Space pressure shall be monitored and a low level alarm reported if space pressure exceeds an initial setpoint of +0.01" with respect to outdoors.

c. The energy reclaim wheel shall run continuously during occupied periods however, if outdoor air enthalpy is below return air enthalpy and cooling is required the wheel speed shall modulate to maintain supply air setpoint. Economizer shall be disabled if the OA dry bulb rises above a setpoint of 70F or the OA enthalpy rises above 26 BTU/lb. One the wheel is fully stopped, the wheel bypass dampers shall open.

d. Energy wheel speed shall modulate as frost protection for the wheel insuring that the minimum exhaust air temperature off the wheel does not fall below a setpoint as described below and reset as follows. The final accepted unit and wheel manuf. must be consulted to verify the below values are applicable for their wheel.

RA Humidity	Defrost Enable Outdoor Air Temp	Vary Wheel to Wheel Exhaust Temp
20% RH	-10 F	15 F
30% RH	0 F	20 F
40% RH	10 F	25 F

Pressure drop across wheel in excess of a predefined limit (confirm with factory) shall also indicate a potential frost condition and shall enable defrost mode.

e. If wheel run indicator detects a loss of wheel rotation either due to loss of current or reduced current indicating belt loss an alarm shall be reported by the EMS.

f. Main return air carbon dioxide levels shall be monitored and if levels exceed a maximum CO2 setpoint level of 800 ppm (adj.) or greater a low level alarm shall be reported by the EMS.

4. Unoccupied Mode

a. At the commencement of unoccupied mode the outdoor air dampers shall close and the fans shall cycle off. If required, the fans shall cycle on to maintain unoccupied space heating setpoint of 60°F if the VRF has failed or cannot maintain space temperatures.

5. Cooling/Dehumidification Control

a. The total enthalpy of the return air and outdoor air streams shall be compared and, if advantageous, the energy reclaim wheel speed shall modulate so as to allow the system to reach supply air setpoint as indicated herein. If the wheel is fully stopped the bypass dampers shall open to full bypass.

b. If there is a call for space dehumidification as determined by return air dewpoint rising above a setpoint of 55°F, the DX compressor stages shall stage (inverter or digital compressor shall modulate) to maintain a cooling coil temperature (as measured via refrigerant gas pressure sensor) setpoint of 45 degrees. Stages shall

increase as the distance and time from setpoint increase with a minimum of 10 minute delay between compressor stages (coordinate with delays built into condenser controller. Hot gas reheat shall be modulated as required to maintain supply air setpoint.

c. Hot Gas Reheat Valve (HGRV) Purge Cycle: When the hot gas reheat valve has not been open for at least 2 consecutive minutes within the last hour and a compressor is running in the reheat circuit, the hot gas reheat purge cycle shall be enabled and the HGRV shall be forced 100% open for an adjustable purge duration of 2 minutes. The purge cycle may occur once every 60 minutes (adj.).

d. Supply air discharge setpoint shall be reset between 60°F and 70°F based on an average of the cooling demand from spaces. If more than 3 zones on the system are above cooling setpoint by greater than a setpoint of 3°F, the supply air reset schedule shall reset down towards the minimum overriding the average demand.

g. If airflow is not proven via a pressure sensor an adjustable differential pressure sensor across the DX coil, the compressors circuits shall be deactivated without regard for minimum compressor run times (coordinate with compressor controller).

6. Heating Control

a. The hot water heat valve shall modulate if required to maintain the supply air reset schedule as identified in the cooling sequence initially 60°F to 70°F. Hot water valve shall be closed if DX cooling or dehumidification mode is operational.

c. During unoccupied periods when outdoor air temperatures are below a setpoint of 38ºF and the unit is off, the hot water coil valves shall modulate to maintain a hot water leaving coil air temperature of 70°F to insure minimum flow through the heating coils and to prevent nuisance trips of the freeze stats.

d. If the VRF system is in alarm (failed) or the space temperature are 3°F below heating setpoint for longer than 3 hours, the supply discharge setpoint shall be reset to 80°F and reset down accordingly, if spaces reach heating setpoint in an effort to provide emergency heat to the spaces.

7. System Safeties & Misc.:

a. The units have glycol in the hot water coils for freeze protection. If the hot water coil freeze stat detects a leaving air temperature below 38°F for longer than 60 seconds, the unit shall report a low temperature alarm but shall not shutdown. If the system discharge air temperature drops below 40°F for longer than 30 seconds, the ATC shall report a freeze condition to the EMS and the following shall occur:
Disable supply air and exhaust air fans.
Close the outdoor and exhaust air dampers and open the return air damper.
Open hot water coil valve 100%
Annunciate a local alarm

b. Normal damper positions are as follows:
O.A. damper – normally closed
R.A. damper – normally open
E.A. damper – normally closed

c. Smoke Alarm – Upon a smoke detector activation or if any smoke damper in the system is in a position other than fully open, the unit and fans shall shutdown and the dampers shall go to their normal position (i.e. O.A.-Closed). An alarm shall be reported to the EMS system and the building fire alarm system.

f. The factory condensing unit controller shall perform hot gas reheat coil flush cycles as needed to insure no refrigerant oil is tied up in the coils.

g. Coordinate with factory for minimum on & off times, time delays and such for compressors.

8. DDC Point List – RTU-15 & 24

a. Refer to the plans and these sequences of operation and provide all points required and inferred to make for a fully functional and operation system. Being that the units condensing section shall be BacNet compatible several points may be extracted from the interface however this contractor must provide any points and all points needed to achieve the operation and monitoring level specified. The EMS contractor shall provide all points are units are customized in this regard with the exception of those points integral to the RTU condenser section as furnished by the manufacturer. Points in **Bold** are point supplied and/or controlled by the unit manufacturer. Unitary dampers are supplied by the unit manufacturer however, the damper motors and operators are provided by the EMS vendor. As a minimum the following points being monitored and controlled for each unit:

Inputs	Outputs
Filter Diff. Pressure AI (3)	Supply fan S/S DO
Return air volume AI	Exhaust fan S/S DO
Freezestat AI	Supply fan VFD AO
Mixed air temp. AI	O.A. damper AO
Supply duct static AI	Return/recirc Air damper AO
Supply fan status	Hot Water Coil Valve AO
amp. AI	Exhaust Fan VFD AO
Exhaust fan status/	Wheel Bypass Dampers DO (2)
amp. AI	DX Cooling Stages (multiple) DO & AO
Duct Smoke Det. DI (mult)	DX Heat Stages (mult) DO&AO
Discharge air temperature AI	**Hot Gas Reheat Valves AO (multiple)**
R.A. temperature AI	Wheel Enable and Speed DO & AO
DX Coil Press./Temp AI (mult)	**Condenser section Bacnet Interface**
R.A. humidity AI	
R.A. CO2 AI	
Space CO2 AI (mult.)	
Wheel discharge air temp AI	
Wheel rotation DI	
Wheel Pressure Drop AI	
DX Coil Air DP AI	
Wheel Supply Leaving Temp AI	
Supply Air Volume AI	
Exhaust Air Volume AI	
Factory Discharge Air sensor	
Factory OA Temp sensor AI	

O.A. temperature AI (global) also integral to unit
O.A. humidity AI (global) also integral to unit
Condenser section Bacnet Interface

Note: OA, RA and Bypass damper actuators as well as wheel rotation sensor are furnished with units but must be wired and controlled by EMS. Freezestat is furnished and installed by unit manufacturer but must be wired from terminal strip to EMS.

AA. SEQUENCE OF OPERATION – VAV TERMINALS:

1. General: The VAV units with hot water coils provide heating, cooling and ventilation of the respective building areas.

2. If space temperature rises above an occupied cooling setpoint (initially 75 deg. F) the VAV damper shall modulate open to supply cool air to the room. Damper shall modulate open and close to its minimum position as required to maintain cooling setpoint and space CO2 setpoint (CO2 for classrooms, media and café only). Unoccupied cooling setpoint is 88°F.

3. For classrooms and media VAV zones, if space CO2 rises above a setpoint of 800 PPM a demand ventilation signal shall be sent first to the RTU to introduce more outside air. If RTU OA is at maximum OA design limit and CO2 level is still above setpoint VAV shall modulate open further to introduce more but no further than maximum supply air limit. If space overcools to below heating setpoint the CO2 VAV damper override shall be overridden and damper shall modulate to not allow space to fall below heating setpoint. If space CO2 rises above 1000 ppm a low level alarm shall be reported.

4. Exhaust VAV boxes in art rooms shall maintain proper negative space pressure relationship of -0.01 in relation to adjacent corridor.

5. During morning warm-up the VAV boxes shall operate in reverse, opening to allow warm air to bring the space up to occupied heating setpoint (initially 72 deg. F.). If respective space is at heating setpoint while in morning warm-up mode the VAV box shall close.

6. <u>For units with hot water coils</u>: If space continues to cool down to the heating setpoint (initially 72 deg. F) the VAV damper shall first be at its minimum position and the hot water valve shall modulate open to maintain heating setpoint. VAV box discharge air temperature sensor shall modulate coil valve so that supply air temperature does not exceed 110°. Upon a continued call for heat, the damper shall modulate open to allow more heated air into the space. Unoccupied heating setpoint is 60°F.

7. <u>For units with hot water and associated baseboard radiation</u>: If space continues to cool down to the heating setpoint (initially 72 deg. F) the VAV damper shall first be at its minimum position and the respective zone of baseboard radiation shall modulate open along with the VAV heat coil to maintain space heating setpoint. During unoccupied periods when the central fan system is off, the baseboard radiation shall cycle to maintain unoccupied setpoint. Unoccupied heating setpoint is 60°F.

8. For exhaust VAV's when any science room and art rooms when room is occupied as determined by the space occupancy sensor, the exhaust VAV serving this area shall modulate as required to maintain the minimum scheduled exhaust airflow rate higher

than the supply VAV box airflow rate as shown on the drawings but in no case to exceed (more negative) room negative pressure of -0.01". Space pressure shall be monitored and if space pressure during occupied period is higher (more positive) than -0.01"w.g. with respect to the main corridor for longer than 15 minutes a low level alarm shall be reported by the EMS. For exhaust VAV's serving the Janitors closet, etc… the VAV shall open to schedule maximum airflow during all occupied periods.

9. Points List

   a. As a minimum, the following points will be monitored and controlled for each VAV Unit. See also points indicated on drawings:

Inputs	Outputs
Velocity Sensor AI	Damper AO
Space temp. AI	Hot water coil valve AO
Space temp. adj AI	Baseboard Valve AO
Push button override DI	
Supply Temp AI	
Space CO2 AI	
Room Occupancy Sensor DI (via lighting control BacNet interface)	
Science, Art and Prep. Space Pressure AI	

BB. SEQUENCE OF OPERATION – CHANGEOVER DISPLACEMENT DIFFUSERS:

1. During occupied periods the displacement diffusers shall be in normal cooling/ventilation position. Upon a call for heat, the respective VAV reheat coil (see VAV sequence of operation) shall warm the supply air and when the air supply is above 75° the diffuser dampers will change over to heating mode and warm air will discharge to the room. VAV serving space shall modulate to maintain space with a maximum supply air temperature not exceeding 100°F. In general, the displacement diffusers shall be in normal cooling mode when supply air temperatures are below 70°F and in heating mode when supply temperatures are above 75°F.

2. Points List

   a. As a minimum, the following points will be monitored and controlled for each displacement/changeover diffuser. See also points indicated on drawings:

Inputs	Outputs
Space temp. AI	Damper Heat DO (multiple per room)
Supply Temp AI	Damper Cool DO (multiple per room)
Space Temp Override AI	

CC. SEQUENCE OF OPERATION - ELECTRIC CABINET, BASEBOARD & PANEL HEATERS

1. For Electric Cabinet Heaters: Integral adjustable thermostat shall enable and disable heaters and fan to maintain space temperature setpoint initially set for 60°F for utility and entry vestibule areas and a setpoint of 60°F during unoccupied periods and 68°F during occupied periods for no utility areas. EMS shall have full interface control via BacNet and the EMS shall be able to control unit setpoint and start/stop feature thru this interface as specified. For rooms where a wall thermostat is reflected on the drawings

the unit shall be controlled by the EMS with a setpoint of 62°F. EMS shall monitor space for low or high temperature alarms.

2. For Electric Baseboard and Radiant Panel Heaters: EMS shall enable and disable power to the respective heaters to maintain space temperature setpoint initially set for 60°F during unoccupied periods and 68°F during occupied periods.

3. DDC Point List Electric Cabinet Heaters:
As a minimum the following points shall be monitored and controlled for each electric cabinet heater:

Inputs	Outputs
Space Temperature – A.I.	Heater Enable/Disable DO

DD. SEQUENCE OF OPERATION - HOT WATER UNIT & CABINET HEATER

1. Space mounted temperature sensors shall enable and disable heater fans as required to maintain space temperature setpoint initially set for 62°F during unoccupied periods and 72°F during occupied periods. On cabinet heaters, a valve shall also cycle with the fan. If system is not in heating mode the fan shall be disabled.

2. DDC Point List:
As a minimum the following points shall be monitored and controlled for each hot water unit heater and cabinet heater:

Inputs	Outputs
Space Temperature AI	Fan start/stop DO
	Coil valve DO (only on cabinet unit heaters)

EE. SEQUENCE OF OPERATION DUCTLESS SPLIT UNITS (non VRF):

1. The building EMS shall monitor and control the ductless split units. Once enabled, the units shall stage on and off on their own factory controls.

2. The thermostat upon sensing a change in space temperature from setpoint shall stage cooling to maintain setpoint. Indoor fan shall cycle with cooling demand as required. Initially setpoints shall be 75°F for cooling. Coordinate with zones with VAV boxes to insure ductless split unit cooling setpoint is set at least one degree higher than VAV box setpoint. Building shall alarm conditions more than 4°F beyond this limit.

a. DDC Point List:
As a minimum the following points shall be monitored and controlled through the EMS

Inputs	Outputs
Space Temperature AI	Enable/Disable DO
BacNet Interface to factory space sensor and unit control	

FF. SEQUENCE OF OPERATION – GENERAL & BATHROOM EXHAUST FANS

1. All general & bathroom exhaust fans shall be controlled through the DDC and shall operate continuously during the occupied periods or as otherwise indicated herein.

2. At commencement of occupied periods motorized dampers shall open and respective exhaust fans shall start and run.
3. During unoccupied periods the exhaust damper shall close and the exhaust fans shall be disabled.
4. Electric room exhaust fans (and other rooms have exhaust fans and associated intake dampers) shall come on and exhaust and intake air damper open during any period if space temperature exceeds cooling setpoint, initially 85°F. Coordinate with E.C. for fans controlled by line voltage thermostats.
5. Exhaust fans shown or scheduled as serving heat producing non occupied rooms shall cycle and open respective exhaust dampers as required to maintain a cooling setpoint, initially 85°F. Coordinate with E.C. for fans controlled by line voltage thermostats.
6. For fans scheduled with ECM motors or variable speed drives reflected on the control drawings with a VFD, the EMS shall send a 0 to 10 VDC signal to start and stop the fan and modulate its speed. For fans scheduled with ECM motors reflected on the control drawings with a HS or HOA, the EMS shall send a 0 to 10 VDC signal to start and stop the fan and the final running control voltage signal shall be coordinated with the balancer. For fans scheduled with ECM motors reflected on the control drawings with a HS or HOA and also scheduled to have a potentiometer dial, the EMS shall send a start and stop signal to the fan.
7. DDC Point List – Bathroom & General Exhaust Fans

   As a minimum the following points shall be monitored and controlled for each fan:

Inputs	Outputs
Space Temperature – AI	Start/Stop - DO
Run Indicator AI	Damper – DO
Occupancy Sensor – DI (from lighting control system)	
VFD Start/Stop DO	
Space Pressure AI	VFD Speed AO
	ECM VFD Fan Start/Stop & Speed AO
	ECM HS/HOA (no potentiometer) Start/Stop AO
	ECM HS/HOA (with potentiometer) Start/Stop DO

GG. SEQUENCE OF OPERATION – Variable Refrigerant Flow System With Heat Recovery - VRF (ACHP-1AB, ACHP-1B2 & ACHP-2B2 & associated FC's):

1. Based on an occupancy schedule, the fan coil zones shall cycle their fans, branch selector valve and respective heat pump unit for cooling or heating as required to maintain scheduled space temperature setpoint initially set for 72°F occupied & 62°F unoccupied for heating and 75°F occupied and 88°F unoccupied for cooling. If a room occupancy sensor detects space occupancy (via interface information from lighting control system), the fan coil shall operate continuously and a signal shall be sent to the respective central ventilation unit to operate (see RTU-15, RTU-24 and ERU-1 sequence within this specification).
2. The fan coil fan shall operate on low speed when room conditions have met setpoint and shall speed up as needed when space demand requires either cooling or heating. In unoccupied rooms the fan shall be allowed to cycle off until such time as occupancy is realized or if space cooling or heating is required.

3. If a fan coil unit with integral condensate drain pump detects an overflow condition in the condensate pump well, the fan coil cooling cycle shall be disabled and an alarm shall be reported to the front-end.
4. BMS shall communicate with VRF system to prevent simultaneous cooling and heating in the space as well as to acquire all space temperature conditions, setpoints and system status.
5. Points List: Refer to the plans and these sequences of operation and provide all points required and inferred to make for a fully functional and operation system. Being that the unit shall be BacNet compatible many points may be extracted from the interface however this contractor must provide any and all points needed to achieve the operation and monitoring level specified. Refer to VAV and ERU sequence for additional interface points and logic. Points in **Bold** are VRF manuf. devices. As a minimum, the following points will be monitored and controlled for each fan coil unit.

Inputs	Outputs
Space temp. AI	**Fan Coil Fan S/S DO/AO (mult. speed)**
Space temp. adj AI	**Fan Coil Cooling S/S DO**
Push button override DI	**Fan Coil Heating S/S DO**
Unit Alarm DI	Occ. command DO
Space Occupancy DI (via BacNet to lighting control)	
Condensate Pump Alarm DI	

Note: Most points above are part of the VRF package. EMS must install and wire all VRF control devices and acquire data from the VRF system via BacNet for control reset and scheduling.

HH. SEQUENCE OF OPERATION – Variable Refrigerant Flow System Non Heat Recovery - VRF (VRF ACCU-“ & associated FC’s):

1. Most non heat recovery VRF units support unoccupied spaces or occupied spaces supported with outside air ventilation provided directly to the rooms from other systems. In addition, these systems are primarily intended to operate in a cooling only mode although changeover to heating mode shall occur if more than 75% of the FC zones are calling for heating, which once addressed, the unit shall switch back to cooling mode.
2. The FC units shall generally operate in a fan cycle mode. For occupied areas, based on an occupancy schedule, the fan coil zones shall cycle their fans and respective heat pump unit for cooling or heating as required to maintain scheduled space temperature setpoint initially set for 72°F occupied & 62°F unoccupied for heating and 75°F occupied and 88°F unoccupied for cooling.
3. For units serving, electric rooms, tel/data rooms and other similar spaces, the unit fan coil zones shall cycle their fans and respective heat pump unit for cooling or heating as required to maintain a fixed space temperature setpoint initially set for 72°F for tel/data rooms and 80°F for electrical rooms. unoccupied for cooling
2. The fan coil fans shall vary fan speed as required to support space conditions. The fan shall be allowed to cycle off until such time as occupancy is realized or if space cooling or heating is required.

3. If a fan coil unit with an integral or external condensate drain pump detects an overflow condition in the condensate pump well, the fan coil cooling cycle shall be disabled and an alarm shall be reported to the front-end.
4. BMS shall communicate with VRF system to prevent simultaneous cooling and heating in the space as well as to acquire all space temperature conditions, setpoints and system status.
5. Points List: Refer to the plans and these sequences of operation and provide all points required and inferred to make for a fully functional and operation system. Being that the unit shall be BacNet compatible many points may be extracted from the interface however this contractor must provide any and all points needed to achieve the operation and monitoring level specified. Refer to VAV and ERU sequence for additional interface points and logic. Points in **Bold** are VRF manuf. devices. As a minimum, the following points will be monitored and controlled for each fan coil unit.

Inputs	Outputs
Space temp. AI	**Fan Coil Fan S/S DO/AO (mult. speed)**
Space temp. adj AI	**Fan Coil Cooling S/S DO**
Push button override DI	**Fan Coil Heating S/S DO**
Unit Alarm DI	Occ. command DO
Space Occupancy DI (via BacNet to lighting control)	
Condensate Pump Alarm DI	

Note: Most points above are part of the VRF package. EMS must install and wire all VRF control devices and acquire data from the VRF system via BacNet for control reset and scheduling.

II. SEQUENCE OF OPERATION – FUME HOOD EXHAUST FANS

1. Upon activation of any of the fume hood switches mounted on face of hood or upon opening of a fume hood sash, the EMS shall open the main exhaust damper and enable the respective fume hood fan and the fume hood airflow monitoring system shall be activated. Activation can also be programmed via schedule depending on Owner preference. Respective RTU serving this space shall be placed in an occupied mode to support the make-up air demand (see respective RTU control).

2. The VFD shall modulate fan speed as required to maintain an exhaust duct negative static pressure initially set for -0.75” and shall be field adjusted during balancing.

3. The respective fume hood exhaust damper shall modulate so as to maintain an open sash velocity of no less than 100 FPM or as otherwise specified by hood manufacturer. Low airflow alarms lasting longer than 30 seconds shall be reported by the EMS.

4. EMS shall command all hoods to “Hibernate Mode” at the end of occupied periods unless otherwise scheduled.

5. DDC Point List – EF-1 System:
As a minimum the following points shall be monitored and controlled for this system. Refer to control drawings for additional information:

Inputs	Outputs
Run Indicator – AI	EF-# Fan Start/Stop - DO

Duct Static – AI	EF-# Damper – DO (multi)
Hood Enable/Disable – DI (multi)	EF-# VFD Fan Speed - AO
Hood Velocity Sensor – AI (multi)	Hood Exhaust Damper – AO (multi)
Hood Velocity Alarm – DI (multi)	Hibernate Command – DO (multi)
Hibernate Enable – DI (multi)	

JJ. SEQUENCE OF OPERATION – KILN AND KILN ROOM EXHAUST FAN EF-#

1. The Kiln exhaust fan shall be controlled through the kiln's factory controller. The kiln room exhaust fan shall be controlled through the DDC and shall operate continuously when either of the room occupancy sensors detect room occupancy or if the Kiln exhaust fan is on as determined via a current sensor.
2. At commencement of occupied periods or if the Kiln switch place in the on position the motorized damper shall open and room exhaust fan shall start and run. The fan shall run at 25% speed and shall speed up to maintain space temperature cooing setpoint of 78°F.
3. During unoccupied periods and if the Kiln exhaust fan is off the exhaust damper shall close and the exhaust fans shall be disabled.
4. DDC Point List – Kiln Room Exhaust Fan EF-#

   As a minimum the following points shall be monitored and controlled for each fan:

Inputs	Outputs
EF Fan Run Indicator AI	Start/Stop & Fan Speed – DO & AO
Kiln Exhaust Fan status DI	Damper – DO
Occupancy Sensor (#)	

KK. SEQUENCE OF OPERATION - HOT WATER FAN COIL UNIT

1. The hot water fan coil units primarily support unoccupied areas and are intended to prevent overcooling of these spaces. Space mounted temperature sensors shall cycle the unit valve open and enable and disable the fan as required to maintain space temperature setpoint initially set for 60°F.
2. DDC Point List:
   As a minimum the following points shall be monitored and controlled for each hot water fan coil unit:

Inputs	Outputs
Space Temperature AI	Fan start/stop DO
Supply Air Temp AI	Coil valve DO

KK. SEQUENCE OF OPERATION: MISCELLANEOUS MONITORING & ALARMS

1. Kitchen Cooler & Freezer Alarm – If the cooler temperature drops below 32°F degrees or rises above a setpoint of 42°F for longer than 30 minutes an alarm shall be reported by the EMS. If the freezer temperature rises above a setpoint of 15°F for longer than 30 minutes an alarm shall be reported by the EMS.

2. The Culinary cooler prep. Room shall have a CO2 sensor and a refrigerant sensor. When either of these sensors detects and alarm condition a horn and strobe shall sound both in the room and outside of the room to warn of a hazardous condition.

3. The EMS shall monitor the main water meter serving the building as well as the main domestic hot water meter and the boiler water meter and report flow and totalize daily and monthly.

4. The EMS shall monitor the domestic hot water boilers and monitor and control the domestic water recirculation pump. The EMS shall monitor the domestic hot water tank temperatures and recirculation temperatures. If the tank temperatures should fall below a setpoint of 110°F for longer than 60 minutes, an alarm shall be reported by the EMS. The domestic hot water recirculation pumps shall operate during all occupied periods. During unoccupied periods the recirculation pumps shall be disabled. If pumps are placed in extended unoccupied mode (i.e. weekends, school vacations, etc…), they shall be programmed to operate a minimum of 30 minutes for every 24 hours of off time to mitigate potential stagnant water issues.

5. The EMS shall provide two (2) potable water flow switch (one in each of the emergency shower loops) set to alarm should flow rate exceed 10 GPM. If in alarm it shall report to the EMS as a high level alarm and shall be indicate as “Emergency Shower Flow – Science Rooms” or Emergency Shower – Auto/Diesel” respectively at the front end.

6. The EMS shall monitor hourly and total gas usage from the main building, heating boilers and the domestic hot water heaters.

DDC Point List

a. Refer to the plans and these sequences of operation and provide all points required and inferred to make for a fully functional and operation system. As a minimum the following points being monitored and controlled:

Inputs	Outputs
	Recirc Pump #1 Start/Stop DO
	Horn & Strobe DO (2)
Freezer Temperature AI	
Cooler Temperature AI	
Domestic Boiler BLR-1 Status DI	
Domestic Boiler BLR-1 Alarm DI	
Recirc Pump #1 Status AI	
Domestic WH Storage Temp #HWS-1 AI	
Domestic WH Storage Temp #HWS-2 AI	
Building Water Meter AI	
Dom. Water Heating Water Meter AI	
Heating Boiler Water Meter AI	
Main Domestic HW Temp AI	
Main Gas Meter AI	
Boiler Gas Meter AI	
Dom Water Heater Gas Meter AI	
CO2 Sensor AI	
Refrigerant Sensor AI	
Emergency Shower Flow DI (2)	

PART 3 - EXECUTION

3.01 SURFACE CONDITIONS

A. Examine the areas and conditions under which work of heating, ventilating and air conditioning system will be performed. Correct conditions detrimental to timely and proper completion of the Work. Do not proceed until unsatisfactory conditions are corrected.

3.02 INSTALLATION

A. Install equipment ductwork, piping and controls where shown with recognized industry standards and practices, to ensure that installation complies with requirements and serves intended purposes.

B. Coordinate with other work as necessary to interface installation of ductwork, piping and equipment with other components of systems.

C. Installation of Ductwork

1. Installation of ductwork shall be coordinated with other work as necessary to interface installation or ductwork with other components of systems. Duct sizes shown on the drawings at connection to fans or other equipment may vary in actual installation. Contractor shall provide transition pieces as required. Ducts, casings and hangers shall be installed straight and level and shall be free of vibration and noise when fans are operating. All ducts shall be protected and sealed during construction to prevent moisture and dust entry. After installation duct segments and systems shall be pressure tested per SMACNA standards.

2. Provide fire safing to close all floor and wall (where fire rated) openings around ductwork - pack annular space with rockwool and 18 gauge sheet metal safing.

3. Seal the ductwork at joists and seams with LEED EQ. Credit compliant water based duct sealer DuctMate® EZ-Seal or approved equal.

4. When ductwork penetrates an insulated joist bay in the attic area, maintain insulation integrity. Support ductwork to prevent movement and secure insulation and fill all gaps.

5. 1/8” thick galvanized steel angle irons shall be used to support ductwork mounted on the roof. Angles shall be securely fastened to the ductwork and the roof before installation of the roofing membrane. Roofer shall flash in angle supports.

6. This contractor is responsible for sleeving all duct penetrations before pouring of slab. If additional holes are required this contractor shall have pay for the coring of such holes in coordination with the general contractor and with prior consent of the Architect.

7. Fabrication, installation, sealing, protecting and testing of all ductwork and duct liner shall comply with the most recent publications from the Sheet Metal and Air Conditioning Contractors' National Association (SMACNA) including but not limited to the following. All smoke control ductwork must be pressure tested as well as all other ductwork required by code and/or otherwise required by SMACNA standards described herein:
   - SMACNA IAQ Guidelines for Occupied Buildings under Construction with special emphasis placed on the section regarding Duct Cleanliness and Protection for New Construction.
   - SMACNA Duct Cleanliness for New Construction Guideline.

- This project must comply with SMACNA Duct Cleanliness Guidelines Advanced Level.
- SMACNA HVAC Duct Construction Standards – Metal and Flexible
- SMACNA Air Duct Leakage Test Manual

8. Duct pressure tests shall take place after all takeoffs and wall penetrations are in place and before applying exterior insulation. Correct any leaks found. Pressure test all high-pressure ductwork (duct rated for over 3"w.g.) and 25% of all medium and low pressure ductwork (ductwork rated for under 3" w.g.) on the project at 150% of its duct construction class pressure in accordance with SMACNA standards.

9. Duct leakage testing shall be per SMACNA HVAC Air Duct Leakage Test Manual. Provide orifice assembly including straightening vanes, orifice plate mounted in straight tube with properly located pressure taps, and U-tube manometer or other device as specified by SMACNA. Submit leak test report in SMACNA format along with ductwork drawings for designer review.

10. All ductwork shall be shipped to the site with protective film on all open connections to prevent dust from entering. Film shall be reapplied to all open ends as the duct is installed until such time as building is clean and system is ready for start-up

D. Installation of Piping

1. Contractor shall examine location where the piping is to be installed and determine space conditions. Provide and erect in a workmanlike manner, according to the best practices of the trade, all piping shown on the Drawings or required to complete the installation intended by these Specifications.

2. All drain piping from condensate drain pans shall be properly trapped in accordance with the static pressures involved. Condensate drain piping sizes shall be not less than 3/4 inch.

3. This contractor is responsible for coring of all holes related to his/her work in coordination with the general contractor and with prior consent of the Architect.

4. Provide fire safing to seal all floor and wall (where fire rated) openings around piping.

5. Provide 24 hour duration pressure test for all piping systems. Test pipes with clear water (propylene glycol mix if freezing could occur) at 1.5 times the system design pressure unless a more stringent or lengthy test is required by the local AHJ or under other Divisions. Any products or materials not rated for this pressure or the relief pressure must be isolated from the test. Provide a temporary 100 psi relief device on the tested system(s) to avoid damage due to thermal expansion during the test. Record ambient and system water pressure and temperature at start and end of test and report to Engineer. Inspect piping for leaks and if any are found repair and repeat test.

6. All systems shall be thoroughly flush with clear water and then filled with clear water and circulated for a period no less than 8 hours. Drain water, clean all strainers and then refill the hot water system with clean water and chemically treat.

7. For glycol systems, once the piping is tested and flushed, fill the system with a pre-mixed concentration of 30% corrosion inhibited propylene glycol.

E. Installation of Equipment

1. Contractor shall examine location where equipment is to be installed and determine space conditions and notify Architect, in writing, of conditions detrimental to proper and timely completion of work.

2. Install equipment where shown in accordance with manufacturer's written instructions.

3.03 FIELD QUALITY CONTROL

A. Upon completion of installation of the automatic temperature control system and after motors have been energized with normal power source, test system to demonstrate compliance with requirements. When possible, field correct malfunctioning controls then retest to demonstrate compliance. Replace controls, which cannot be satisfactorily corrected. Refer to Section - Test and Balancing. Fully coordinate all testing with the commissioning agent. In addition, to the commissioning agents reports, the balancing contractor (TAB) and the controls contractor shall submit written reports of testing procedures and findings.

3.04 SERVICE

1. After completion of the control system installation, the controls contractor shall regulate and adjust all thermostats, control valves, damper motors, etc., and place in complete operating condition, subject to the approval of the Owner. Complete instructions shall be given to the operating personnel. There shall be 40 hours of instruction given on the operation of the entire system at a training schedule determined by the Owner.

2. Start-Up and Commissioning

For all boilers, air handlers, rooftop units, etc… provide factory service/start-up technician to check, test and start equipment. Technician shall coordinate mapping of all control points with EMS contractor and commissioning of unit. Technician shall work with project commissioning agent to verify proper operation of unit. In coordination with the mechanical contractor and control contractor the factory technician shall provide Owner training of unit controls, maintenance, etc…

3.05 TESTING, ADJUSTING AND BALANCING (TAB)

A. General

1. Section Includes
   a. Testing, adjusting, and balancing of Air Systems.
   b. Testing, adjusting, and balancing of Hydronic Systems.
   c. Measurement of final operating conditions of HVAC Systems.
2. Related Documents
   a. Drawings and General Provisions of Contract, including General and Supplementary Conditions, apply to work of this section.
3. References
   a. ASHRAE - Standard 111 - 1988 Practices for Measurement, Testing, Adjusting, and Balancing of Building Heating, Ventilation, Air Conditioning, and Refrigeration Systems.

b. ASHRAE - 2007 HVAC Applications Handbook: Chapter 37, Testing, Adjusting and Balancing.
c. AABC- National Standards for Total System Balance.
d. NEBB - Procedural Standards for Testing, Balancing and Adjusting of Environmental System.
e. SMACNA - HVAC System Testing, Adjusting and Balancing.
f. Sheet Metal Industry - Certification of Testing, Adjusting and Balancing Technicians.

4. Quality Assurance
   a. Agency shall be a firm specializing in the adjusting and balancing of systems specified in this Section with minimum three years documented experience, acceptable to the Designer.
   b. Perform the work under the supervision of one of the following:
      1) AABC Certified Test and Balancing Engineer.
      2) NEBB Certified Testing, Balancing, and Adjusting Supervisor.
      3) TABIC Certified Contractor.
   c. Work shall be performed only by a Balancing Sub-Sub Contractor which employs Certified Testing, Adjusting and balancing Technicians as listed by the Sheet Metal Industry National Certification Board for TAB Technicians.
   d. The work must be performed by a Certified Testing, Adjusting and Balancing Technician who may be assisted by other TAB Technicians. The Certified Testing, Adjusting and Balancing Technician is responsible for :
      1) Procedures to follow.
      2) Accuracy of all testing.
      3) Integrity of recorded data
      4) Entering all data and any abnormal or notable conditions in report forms.
      5) Initialing and dating each sheet.
   e. The General Section of the Balance Report shall include the names, signatures, and registration numbers of the Technicians who were assigned to the project.
5. Submittals
   a. Submit name of the Balancing Sub-Sub Contractor for approval within 30 days after award of contract.
   b. Submit for review, prior to commencement of work, a list of equipment and procedures to be used in balancing the systems.
   c. Submit reports of preconstruction plan check and periodic mechanical construction review.
   d. Submit draft copies of report for review prior to final acceptance of project. Provide final copies to the Designer and for inclusion in operating and maintenance manuals.
6. Procedures, General
   a. All Air and Hydronic Systems shall be balanced using a procedure which results in minimum restrictions being imposed.
      1) At Completion of balancing:
         a) At least one damper for an outlet/inlet shall be fully open on every branch duct.
         b) At least one branch duct balancing damper shall be fully open on every trunk duct.
         c) At least on trunk (zone) balancing damper shall be fully open in each Air System.
         d) Supply/exhaust fan RPM shall be set so the static pressure at the terminal which is most difficult to supply/exhaust is adequate, but not excessive.

e) At least one hydronic terminal unit balancing valve in each piping branch shall be fully open.
f) At least one branch line balancing valve in each Hydronic System shall be fully open.

7. Final Reports
   a. Submit reports on previously approved Test Data Forms
   b. Forms shall include the following information:
      1) Title Page:
         a) Company name
         b) Company address
         c) Company telephone number
         d) Name, signature, and registration number of each technician
         e) Project name
         f) Project location
         g) Project Architect
         h) Project Engineer
         i) Project Contractor
         j) Project altitude
         k) Date of report
      2) Instrument List:
         a) Instrument
         b) Manufacturer
         c) Model
         d) Serial number
         e) Range
         f) Calibration date
      3) Air Moving Equipment
         a) Designation
         b) Location
         c) Manufacturer
         d) Model
         e) Airflow, specified and actual
         f) Return airflow, specified and actual
         g) Outside airflow, specified and actual
         h) Total static pressure (total external), specified and actual
         i) Inlet pressure
         j) Discharge pressure
         k. Fan RPM
      4) Return\ Exhaust Fan Data:
         a) Designation
         b) Location
         c) Manufacturer
         d) Model
         e) Airflow, specified and actual
         f) Total static pressure (total external), specified and actual
         g) Inlet pressure
         h) Discharge pressure
         i) Fan RPM, initial and final
      5) Electric Motor:
         a) Manufacturer
         b) HP
         c) Frame

d) Phase, voltage, amperage; nameplate and actual
e) RPM
f) Service factor
g) Starter size, rating, heater elements

6) V-Belt Drive:
a) Identification
b) Driven sheave, diameter
c) Belt, size and quantity
d) Motor sheave, diameter
e) Center to center distance, maximum, minimum, and actual
f) Final components

7) Duct Traverse:
a) System zone/branch
b) Duct size
c) Area
d) Design velocity
e) Design airflow
f) Test velocity
g) Test airflow
h) Duct static pressure
i) Air temperature
j) Air correction factor

8) Air Monitoring Station Data:
a) Identification/location
b) System
c) Size
d) Area
e) Design velocity
f) Design airflow
g) Test velocity
h) Test airflow

9) Air Distribution Test sheet:
a) Air terminal number
b) Room number/location
c) Terminal type
d) Terminal Size
e) Area factor
f) Design velocity
g) Design airflow
h) Test velocity, initial and final
i) Test airflow, final
j) Percent of design airflow, initial and final

10) VAV Terminal Data:
a) Designation
b) Location
c) Manufacturer
d) Type
e) Model
f) Size
g) Design airflow
h) Actual airflow
i) Design Water Flow

j) Actual Water Flow

11) Cooling Coil Data:
   a) Designation
   b) Location
   c) Service
   d) Manufacturer
   e) Size, face area, and fins/inch
   f) Airflow, design and actual
   g) Entering Air DB temperature, design and actual
   h) Entering air WB temperature, design and actual
   i) Leaving air DB temperature, design and actual
   j) Leaving air DB temperature, design and actual
   k) Air pressure drop, design and actual

12) Heating Coil Data:
   a) Designation
   b) Location
   c) Service
   d) Manufacturer
   e) Size, face area, and fins/inch
   f) Airflow, design and actual
   g) Water flow, design and actual
   h) Water pressure drop, design and actual
   i) Entering water temperature, design and actual
   j) Leaving water temperature, design and actual
   k) Entering air temperature, design and actual
   l) Leaving air temperature, design and actual
   m) Air pressure drop, design and actual.

c. Report is to include a listing of any abnormal or notable conditions not contained in the above.

d. Provide four copies of reports in soft cover, letter size, 3-ring binder manuals, complete with index page and indexing tabs, with cover identification at front and side. Include set of reduced drawings with air outlets and equipment identified to correspond with data sheets, and indicating thermostat locations.

8. HVAC Sub-Contractor Responsibilities
   a. Prepare each system for testing and balancing
   b. Cooperate with Balancing Sub-Sub Contractor, provide access to equipment and systems. Operate systems at designated times, and under conditions required for proper testing, adjusting, and balancing.
   c. Notify Balancing Sub-Sub Contractor seven days prior to time system will be ready for testing, adjusting, and balancing.
   d. Where fans (air handling units, supply fans, return fans, exhaust fans, etc.) are provided with variable pitch sheaves, HVAC Sub-Contractor shall adjust sheaves, as required, at no additional cost to the Owner, until desired Design Points (CFM and/or Static Pressure) are reached. If adjustment of the variable pitch sheaves is beyond the range of the sheaves, HVAC Sub-Contractor shall replace sheaves, as required, at no additional cost to the Owner, until the desired Design Points (CFM and/or Static Pressure) are reached. Where fans (air handling, supply, return, exhaust, etc.) are specified with fixed ratio sheaves, HVAC Sub-Contractor shall replace sheaves with new sheaves, at no additional cost to the Owner until desired Design Points (CFM and/or Static Pressure) are reached.
9. Sequencing and Scheduling
   a. Sequencing work to commence after completion of systems and schedule

completion of work before Substantial Completion of Project.

10. Drawing and Construction Review
    a. Perform a pre-construction review of the following documents:
        1) Contract drawings.
        2) Contract specifications.
        3) Addenda.
        4) Submittal data.
        5) Shop drawings.
        6) Automatic Control drawings.
    b. Prepare a report of the preconstruction review list of recommended changes to allow most effective balancing.
    c. Perform two construction reviews of the mechanical installation during the progress of the project. Purpose of the reviews to be:
        1) Identify potential problems for performing balancing.
        2) Identify modifications which will aid balancing.
        3) Schedule and coordinate balancing with other work.
    d. Prepare a report of each construction review.
11. Equipment
    a. Provide all necessary tools, scaffolding and ladders.
    b. Provide all necessary instruments. Instruments shall be used and applied which are best suited to the system function being tested. Instruments shall be in first class state of repair and have been calibrated within a period of six months prior to starting the job. Calibration history of each instrument shall be available for examination. Instruments shall be re-calibrated upon completion of the job if required by the Designer to prove reliability.
12. Examination
    a. Before commencing work, verify that systems are complete and operable. Ensure the following:
        1) Equipment is operable an in safe and normal condition.
        2) Temperature control systems are installed complete and operable.
        3) Proper thermal overload protection is in place for electrical equipment.
        4) Final filters are clean and in place. If required, install temporary media in addition to final filters.
        5) Duct systems are clean of debris.
        6) Correct fan rotation.
        7) Fire and volume dampers are in place and open.
        8) Coil fins have been cleaned and combed.
        9) Access doors are closed and duct end caps are in place.
        10) Air outlets are installed and connected.
        11) Duct system leakage has been minimized.
        12) Proper strainer baskets are clean and in place.
        13) Correct pump rotation.
        14) Hydronic systems have been flushed, filled, and vented.
        15) Service and balance valves are open.
    b. Report to the Designer any defects or deficiencies noted during performance of services.
    c. Promptly report abnormal conditions in mechanical systems or conditions which prevent system balance.
    d. If, for design reasons, system cannot be properly balanced, report as observed.
    e. Beginning of work means acceptance of existing conditions.
13. Preparation

a. Provide instruments required for testing adjusting and balancing operations. Make instruments available to the Designer to facilitate spot checks during testing.

14. Installation Tolerances
    a. Adjust Air Handling Systems to the following tolerances:
        1) Supply systems shall be balanced so that:
            a) The total quantity to each space is within -5% to +10% of design values.
            b) If two outlets in space, each outlet is within -10% to +10% of design value.
            c) If three or more outlets in space, each outlet is within -15% to +15% of design value.
        2) Exhaust and return systems shall be balanced so the total quantity from each space is -10% to +10% of design values.
    b. Adjust Hydronic Systems to the following tolerances:
        1) Heating System:
            a) Supply water temperature above 160°F: -10% to +10% of design value.
15. Adjusting
    a. Recorded data shall represent actually measured or observed condition.
    b. Permanently marked settings of valves, dampers, and other adjustment devices, allowing settings to be restored. Set and lock memory stops.
    c. After adjustment, take measurements to verify balance has not been disrupted or that such disruption has been rectified.
    d. Leave systems in proper working order, replacing belt guards, closing access doors, closing doors to electrical switch boxes, and restoring thermostats to specified settings.
16. Air System Procedure
    a. Measure and balance air quantities at air inlets an outlets.
    b. Adjust Air Handling and Distribution Systems to provide design supply, return and exhaust air quantities at site altitude.
    c. Make air quantity measurements in ducts by pitot tube traverse of entire cross sectional area duct.
    d. Adjust distribution system to obtain uniform space temperatures free from objectionable drafts and noise.
    e. Effect volume control at outlets by use of dampers installed in the ductwork. Do not use volume dampers that are integral with the outlets.
    f. Measure static air pressure conditions on air supply units, including filter and coil pressure drops, and total pressure across the fan. Make allowances for 50 percent loading of filters.
    g. Adjust outside air automatic dampers, outside air, return air, and exhaust dampers for design conditions.

    h. Measure temperature conditions across outside air, return air, and exhaust air dampers to check leakage.
    i. Where modulating dampers are provided, take measurements and balance at extreme conditions. Set variable volume terminals at maximum airflow rate, full cooling with design diversity; read volumes at minimum airflow rate and full heating.
    j. Measure building static pressure and adjustable supply, return and exhaust air systems to provide required relationship between each to maintain approximately 0.05 inches positive static pressure near the building entries.

17. Water System Procedure
    a. Adjust water systems to provide design quantities.
    b. Use calibrated flow meters and pressure gages to determine flow rates for system balance. Where flow metering devices are not installed, base flow balance on temperature difference across various heat transfer elements in the system.
    c. Adjust systems to provide specified pressure drops and flows through heat transfer elements prior to thermal testing. Perform balancing by measurement of temperature differential in conjunction with air balancing.
    d. Effect system balance with automatic control valves fully open to heat transfer elements.
    e. Effect adjustment of water distribution systems by means of balancing cocks, valves, and fittings. Do not use service or shut-off valves for balancing unless indexed for balance point.
18. Field Verification
    a. The Designer may request verification of the data contained in the Balancing Report. If so, the TAB Technician who originally initialed the data sheets shall read outlets selected at random by the Designer who will compare the values with those in the report.
    b. It is understood that the verification process shall take place within one week after delivery of the report. The operating mode of the system shall be the same for verification as it was during the balancing procedure.
    c. The number of readings to be verified shall not exceed 10% of the total contained in the report.
    d. If the field verification is not satisfactory, the firm doing the TAB work shall completely rebalance the system and a new report shall be prepared. The Designer may notify the Sheet Metal Industry Certification Board for TAB Technicians so that appropriate action can be taken.

B. It shall be division 23.00.00 responsibility to provide all personnel as required to fully coordinate with the commissioning agent as applicable. The hours of training and instruction outlined in division 23.00.00 and the Testing and Balancing requirements shall be in addition to those tests and requirements outlined in the commissioning section as applicable.

C. Certified Reports

1. For the reports required to be submitted within this section, provide certification by an independent balancing and testing contractor who is versed in the field of air balancing and who is not affiliated with any firm involved in the design or construction phases of this work.

2. Identify in the reports each item not complying with the Contract requirements, or obvious misoperation or design deficiencies of equipment or controls.

D. Additional Commissioning Coordination & Requirements

1. The Testing, Adjusting, & Balancing (TAB) Balancing Contractor shall submit their TAB procedures as part of the SUBMITTAL criteria in Division 1 of this specification. Integral with this submittal shall be the TAB strategy/plan for water system, which shall include the following
    a. Furnish one-line, schematic system drawings for the Commissioning Agent review

of the Hot Water Piping System.

2. Each hydronic system drawing will be 1-line schematic representation of the system to be they are installed, indicating all coils, balancing valves, strainers, automatic control valves, pressure regulating valves, meters, etc.

3. Each hydronic system flow diagram shall indicate all pressure drops (design conditions and actual conditions) of each component, as well as associated flows and temperatures (design and actual).

4. Furnish one-line, schematic system drawings for the Commissioning Agent review of the Duct System for the follows:

   a. Central HVAC system(s)

   b. General exhaust system(s)

5. Each air system drawing will be 1-line schematic representation of the system to be they are installed, indicating all louvers, dampers, filters, coils, fans, dampers, balancing valves, volume terminal devices, etc.

6. Each air system flow diagram shall indicate all pressure drops (design conditions and actual conditions) of each component, as well as associated flows, velocity, and temperatures (design and actual)

E. NFPA 72 Testing

1. The HVAC contractor shall assist the electric contractor in performing the required NFPA 72 testing of devices effecting HVAC systems such as duct smoke detectors, smoke dampers and fire/smoke dampers. In addition, after one year from date of substantial completion or from first accepted NFPA 72 test, whichever is the later, the contractor shall assist the electric contractor in re-performing the required NFPA 72 testing of the related devices for recertification.

3.06 LABELING

A. Provide pipe markers of either pressure sensitive tape or laminated plastic, color coded and indicating the type and direction of flow of the piping service. Duct labels shall be stenciled and painted on the ductwork. All heating supply and return water, glycol supply & return water, refrigeration piping (Vapor & Liquid), cold (domestic) water feeding HVAC systems and condensate drain piping throughout the building shall be labeled. All piping containing electric heat trace under insulation must be labeled as containing such. All supply, return and exhaust ductwork mains shall be labeled with flow direction, service and associated air moving unit. Ducts and piping excluded from the labeling requirement are any of the following: 1) Ducts exposed within finished spaces, 2) Branch ducts downstream of a VAV, 3) branch ducts serving individual VAV, diffuser, register or grille. Labels shall be at the inlet and outlet to each piece of equipment, at the entrance and exit of each room and at intervals along the duct and pipe of a minimum of every 20 feet.

B. All equipment, starters and VFD’s shall be labeled with engraved laminated nametags.

C. 1-1/2” Brass valve tags with recessed stamped black lettering indicating service and valve number shall be provided at every shut-off, bypass and control valve in the building. Shut-off valves at individual VAV’s, cabinet heaters and baseboard heaters located within 5 feet of the serviced terminal need not be tagged. A typed valve chart shall be made and inserted in each copy of the operation and maintenance. In addition the valve chart shall be mounted

in a glass frame affixed to a wall in the boiler room. Chart shall show valve number, valve type and valve service. Directions for system seasonal drain down or isolation of components shall be included on this chart.

3.07 PAINTING

A. Equipment installed under this Section shall have shop coat of factory applied non-lead paint, unless otherwise specified. Touch-up any scratches with matching paint. Hangers and supports shall have one coat of non-lead primer.

3.08 SPARE STOCK

A. It is the intent of this specification that all equipment requiring or specified with air filters be furnished with two (2) spare sets of filters (both pre and final) for each piece of equipment in addition to those supplied with the unit and after flush-out. Presuming the unit has not been operated during construction (operation during construction only allowed with written approval from Architect) the set of filters initially installed in the unit shall be utilized during testing and balancing and building flush out. After flush out, a new set of air filters shall be installed leaving the Owner with two (2) full spare sets. All pre-filters shall have a minimum efficiency of MERV 8 and all final filters and single filter units shall have a minimum efficiency of MERV 13. Note: All units included in the 3-year warranty and maintenance plan shall not be supplied with spare filters as the contractor shall own filter changes for 3 years as part of the contract.

   All RTU, AHU and MAU filter sections must be fitted with differential pressure gauges viewable from the outside of the unit. Gauges shall be connected to EMS where specified elsewhere in this specification.

B. Belts & Spare Stock:
   It is the intent of this specification that all equipment requiring or specified with belt drives (i.e. fans, energy recovery wheels in RTU's, AHU's, MAU's exhaust fans, etc…) be furnished with two (2) spare sets of belts for each piece of equipment in addition to those supplied with the unit.

   In addition, any items considered consumable or required for routine maintenance and service replacement within the first 18 months of an equipment's operation shall be supplied of adequate quantity to operate the equipment for a period of 24 months.

   Note: All units included in the 3-year warranty and maintenance plan shall not be supplied with spare belts as the contractor shall own belt changes for 3 years as part of the contract.

C. Consumables and Other Spare Stock:

   Any items considered consumable or required for routine maintenance and service replacement within the first 18 months of an equipment's operation shall be supplied of adequate quantity to operate the equipment for a period of 24 months. This shall include but not be limited to boiler ignitors and other items required for routine maintenance/replacement in equipment with the first 18 months of operation.

END OF SECTION 23 00 00

DO NOT REMOVE
THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 23 08 00

COMMISSIONING OF HVAC SYSTEMS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this section.

B. The OPR and BOD documentation are included by reference for information only.

1.02 SUMMARY

A. This section includes commissioning process requirements for HVAC&R systems, assemblies, and equipment.

B. Related Sections:

1. Division 01 Section "General Commissioning Requirements" for general commissioning process requirements.

1.03 DESCRIPTION

A. Refer to Division 01 Section “General Commissioning Requirements” for the description of commissioning.

1.04 DEFINITIONS

A. Refer to Division 01 Section “General Commissioning Requirements” for definitions.

1.05 SUBMITTALS

A. Refer to Division 01 Section “General Commissioning Requirements” for CxA’s role.

B. Refer to Division 01 Section “Submittals” for specific requirements. In addition, provide the following:

C. Certificates of readiness

D. Certificates of completion of installation, prestart, and startup activities.

E. O&M manuals

F. Test reports

1.06 QUALITY ASSURANCE

A. Test Equipment Calibration Requirements: HVAC Contractors will comply with test manufacturer’s calibration procedures and intervals. Recalibrate test instruments immediately after instruments have been repaired resulting from being dropped or damaged. Affix calibration tags to test instruments. Furnish calibration records to CxA upon request.

1.07 COORDINATION

A. Refer to Division 01 Section “General Commissioning Requirements” for requirements pertaining to coordination during the commissioning process.

PART 2 - PRODUCTS

2.01 TEST EQUIPMENT

A. All standard testing equipment required to perform startup, initial checkout and functional performance testing shall be provided by the Contractor for the equipment being tested. For example, the mechanical contractor of Division 23 shall ultimately be responsible for all standard testing equipment for the HVAC&R system and controls system in Division 23, except for equipment specific to and used by TAB in their commissioning responsibilities.

B. Special equipment, tools and instruments (specific to a piece of equipment and only available from vendor) required for testing shall be included in the base bid price to the Owner and left on site, except for stand-alone data logging equipment that may be used by the CxA.

C. Proprietary test equipment and software required by any equipment manufacturer for programming and/or start-up, whether specified or not, shall be provided by the manufacturer of the equipment. Manufacturer shall provide the test equipment, demonstrate its use, and assist in the commissioning process as needed. Proprietary test equipment (and software) shall become the property of the Owner upon completion of the commissioning process.

D. All testing equipment shall be of sufficient quality and accuracy to test and/or measure system performance with the tolerances specified in the Specifications. If not otherwise noted, the following minimum requirements apply: Temperature sensors and digital thermometers shall have a certified calibration within the past year to an accuracy of 0.5°F and a resolution of + or - 0.1°F. Pressure sensors shall have an accuracy of + or - 2.0% of the value range being measured (not full range of meter) and have been calibrated within the last year.

PART 3 - EXECUTION

3.01 GENERAL DOCUMENTATION REQUIREMENTS

A. With assistance from the installing contractors, the CxA will prepare Pre-Functional Checklists for all commissioned components, equipment, and systems

B. Red-lined Drawings: The contractor will verify all equipment, systems, instrumentation, wiring and components are shown correctly on red-lined drawings. Preliminary red-lined drawings must be made available to the Commissioning Team for use prior to the start of Functional Performance Testing. Changes, as a result of Functional Testing, must be incorporated into the final as-built drawings, which will be created from the red-lined drawings. The contracted party, as defined in the Contract Documents will create the as-built drawings.

C. Operation and Maintenance Data: Contractor will provide a copy of O&M literature within 45 days of each submittal acceptance for use during the commissioning process for all commissioned equipment and systems. The CxA will review the O&M literature once for conformance to project requirements. The CxA will receive a copy of the final approved O&M literature once corrections have been made by the HVAC Contractor.

D. Demonstration and Training: Contractor will provide demonstration and training as required by the specifications. A complete training plan and schedule must be submitted by the contractor to the CxA four weeks (4) prior to any training. A training agenda for each training session must be submitted to the CxA one (1) week prior the training session

3.02 HVAC CONTRACTOR'S RESPONSIBILITIES

A. Perform commissioning functional test procedures at the direction of the CxA. This includes but is not limited to the controls contractor verifying with the CxA that all sequences of operations are functioning properly.

B. Attend construction phase controls coordination meetings.

C. Attend testing, adjusting, and balancing review and coordination meetings.

D. Participate in HVAC&R systems, assemblies, equipment, and component maintenance orientation and inspection as directed by the CxA.

E. Provide information requested by the CxA for final commissioning documentation. This may include but is not limited to pipe pressure tests, duct leakage tests and flushing / cleaning reports.

F. Include requirements for submittal data, operation and maintenance data, and training in each purchase order or sub-contract written.

G. Prepare preliminary schedule for Mechanical system orientations and inspections, operation and maintenance manual submissions, training sessions, pipe and duct system testing, flushing and cleaning, equipment start-up, testing and balancing and task completion for owner. Distribute preliminary schedule to commissioning team members.

H. Update schedule as required throughout the construction period.

I. Assist the CxA in all verification and functional performance tests. While the CxA is onsite the contractor does not need to be with the CxA throughout the entire day but only needs to be available if assistance is needed (such as turning a piece of equipment on). The exception is that the controls contractor is expected to verify all sequences of operation with the CxA.

J. Provide measuring instruments and logging devices to record test data, and provide data acquisition equipment to record data for the complete range of testing for the required test period.

K. Gather operation and maintenance literature on all equipment, and assemble in binders as required by the specifications. Submit to CxA 45 days after submittal acceptance.

L. Coordinate with the CxA to provide 48-hour advance notice so that the witnessing of equipment and system start-up and testing can begin.

M. Notify the CxA a minimum of two weeks in advance of the time for start of the testing and balancing work. Attend the initial testing and balancing meeting for review of the official testing and balancing procedures.

N. Participate in, and schedule vendors and contractors to participate in the training sessions.

O. Provide written notification to the CM/GC and CxA Authority that the following work has been completed in accordance with the contract documents, and that the equipment, systems, and sub-system are operating as required.

P. The equipment supplier shall document the performance of his equipment.

Q. Provide a complete set of red-lined drawings to the CxA prior to the start of Functional Performance Testing.

R. Test, Adjust and Balance Contractor

1. Attend initial commissioning coordination meeting scheduled by the Commissioning Authority.
2. Submit the site specific testing and balancing plan to the CxA and AE for review and acceptance.
3. Attend the testing and balancing review meeting scheduled by the CxA. Be prepared to discuss the procedures that shall be followed in testing, adjusting, and balancing the HVAC&R system.
4. At the completion of the testing and balancing work, and the submittal of the final testing and balancing report, notify the HVAC&R contractor and the CM/GC.
5. At the completion of testing and balancing work, and the submittal of the final testing and balancing report, notify the HVAC&R Contractor and the CM/GC.

6. Participate in verification of the testing and balancing report, which will consist of repeating measurements contained in the testing and balancing reports. Assist in diagnostic purposes when directed.

S. Equipment Suppliers
   1. Provide all requested submittal data, including detailed start-up procedures and specific responsibilities of the Owner, to keep warranties in force.
   2. Assist in equipment testing per agreements with contractors.
   3. Provide information requested by CxA regarding equipment sequence of operation and testing procedures.

T. Refer to Division 01 Section “General Commissioning Requirements” for additional contractor responsibilities.

3.03 CxA'S RESPONSIBILITIES

A. Refer to Division 01 Section “General Commissioning Requirements” for CxA’s Responsibilities.

3.04 TESTING PREPARATION

A. Certify in writing to the CxA that HVAC&R systems, subsystems, and equipment have been installed, calibrated, and started and are operating according to the Contract Documents.

B. Certify in writing to the CxA that HVAC&R instrumentation and control systems have been completed and calibrated, that they are operating according to the Contract Documents, and that pretest set points have been recorded.

C. Certify in writing that testing, adjusting, and balancing procedures have been completed and that testing, adjusting, and balancing reports have been submitted, discrepancies corrected, and corrective work approved.

D. Place systems, subsystems, and equipment into operating mode to be tested (e.g., normal shutdown, normal auto position, normal manual position, unoccupied cycle, emergency power, and alarm conditions).

E. Inspect and verify the position of each device and interlock identified on checklists.

F. Check safety cutouts, alarms, and interlocks with smoke control and life-safety systems during each mode of operation.

G. Testing Instrumentation: Install measuring instruments and logging devices to record test data as directed by the CxA.

3.05 TESTING, ADJUSTING AND BALANCING VERIFICATION

A. Prior to performance of Testing, Adjusting and Balancing work, provide copies of reports, sample forms, checklists, and certificates to the CxA.

B. Notify the CxA at least ten (10) days in advance of testing and balancing Work, and provide access for the CxA to witness testing and balancing Work.

C. Provide technicians, instrumentation, and tools to verify testing and balancing of HVAC&R systems at the direction of the CxA.

1. The CxA will notify testing and balancing subcontractor ten (10) days in advance of the date of field verification. Notice will not include data points to be verified.
2. The testing and balancing subcontractor shall use the same instruments (by model and serial number) that were used when original data were collected.
3. Failure of an item includes, other than sound, a deviation of more than 10 percent. Failure of more than 10 percent of selected items shall result in rejection of final testing, adjusting, and balancing report. For sound pressure readings, a deviation of 3 dB shall result in rejection of final testing. Variations in background noise must be considered.
4. Remedy the deficiency and notify the CxA so verification of failed portions can be performed.

3.06 GENERAL TESTING REQUIREMENTS

A. Provide technicians, instrumentation, and tools to perform commissioning test at the direction of the CxA.

B. Scope of HVAC&R testing shall include entire HVAC&R installation, from central equipment for heat generation and refrigeration through distribution systems to each conditioned space. Testing shall include measuring capacities and effectiveness of operational and control functions.

C. Test all operating modes, interlocks, control responses, and responses to abnormal or emergency conditions, and verify proper response of building automation system controllers and sensors.

D. The CxA along with the HVAC&R contractor, testing and balancing Subcontractor, and HVAC&R Instrumentation and Control Subcontractor shall prepare detailed testing plans, procedures, and checklists for HVAC&R systems, subsystems, and equipment.

E. Tests will be performed using design conditions whenever possible.

F. Simulated conditions may need to be imposed using an artificial load when it is not practical to test under design conditions. Before simulating conditions, calibrate testing instruments. Provide equipment to simulate loads. Set simulated conditions as directed by the CxA and document simulated conditions and methods of simulation. After tests, return settings to normal operating conditions.

G. The CxA may direct that set points be altered when simulating conditions is not practical.

H. The CxA may direct that sensor values be altered with a signal generator when design or simulating conditions and altering set points are not practical.

I. If tests cannot be completed because of a deficiency outside the scope of the HVAC&R system, document the deficiency and report it to the Owner. After deficiencies are resolved, reschedule tests.

J. If the testing plan indicates specific seasonal testing, complete appropriate initial performance tests and documentation and schedule seasonal tests.

3.07 HVAC&R SYSTEMS, SUBSYSTEMS, AND EQUIPMENT TESTING PROCEDURES

A. Equipment Testing and Acceptance Procedures: Testing requirements are specified in individual Division 23 sections. Provide submittals, test data, inspector record, and certifications to the CxA.

B. HVAC&R Instrumentation and Control System Testing: Field testing plans and testing requirements are specified in Division 23 Sections. Assist the CxA with preparation of testing plans.

C. Pipe system cleaning, flushing, hydrostatic tests, and chemical treatment: Test requirements are specified in Division 23 piping Sections. HVAC&R Contractor shall prepare a pipe system cleaning, flushing, and hydrostatic testing plan. Provide cleaning, flushing, testing, and treating plan and final reports to the CxA. Plan shall include the following:

1. Sequence of testing and testing procedures for each section of pipe to be tested, identified by pipe zone or sector identification marker. Markers shall be keyed to Drawings for each pipe sector, showing the physical location of each designated pipe test section. Drawings keyed to pipe zones or sectors shall be formatted to allow each section of piping to be physically located and identified when referred to in pipe system cleaning, flushing, hydrostatic testing, and chemical treatment plan.
2. Description of equipment for flushing operations.
3. Minimum flushing water velocity.
4. Tracking checklist for managing and ensuring that all pipe sections have been cleaned, flushed, hydrostatically tested, and chemically treated.

D. Refrigeration System Testing: Provide technicians, instrumentation, tools, and equipment to test performance of chillers, cooling towers, refrigerant compressors and condensers, heat pumps, and other refrigeration systems. The CxA shall determine the sequence of testing and testing procedures for each equipment item and pipe section to be tested.

E. HVAC&R Distribution System Testing: Provide technicians, instrumentation, tools, and equipment to test performance of air, steam, and hydronic distribution systems; special exhaust; and other distribution systems, including HVAC&R terminal equipment and unitary equipment.

F. Vibration and Sound Tests**:** Provide technicians, instrumentation, tools, and equipment to test performance of vibration isolation and seismic controls.

G. The work included in the commissioning process involves a complete and thorough evaluation of the operation and performance of all components, systems and sub-systems. The following equipment and systems shall be evaluated:

HVAC Systems
Boilers
Chillers
Piping
Heat Exchangers
Pumps and drives
Air handler systems
Roof Top Units
Heating and ventilating units
Induction Units
Displacement terminal units
Unit Ventilators
Cabinet unit heaters
Fan coil units
Unit heaters
Radiant panels
Finned tube radiation
Convectors
Chilled Beams
Exhaust fans
Combustion air units
Split system AC
Make-up air units
Fume hoods
Heat recovery systems
Thermal Solar Systems
Testing, adjusting and balancing spot check
Automated temperature controls and energy management systems
Building Automation and Controls
Interface of these systems with HVAC systems, fire alarm and security systems.

3.08 DEFICIENCIES/NON-CONFORMANCE, COST OF RETESTING, FAILURE DUE TO MANUFACTURER DEFECT

A. Refer to Division 01 Section “General Commissioning Requirements” for requirements pertaining to deficiencies/non-conformance, cost of retesting, or failure due to manufacturer defect.

3.09 APPROVAL

A. Refer to Division 01 Section “General Commissioning Requirements” for approval procedures.

3.10 DEFERRED TESTING

A. Refer to Division 01 Section “General Commissioning Requirements” for requirements pertaining to deferred testing.

3.11 OPERATION AND MAINTENANCE MANUALS

A. The Operation and Maintenance Manuals shall conform to Contract Documents requirements as stated in Division 01.

B. Refer to Division 01 Section “General Commissioning Requirements” for the AE and CxA roles in the Operation and Maintenance Manual contribution, review and approval process.

3.12 TRAINING OF OWNER PERSONNEL

A. Refer to Division 01 Section “General Commissioning Requirements” for requirements pertaining to training.

END OF SECTION

DO NOT REMOVE
THIS PAGE INTENTIONALLY LEFT BLANK

Section 26 00 01

ELECTRICAL

(TRADE CONTRACT REQUIRED)

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 TIME, MANNER AND REQUIREMENTS FOR SUBMITTING SUB-BIDS:

A. Sub-bids for work under this Section shall be for the complete work and shall be filed in a sealed envelope with the City of Worcester, Department of Public Works and Parks, Architectural Division, 50 Skyline Drive, Worcester, MA 01605 at time and place stipulated in the “Invitation to Bid/Notice to Contractors”. The following shall appear on the upper left hand of the envelope:

Name of Sub-Bidder: *Print Name of Sub-bidder*

Project: SOUTH HIGH COMMUNITY SCHOOL

Sub-Bid for Section: 260001 – ELECTRICAL

B. Each sub-bid submitted for work under this Section shall be on forms furnished by the City of Worcester as required by Section 44F of Chapter 149 of the General Laws, as amended. Sub-Bid forms may be obtained at the Department of Public Works and Parks, Architectural Division, 50 Skyline Drive, Worcester, MA 01605 in person, or by written request.

C. Sub-bids filed with the City of Worcester shall be accompanied by a BID BOND or CASH or CERTIFIED CHECK or a TREASURER’S or CASHIER’S CHECK issued by a responsible bank or trust company payable to the City of Worcester in the amount of five (5) percent of the bid. A sub-bid accompanied by any other form of bid deposit than those specified will be rejected.

D. Additional Requirements:

1. Sub-bidder's attention is directed to Massachusetts G.L. Chapter 149 §44H, as amended, which provides in part as follows:

2. Each sub-bidder shall list in Paragraph E of the "Form for Sub-bids" the name and bid price of each person, firm or corporation performing each class of work or part thereof for which the Section of the Specifications for that sub-subtrade requires such listing, provided that, in the absence of a contrary provision in the Specifications, any sub-bidder may, without listing any bid price, list his own name or part thereof and perform that work with persons on his own payroll, if such sub-bidders, after sub-bid openings, shows to the satisfaction of the Awarding Authority that he does customarily perform such class of work with persons on his own payroll and is qualified to do so. This Section of the Specifications requires that the following classes of work shall be listed in Paragraph E under the conditions indicated herein.

Class of Work	Reference Specification
Electric Vehicle Charging Station	26 27 29
Photovoltaic System	26 31 00
Lightning Protection for Structures	26 41 13
Stage and House Lighting and Controls	26 50 00
Exterior Athletic Field Lighting	26 56 68
Communications Backbone Cabling	27 13 00
Communications Horizontal Cabling	27 15 00
Testing of Fiber Infrastructure	27 17 10
Testing Category 6A Twist Pair Infrastructure	27 12 20
Data Communications Network Equipment	27 21 00
Area of Refuge System	27 30 00
Voice Communications Equipment	27 31 00
Audio-Video Communications	27 41 00
Integrated Audiovisual Systems	27 41 16
In-Ceiling Classroom Audio System	27 41 20
In-Building Cellular Amplification System	27 50 00
Handheld Radio Amplification System	27 50 10
Public Address System	27 51 16
Digital Signage and Clock System	27 51 29
Public Safety Radio DAS	27 53 19
Unified Security System	28 10 00
Addressable Fire-Alarm System	28 31 11

E. The work done by this sub-bidder is shown on the following drawings:

1. The work of this Trade Contract is shown on the following drawings:

ELECTRICAL

E0.1, E0.2, E0.3A, E0.3B, E0.3C, E0.3D, E0.4A, E0.4B, E0.4C, E0.4D, E0.4E, E0.4F, E0.5, E0.6, E0.7, E0.8, E0.9, E1.1, E1.2, E1.3, E1.4, E1.5, E1.6, E1.7, E1.8, E1.9, E1.10, E1.11, E1.12, E1.13, E1.14, E2.1, E2.2, E2.2A, E2.3, E2.4, E2.4A, E2.4B, E2.5, E2.6, E2.7, E2.8, E2.9, E2.10, E2.11, E2.12, E3.1, E3.2, E3.3, E3.4, E3.5, E3.6, E3.7, E3.8, E3.9, E3.10, E3.11, E3.12, E3.13, E3.14, E3.15, E3.16, E3.17, E3.18, E4.1, E4.2, E4.3, E4.4, E4.5, E4.6, E4.7, E4.8, E4.9, E4.10, E4.11, E4.12, E5.1, E5.2, E5.3, E5.4, E5.5, E5.6, E5.7, E5.8, E5.9, E5.10, E5.11, E5.12, E5.13, E5.14, E5.15, E5.16, E6.1, E6.2, E6.3, E6.4, E6.5, E6.6A, E6.6B, E6.7A, E6.7B, E6.7C, E7.0, E7.1, E7.2, E7.3, E7.4, E7.5, E7.6, E7.7, E8.0A, E8.0B, E8.0C, E8.0D, E8.0E, E8.0F, E8.0G, E8.1A, E8.1B, E8.2A, E8.2B, E8.2C, E8.2D, E8.3A, E8.3B, E8.3C, E8.3D, E8.4A, E8.4B, E8.4C, E8.5A, E8.5B, E8.5C, E8.5D, E8.6A, E8.6B, E8.7, E8.8A, E8.8B, E8.8C, E9.01, E9.02, E9.03, E9.04, E9.05, E9.06, E9.07, E9.08, E9.09, E9.10, E9.11, E9.12, E9.13, E9.14, E9.15

AUDIO VISUAL

AV0.0, AV0.1, AV0.2, AV3.3, AV3.4, AV3.5, AV3.7, AV3.8, AV3.9, AV3.10, AV3.18, AV4.5, AV4.6, AV4.7, AV4.8, AV4.9, AV5.0, AV5.1, AV5.2, AV5.3, AV5.4, AV5.5, AV5.6, AV5.7, AV6.1, AV6.2, AV6.3, AV7.1, AV7.2, TL1, TL2, TL3, TL4, TR1, TR2, TR3, TR4

2. Related items which may require coordination or impact work of this trade are shown on the following Drawings:

EXISTING SITE

EX1.0, EX2.0, EX2.1, EX2.2, EX2.3, EX2.4, C1.0

CIVIL

C2.0, C3.0, C3.1, C3.2, C3.3, C3.4, C4.0, C4.1, C4.2, C4.3, C4.4, C5.0, C5.1, C5.2, C5.3, C5.4, C6.0, C6.1, C6.2, C6.3, C7.0, C7.1, C7.2, C7.3, C7.4, C8.0, C8.1, C8.2, C8.3, C8.4, C9.0, C9.1, C9.2, C9.3, C9.4, C10.0, C10.1, C10.2, C10.3, C10.4, C10.5, C10.6, C10.7, C11.0, C11.1, C11.2, C11.3, C11.4, C11.5, C11.6, C11.7

CIVIL ATHLETIC

CA1.1, CA2.1, CA2.2, CA3.1, CA3.2, CA3.3, CA4.1, CA4.2, CA4.3, CA4.4, CA4.5, CA4.6, CA4.7, CA4.8

LANDSCAPE

L1.0, L2.0, L2.1, L2.2, L2.3, L2.4, L2.5, L2.6, L2.7, L2.8, L2.9, L3.0, L3.1, L3.2, L3.3, L3.4, L3.5, L4.0, L4.1, L4.2, L4.3, L5.0, L5.1, L5.2, L5.3, L5.4, L5.5, L5.6

STRUCTURAL

S1.1, S1.2, S1.3, S3.1, S3.2, S3.3, S3.4, S3.5, S3.6, S3.7, S3.8, S3.9, S3.10, S3.11, S3.12, S3.13 S3.14, S3.15, S3.16, S4.11, S4.12, S4.13, S4.14, S4.15, S4.16, S4.17, S4.18, S4.19, S4.20, S4.21, S4.22, S4.23, S4.24, S5.1, S5.2, S5.3, S5.4, S5.5, S5.6, S6.1, S7.1, S7.2, S7.3, S7.4, S7.5

ARCHITECTURAL DEMOLITION

AD1.0

ARCHITECTURAL

A1.1, A2.1, A2.2, A2.3, A2.4, A2.5, A3.0, A3.0A, A3.1, A3.2, A3.3, A3.4, A3.5, A3.6, A3.7, A3.8, A3.9, A3.10, A3.11, A3.12, A3.13, A3.14, A3.15, A3.16, A3.17, A3.18, A4.1, A4.2, A4.3, A4.4, A4.5, A4.6, A4.7, A4.8, A4.9, A4.10, A4.11, A4.12, A5.0, A5.1, A5.2, A5.3, A5.4, A5.5, A5.6, A5.7, A5.8, A5.11, A5.12, A6.1, A6.2, A6.3, A6.4, A6.5, A6.6,

A6.7, A6.8, A6.11, A6.12, A6.13, A6.14, A6.15, A6.16, A6.17, A6.18, A6.21, A6.22, A6.23, A6.24, A6.25, A6.26, A6.27, A6.28, A6.29, A6.31, A6.32, A6.33, A6.34, A6.35, A7.1, A7.2, A7.3, A7.4, A7.5, A7.6, A7.7, A8.1, A8.2, A8.3, A8.4, A8.5, A8.6, A8.7, A8.8, A8.9, A8.10, A8.11, A8.12, A8.13, A8.14, A8.15, A8.16, A8.17, A8.18, A8.19, A8.20, A8.21, A8.22, A8.23, A8.24, A8.25, A8.26, A8.27, A8.28, A8.29, A9.1, A9.2, A9.3, A9.4, A9.5, A9.6, A10.1, A10.2, A10.3, A10.4, A11.1, A11.2, A11.3, A12.1, A12.2, A12.3, A12.4, A12.5, A12.6, A12.7, A12.8, A12.9, A12.10, A12.11, A12.12

FOODSERVICE

K1.1, K1.2, K1.3, K2.1, K2.2, K2.3, K2.4, K3.1, K3.2, K3.3, K3.4, K3.5, K3.6, K3.7, K4.1, K4.2, K4.3, K4.4, K4.5, K4.6, K5.1, K5.2, K6.1, K6.2, K6.3, K6.4, K6.5

FIRE PROTECTION

FP1.1, FP1.2, FP1.3, FP1.4, FP4.1, FP4.2, FP4.3, FP4.4, FP4.5, FP4.6, FP4.7, FP4.8, FP4.9, FP4.10, FP4.11, FP4.12, FP7.1

PLUMBING

P2.1, P2.2, P2.3, P2.4, P3.1, P3.2, P3.3, P3.4, P3.5, P3.6, P3.7, P3.8, P3.9, P3.10, P3.11, P3.12, P3.13, P3.14, P3.15, P3.16, P4.1, P4.2, P4.3, P4.4, P4.5, P4.6, P4.7, P4.8, P4.9, P4.10

HVAC

H3.1, H3.2, H3.3, H3.4, H3.5, H3.6, H3.7, H3.8, H3.9, H3.10, H3.11, H3.12, H3.13, H3.14, H3.15, H3.16, H4.1, H4.2, H4.3, H4.4, H4.5, H4.6, H4.7, H4.8, H4.9, H4.10, H4.11, H4.12, H5.1, H5.2, H5.3, H6.1, H6.2, H6.3, H7.1, H7.2, H7.3

3. The complete List of Drawings for the Project is provided in Section 00 01 15.

1.3 DESCRIPTION OF WORK

A. The work of this section is work of a Publicly Bid Electrical Subcontractor and includes the following requirements:

1. Specification requirements for the Trade Contract “ELECTRICAL WORK” include all of the following listed Specification Sections in their entirety:

a. 26 00 01 Electrical

b. 26 05 00 Common Work Results for Electrical

c. 26 05 19 Electrical Power Conductors and Cables

d. 26 05 26 Grounding and Bonding for Electrical Systems

e. 26 05 29 Hangers and Supports for Electrical Systems

f. 26 05 33 Raceway and Boxes for Electrical Systems

g. 26 05 48 Vibration and Seismic Controls for Electrical Systems

h. 26 05 53 Identification for Electrical Systems
i. 26 05 73 Overcurrent Protective Device Coordination Study
j. 26 09 13 Electrical Power Monitoring and Control
k. 26 09 43 Network Lighting Controls
l. 26 22 00 Low Voltage Transformers
m. 26 24 13 Switchboards
n. 26 24 16 Panelboards
o. 26 24 19 Motor Controls
p. 26 25 00 Low Voltage Plug-In and Feeder Busway
q. 26 27 26 Wiring Devices
r. 26 27 29 Electrical Vehicle Charging Station
s. 26 28 13 Fuses
t. 26 28 16 Enclosed Switches and Circuit Breakers
u. 26 31 00 Photovoltaic System
v. 26 32 13 Engine Generators
w. 26 36 00 Transfer Switches
x. 26 41 13 Lightning Protection for Structures
y. 26 50 00 Stage and House Lighting and Controls
z. 26 51 00 Interior Lighting
aa. 26 56 00 Exterior Lighting
bb. 26 56 68 Exterior Athletic Field Lighting
cc. 27 11 00 Communications Equipment Room Fittings
dd. 27 13 00 Communications Backbone Cabling
ee. 27 15 00 Communications Horizontal Cabling
ff. 27 17 10 Testing of Fiber Infrastructure
gg. 27 12 20 Testing Category 6A Twist Pair Infrastructure
hh. 27 21 00 Data Communications Network Equipment
ii. 27 30 00 Area of Refuge System
jj. 27 31 00 Voice Communications Equipment
kk. 27 41 00 Audio-Video Communications
ll. 27 41 16 Integrated Audiovisual Systems
mm. 27 41 20 In-Ceiling Classroom Audio System
nn. 27 50 00 In-Building Cellular Amplification System
oo. 27 50 10 Handheld Radio Amplification System
pp. 27 51 16 Public Address System
qq. 27 51 29 Digital Signage and Clock System

rr. 27 53 19 Public Safety Radio DAS

ss. 28 10 00 Unified Security System

tt. 28 31 11 Addressable Fire-Alarm System

B. Alternates: Special attention is called to the fact that it shall be the responsibility of all the General and Subcontractors to thoroughly examine all the alternates and evaluate for themselves as to whether or not these alternates in any way affect their respective section. In the event that a Contractor feels that any alternate(s) do reflect a cost difference, additional or a deduction in his bid proposal, then he shall so stipulate this sum and/or sums under the proper alternate(s) as provided for the bid proposals. Failure to do so will in no way relieve the hereinbefore stated contractors of their responsibilities regardless of what alternate(s) are selected at no extra cost will be charged to the Owner. Refer to Section 01 23 00, ALTERNATES for the list and description of Alternates.

C. Items to Be Installed Only: Install the following items as furnished by the designated Sections:

1. Division 8 – OVERHEAD COILING DOORS:
    a. Controllers, wiring and power connections for overhead coiling doors.
2. Division 8 – HOLD OPEN DEVICE:
    a. Controllers, wiring and power connections for hold open devices.
3. Division 10 – VIDEO DISPLAY BOARDS:
    a. Controllers, wiring and power connections for video display boards.
    b. TV/monitor in the lobby.
4. Division 11 – PROJECTION SCREENS:
    a. Controllers, wiring and power connections for electrically-operated projection screens.
5. Division 11 – GYMNASIUM DIVIDER:
    a. Controllers, wiring and power connections for electrically-operated projection screens, curtains, backboards and scoreboards.
6. Division 12 – FURNISHINGS:
    a. Power and telecommunications connections for casework, including boxes and wiring devices.
7. Division 21 – FIRE PROTECTION:
    a. Connections to fire alarm system for water flow switches and tamper switches.
8. Division 22 – PLUMBING:
    a. Power connections for:
        1) Water heaters, hand dryers, automatic flush and faucets.
        2) Gas Sniffers.
        3) Gas Shut-offs.
9. Division 23 – HEATING, VENTILATING AND AIR CONDITIONING:
    a. Power connections for control panels, pumps, fans, electric unit heaters, boilers, VAVs.
10. Division 31 – EARTH WORK:

a. Anchor bolts and conduit sweeps for light pole bases.

D. Items to Be Furnished Only: Furnish the following items for installation by the designated Sections:

1. Division 3 – CAST-IN-PLACE CONCRETE:
   a. Lintels, sleeves, anchors, inserts, plates and similar items for electrical systems.
2. Division 4 – UNIT MASONRY:
   a. Access doors in masonry openings.
3. Division 9 – GYPSUM BOARD ASSEMBLIES:
   a. Access doors in gypsum board assemblies.
4. Division 9 – TILING:
   a. Access doors in tile.
5. Division 9 – ACOUSTICAL PANEL CEILINGS:
   a. Access doors in acoustical tile
6. Division 23 – HEATING, VENTILATING AND AIR CONDITIONING:
   a. Duct smoke detectors and sampling tubes.

E. Related Work: The following items are not included in this Section and will be performed under the designated Sections:

1. Section 01 60 00 – PRODUCT REQUIREMENTS: Owner's proprietary products and requirements for the same.
2. Division 3 – CAST-IN-PLACE CONCRETE for interior concrete equipment pads and installation of backboxes and conduit for electrical devices and light fixtures.
3. Division 5 – STRUCTURAL STEEL FRAMING for structural supports necessary to distribute loading from equipment to roof or floor.
4. Division 6 – ROUGH CARPENTRY for plywood backing panels.
5. Division 7 – FIRESTOPPING for coordination of floor and wall penetrations.
6. Division 8 – DOOR HARDWARE for coordination with electrified door hardware.
7. Division 9 – GYPSUM BOARD ASSEMBLIES for coordination with gypsum ceilings.
8. Division 9 – ACOUSTICAL PANEL CEILINGS for coordination with acoustical ceilings.
9. Division 22 – PLUMBING for coordination with sensors located at plumbing fixtures.
10. Division 23 – HEATING, VENTILATING AND AIR CONDITIONING for coordination with HVAC piping and ductwork, motors, and control wiring except 120 VAC power to control panels as indicated on the Drawings
11. Division 31 – EARTH MOVING for excavation and backfilling for underground work.

F. Commissioning: The Electrical systems will be commissioned by an independent commissioning agent (CxA). This sub-contractor shall review all commissioning requirements outlined in Sections 01 91 13 (GENERAL COMMISSIONING REQUIREMENTS) and 01 43 25 (TESTING AGENCY SERVICES), and shall provide all commissioning task labor and documentations, attend all required meetings, and provide all on-site assistance required by the CxA to properly complete their work.

G. The Electrical Sub-Contractor shall be responsible for filing all documents, payment of all fees, and securing of all inspections and approvals necessary for the electrical work.

H. The Owner shall be responsible for all Utility Company and Municipal backcharges for all materials furnished and work performed by them in conjunction with this Contract and pay same to the respective agency upon demand.

1.4 EXAMINATION OF SITE AND DOCUMENTS

A. Bidders are expected to examine and to be thoroughly familiar with all contract documents and with the conditions under which work will be carried out. The Awarding Authority (Owner) will not be responsible for errors, omissions and/or charges for extra work arising from General Contractor or Filed Subcontractor's failure to familiarize themselves with the Contract Documents or existing conditions. By submitting a bid, the Bidder agrees and warrants that he has had the opportunity to examine the site and the Contract Documents, that he is familiar with the conditions and requirements of both and where they require, in any part of the work a given result to be produced, that the Contract Documents are adequate and that he will produce the required results. Pre-Bid Conference: Bidders are strongly encouraged to attend the Pre-Bid conference; refer to INVITATION TO BID for time and date.

B. Pre-Bid Conference: Bidders are strongly encouraged to attend the Pre-Bid conference; refer to Invitation to Bid for time and date.

1.5 REFERENCES

A. Except where modified by a specific notation to the contrary, it shall be understood that the indication and/or description of any electrical item in the drawings or specifications for electrical work carries with it the instruction to furnish, install and connect the item as part of the electrical work, regardless of whether or not this instruction is explicitly stated.

B. It shall be understood that the specifications and drawings for electrical work are complimentary and are to be taken together for a complete interpretation of the electrical work. Where the specifications and drawings for electrical work conflict with each other the costlier item will take precedence over the less costly unless the Designer rules otherwise.

1.6 REGULATORY REQUIREMENTS

A. Comply with all applicable federal and state laws, and all local codes, by-laws and ordinances.

B. Where provisions of the Contract Documents conflict with any codes, rules or regulations, the latter shall govern. Where the contract requirements are in excess of applicable codes, rules or regulations, the contract provisions shall govern unless the Designer rules otherwise.

C. Request inspections from authorities having jurisdiction, obtain all permits and pay for all fees and inspection certificates as applicable and/or required. All permits and certificates shall be turned over to the Owner at the completion of the work. Copies of permits shall be given to the Owner prior to the start of work.

D. Unless otherwise specified or indicated, materials and workmanship and equipment performance shall conform with the latest edition of the following standards, codes, specifications, requirements and regulations:

1. State Building Code
2. State Electrical Code
3. National Fire Protection Association (NFPA)
4. Local Town Regulations and By-laws

5. Underwriter's Laboratories, Inc. (UL)
6. National Electrical Manufacturer's Association (NEMA)
7. American National Standards Institute (ANSI)

E. All electrical work shall meet or exceed any other state and local codes and/or authorities having jurisdiction including all other standards indicated herein.

1.7 QUALITY ASSURANCE

A. Company specializing in work described in the above listed individual specification sections with minimum 5 years documented experience.

B. The requirements of the State Building Code and local regulations establish the minimum acceptable quality of workmanship and materials, and all work shall conform thereto unless more stringent requirements are indicated or specified herein.

C. All work shall comply with the latest editions of the codes as referenced herein.

D. Follow manufacturer's directions for articles furnished, in addition to directions shown on drawings or specified herein.

E. Protect all work, materials, and equipment from damage during process of work. Replace all damaged or defective work, materials and equipment without additional cost to the Owner.

F. All equipment and materials for permanent installation shall be the products of recognized manufacturers and shall be new.

G. Equipment and materials shall:

1. Where normally subject to Underwriters Laboratory Inc. listing or labeling services, be so listed or labeled.
2. Be without blemish or defect.
3. Not be used for temporary light and power purposes.
4. Be in accordance with the latest applicable NEMA standards.
5. Be products which will meet with the acceptance of all authorities having jurisdiction over the work. Where such acceptance is contingent upon having the products examined, tested and certified by Underwriters or other recognized testing laboratory, the product shall be so examined, tested and certified.

H. Except for conduit, conduit fittings, outlet boxes, wire and cable, all items of equipment or material of one generic type shall be the product of one manufacturer throughout.

I. For items which are to be installed but not purchased as part of the electrical work, the electrical work shall include:

1. The coordination of their delivery.
2. Their unloading from delivery trucks driven into any point on the property line at grade level.
3. Their safe handling and field storage up to the time of permanent placement in the project.
4. The correction of any damage, defacement or corrosion to which they may have been subjected. Replacement if necessary shall be coordinated with Contractor who originally purchased the item.

5. Their field make-up and internal wiring as may be necessary for their proper operation.

6. Their mounting in place including the purchase and installation of all dunnage, supporting members, and fastenings necessary to adapt them to architectural and structural conditions.

7. Their connection to building wiring including the purchase and installation of all termination junction boxes necessary to adapt and connect them to this wiring. Included also shall be the purchase and installation of any substitute lugs or other wiring terminations as may be necessary to adapt their terminals to the building wiring as called for and to the connection methods set forth in these specifications.

J. Items which are to be installed but not purchased as part of the electric work shall be carefully examined upon delivery to the project. Claims that any of these items have been received in such condition that their installation will require procedures beyond the reasonable scope of the electric work will be considered only if presented in writing within one week of the date of delivery to the project of the items in question. The electric work includes all procedures, regardless of how extensive, necessary to put into satisfactory operation, all items for which no claims have been submitted as outlined above.

1.8 SUBMITTALS

A. Comply with requirements specified in Division 1.

B. Material and equipment requiring Shop Drawing Submittals shall include but not be limited to:

1. 26 00 01 Electrical
2. 26 05 00 Common Work Results for Electrical
3. 26 05 19 Electrical Power Conductors and Cables
4. 26 05 26 Grounding and Bonding for Electrical Systems
5. 26 05 29 Hangers and Supports for Electrical Systems
6. 26 05 33 Raceway and Boxes for Electrical Systems
7. 26 05 48 Vibration and Seismic Controls for Electrical Systems
8. 26 05 53 Identification for Electrical Systems
9. 26 05 73 Overcurrent Protective Device Coordination Study
10. 26 09 13 Electrical Power Monitoring and Control
11. 26 09 43 Network Lighting Controls
12. 26 22 00 Low Voltage Transformers
13. 26 24 13 Switchboards
14. 26 24 16 Panelboards
15. 26 24 19 Motor Controls
16. 26 25 00 Low Voltage Plug-In and Feeder Busway
17. 26 27 26 Wiring Devices
18. 26 27 29 Electrical Vehicle Charging Station
19. 26 28 13 Fuses
20. 26 28 16 Enclosed Switches and Circuit Breakers
21. 26 31 00 Photovoltaic System

22. 26 32 13 Engine Generators
23. 26 36 00 Transfer Switches
24. 26 41 13 Lightning Protection for Structures
25. 26 50 00 Stage and House Lighting and Controls
26. 26 51 00 Interior Lighting
27. 26 56 00 Exterior Lighting
28. 26 56 68 Exterior Athletic Field Lighting
29. 27 11 00 Communications Equipment Room Fittings
30. 27 13 00 Communications Backbone Cabling
31. 27 15 00 Communications Horizontal Cabling
32. 27 17 10 Testing of Fiber Infrastructure
33. 27 12 20 Testing Category 6A Twist Pair Infrastructure
34. 27 21 00 Data Communications Network Equipment
35. 27 30 00 Area of Refuge System
36. 27 31 00 Voice Communications Equipment
37. 27 41 00 Audio-Video Communications
38. 27 41 16 Integrated Audiovisual Systems
39. 27 41 20 In-Ceiling Classroom Audio System
40. 27 50 00 In-Building Cellular Amplification System
41. 27 50 10 Handheld Radio Amplification System
42. 27 51 16 Public Address System
43. 27 51 29 Digital Signage and Clock System
44. 27 53 19 Public Safety Radio DAS
45. 28 10 00 Unified Security System
46. 28 31 11 Addressable Fire-Alarm System

1.9 CONTRACT DRAWINGS AND SPECIFICATIONS

A. Drawings are diagrammatic and indicate the general arrangement of the various systems and approximate and relative locations of the materials and equipment defined by the specifications. Coordinate with and obtain the approval of the owner, architect, and engineer for the exact locations of all materials and equipment. Check the drawings, specifications, and all fabrication and shop drawings (including fabrication and shop drawings of other trades) to verify space conditions, headroom requirements, characteristics, and for coordination. Where space conditions and headroom requirements appear inadequate, notify the engineer before submitting a bid. No consideration or allowance will be granted for failure to notify the engineer, or for any alleged misunderstanding of the requirements above. Completely furnish, install, connect, and interconnect all components of all systems in accordance with contract requirements, manufacturer's instructions, applicable codes and standards, and best practices of the trade.

B. Minor deviations, variations, changes, and connections from layouts shown on the drawings (based on coordination, conditions, manufacturer's instructions, codes and standards, shop

drawings, and verification of measurements and conditions) are permitted to facilitate construction provided the changes do not represent potential changes in scope of work (see the section of these specifications "Changes to the Scope of Work") and provided the changes are acceptable to the owner, architect, and engineer.

C. Before submitting bid, examine and check all drawings and specifications relating to all work, including electrical, mechanical, plumbing, general construction, fire protection, and any other trades' drawings and specifications (as well as Division 1 General Conditions) and become fully informed as to the extent and character of work required and its relation to the work of other trades. No consideration, claims, charges, or compensation will be granted for any alleged misunderstanding of the work to be performed, or the force and intent of these specifications.

D. Fully coordinate (prior to releasing doors and hardware) with the General Contractor to ensure that all doors to rooms housing new large electrical equipment swing open in the direction of egress and are equipped with proper "panic" hardware as per the NEC where applicable.

1.10 VISIT TO SITE

A. Before estimating work, visit the project site and verify all measurements and field conditions affecting the work. The contractor is fully responsible for the correctness of all measurements. Submission of bid is considered evidence that this contractor has visited and examined the site. No consideration, claims, charges, or compensation will be granted for extra work as a result of the contractor's failure to visit the site or verify conditions and measurements.

1.11 SURVEYS AND MEASUREMENTS

A. Base all required measurements, both horizontal and vertical, on reference points established by the General Contractor and be responsible for the correct laying out of the electrical work. In the event of a discrepancy between actual measurements and those indicated, notify the General Contractor in writing, and do not proceed with the work required until written instructions have been issued by the General Contractor.

B. The Electrical Contractor is solely responsible for verifying field measurements, conditions, and drawing and specifications information (for all trades) before ordering materials and equipment and before commencing work. The Electrical Contractor is solely responsible for verifying shop drawings (including shop drawings of other trades) before releasing related materials and equipment and before rough in. No consideration, claims, charges, or compensation will be granted due to any differences between the actual dimensions and any dimensions indicated on the drawings.

C. Report any apparent discrepancies or conflicts found at once to the engineer for consideration and wait for a decision before proceeding with any work in the affected area.

D. The engineer's decisions in cases of discrepancies, conflicts, and related to verification of measurements and conditions are final and binding upon the Electrical Contractor, make all installation accordingly.

1.12 EXISTING CONDITIONS AND UTILITIES

A. Existing Conditions

1. Information and data indicated on the drawings regarding existing conditions (including underground utilities) is from the best available sources. However, no assurance is made as to completeness and/or accuracy.

2. Contact all utility companies operating in the project vicinity (water, gas, sewage, electric, telephone, cable television, etc.) and the owner's maintenance department

(where applicable) and verify all existing underground systems before any excavation commences.

3. Relocate any existing underground electrical feeders and wiring in areas of construction and around proposed foundations as required. Include all costs in bid. If any third-party owned wiring or equipment interferes with construction, notify the engineer.

B. Demolition of Utilities

1. The electrical contractor shall be responsible for coordinating with utility company for disconnecting and making safe power to the existing building to facilitate demolition by the general contractor.

1.13 ITEMS NOT SHOWN OR SPECIFIED

A. Provide any items of material not indicated on the drawings and/or not specified, but which are required for the complete and proper installation and/or operation of any part of the work, as if indicated and specified.

B. Provide any work not indicated on the drawings and/or not specified, but which is required for compliance with applicable codes and regulations, as if indicated and specified.

C. No consideration, claims, charges, or compensation will be granted for performing work required for complete and proper installation/operation or required for compliance with applicable codes and regulations.

1.14 COORDINATION

A. Electrical Drawings are diagrammatic. They indicate general arrangements of electrical systems and other work. They do not show all offsets required for coordination nor do they show the exact routings and locations needed to coordinate with structure and other trades and to meet Architectural requirements.

B. Work shall be performed in cooperation with other trades on the project and so scheduled as to allow speedy and efficient completion of the work.

C. Furnish to other trades advance information on locations and sizes of all frames, boxes, sleeves and openings needed for their work, and also furnish information and shop drawings necessary to permit trades affected by the work to install same properly and without delay.

D. In all spaces, prior to installation of visible material and equipment, including access panels, review Architectural Drawings for exact locations and where not definitely indicated, request information from Designer. Where the electrical work shall interfere with the work of other trades, assist in working out the space conditions to make satisfactory adjustments before installation. Without extra cost to the Owner, make reasonable modifications to the work as required by normal structural interferences. Pay the General Contractor for additional openings, or relocating and/or enlarging existing openings through concrete floors, walls, beams and roof required for any work which was not properly coordinated. Maintain maximum headroom at all locations. All piping, duct, conduit, and associated components to be as tight to underside of structure as possible.

E. If any electrical work has been installed before coordination with other trades so as to cause interference with the work of such trades, all necessary adjustments and corrections shall be made by the electrical trades involved without extra cost to the Owner.

F. Where conflicts or potential conflicts exist and engineering guidance is desired, submit sketch of proposed resolution to Designer for review and approval.

G. Protect all materials and work of other trades from damage which may be caused by the electrical work, and repair all damages without extra cost to the Owner.

1.15 MECHANICAL AND ELECTRICAL COORDINATION

A. HVAC Subcontractor shall furnish and install various electrical items relating to the HVAC equipment and control apparatus. The Electrical Subcontractor shall be required to connect power wiring to this equipment unless noted otherwise.

B. The HVAC and Electrical Subcontractors shall coordinate their respective portions of the work, as well as the electrical characteristics of the heating and ventilating equipment.

C. All power wiring and local disconnect switches will be provided by the Electrical Subcontractor for the line voltage power. All control and interlocking wiring shall be the responsibility of the HVAC Subcontractor.

D. 120V and above power wiring sources extended and connected to heating and ventilating control panels, transformers and switches shall be the responsibility of the Electrical Subcontractor. All low voltage thermostat, zone valve and any switch wiring shall be the responsibility of the HVAC Subcontractor.

E. Temperature control and equipment wiring shall be installed by the HVAC Subcontractor.

F. Pipe Tracing shall be furnished and installed by the specified subcontractor. Power connections shall be by the Electrical Subcontractor.

G. The Electrical Subcontractor will provide all magnetic starters and disconnect switches except those furnished as an integral part of packaged equipment.

H. The Electrical Contractor shall be responsible for reviewing submittals (provided by the General Contractor) of other trades prior to submitting electrical submittals, ordering or installing any electrical equipment, conduit, wire, materials, etc. Review:

1. Mechanical equipment submittals.
2. Plumbing equipment submittals.
3. Fire protection equipment submittals.
4. Theatrical dimming and audio-video equipment submittals.
5. Kitchen equipment submittals.
6. Elevator submittals.
7. Media distribution and audio-video equipment submittals.
8. Intrusion detection and access control equipment submittals.
9. Video surveillance equipment submittals.
10. Public address/clock equipment submittals.
11. Owner supplied equipment submittals.

I. The Electrical Contractor must review and incorporate all the electrical loads and characteristics from all the shop drawings submittals of other trades as part of their submittals.

J. Where conflicts or potential conflicts exist, immediately refer the conflicts to the Architect and the engineer in writing for decision to prevent delay in installation of work.

1.16 MECHANICAL AND ELECTRICAL COORDINATION DRAWINGS

A. Refer to Division 1 – PROJECT MANAGEMENT, COORDINATION AND COMMISSIONING for coordination drawing requirements

1.17 INSTALLATION REQUIREMENTS

A. The arrangement of all electrical work shown on the drawings is diagrammatic only and indicates the minimum requirements of the work. Conditions at the building including actual measurements shall determine the details of the installation. All work shall be laid out and installed so as to require the least amount of cutting and patching.

B. Check the Architectural plans and specifications before ordering any material and equipment. Any discrepancies shall be brought to the attention of the Designer for his determination prior to proceeding with the work.

1.18 TYPICAL DETAILS

A. Typical details where shown on the drawings shall apply to each and every item of the project where such items are applicable. They are not repeated in full on the drawings, which in many cases are diagrammatic only, but with the intention that such details shall be incorporated in full. Any alternate method proposed for use by the Electrical Subcontractor shall have the prior approval of the Designer.

1.19 SLEEVES, INSERTS

A. Furnish and install all sleeves, inserts, anchor bolts and similar items to be set into masonry or concrete, as required for mechanical and electrical work. Internal diameter of sleeve shall be 2" larger than the outside diameter of the pipe or insulation covered line passing through it.

B. The Electrical Subcontractor is responsible for coring and sleeving (as applicable) all penetrations of the structure required of their respective work. All penetrations through the structure shall be sealed air and water tight.

1.20 FIRESTOPPING

A. Comply with the requirements of Division 07. Refer to specification section 07 84 00 – FIRESTOPPING.

B. The Electrical Trade Contractor shall be responsible for fire stopping all wall, floor and ceiling penetrations for the electrical work as required for all conduit, wiring, cabinets, panels, etc. Fire stopping materials shall be coordinated with the Construction Manager.

C. All conduit, wiring, cabinets, panels, etc. installed by the Electrical Subcontractor through acoustical partitions shall be sealed with an approved acoustical sealant, by the Electrical Subcontractor.

1.21 CORING, DRILLING

A. Refer to the requirements of Division 1. Core, cut and/or drill all small holes 4 inches in diameter or less in walls and floors required for the installation of sleeves and supports for the electrical work. Penetration larger than 4 inches will be by the General Contractor.

1.22 CUTTING AND PATCHING

A. Comply with Division 01.

1.23 ACCESSIBILITY

A. Install all work such that parts requiring periodic inspection, operation, maintenance and repair are readily accessible.

B. Furnish all access panels appropriate to particular conditions, to be installed by trades having responsibility for the construction of actual walls, floors or ceilings at required locations.

1.24 SUPPLEMENTARY SUPPORTING STEEL

A. Provide all supplementary steelwork required for mounting or supporting equipment and materials.

B. Steelwork shall be firmly connected to building construction as required.

C. Steelwork shall be of sufficient strength to allow only minimum deflection in conformity with manufacturer's published requirements.

D. All supplementary steelwork shall be installed in a neat and workmanlike manner parallel to floor, wall and ceiling construction; all turns shall be made at forty-five and ninety degrees, and/or as dictated by construction and installation conditions.

E. All manufactured steel parts and fittings shall be galvanized.

1.25 TOOLS AND EQUIPMENT

A. Provide all tools and equipment required for the fabrication and installation of the mechanical and electrical equipment at the site.

1.26 PORTABLE AND DETACHABLE PARTS

A. The Electrical Contractor shall retain in their possession all portable and/or detachable parts and portions of materials, devices, equipment etc. necessary for the proper operation and maintenance of the electrical systems until final completion of the work, at which time they shall be handed over to the Owner.

1.27 RECORD DRAWINGS, PROJECT CLOSEOUT

A. Comply with requirements specified in Division 1 – CONTRACT CLOSEOUT.

B. This trade shall submit the record set for approval by the fire and building departments in a form acceptable to the departments, when required by the jurisdiction.

C. Drawings shall show record condition of details, sections, riser diagrams, control changes and corrections to schedules. Schedules shall show actual manufacturer and make and model numbers of final equipment installation.

1.28 OPERATING, INSTRUCTION AND MAINTENANCE MANUALS

A. Refer to Division 1 for submittal procedures pertaining to operating and maintenance manuals.

B. Each copy of the approved operating and maintenance manual shall contain copies of approved shop drawings, equipment literature, cuts, bulletins, details, equipment and engineering data sheets and typewritten instructions relative to the care and maintenance for the operation of the equipment, all properly indexed. Each manual shall have the following minimum contents:

1. TABLE OF CONTENTS

2. Introduction
    a. Explanation of manual and its purpose and use.
    b. Description of the electrical systems.
    c. Safety precautions necessary for equipment.
    d. Illustrations, schematics and diagrams.
    e. Installation drawing.
3. Maintenance
    a. Maintenance and lubricating instructions.
    b. Replacement charts.
    c. Trouble shooting charts for equipment components.
    d. Testing instructions for each typical component.
    e. Two typed sets of instructions for ordering spare parts. Each set shall include name, price, telephone number and address of where they may be obtained.
4. Manufacturer's Literature
    a. The equipment for which shop drawings have been submitted and approved.

1.29 SERVICE CHARACTERISTICS

A. Primary Utility Voltage: 13.8kV

B. Secondary Building Voltage - High Level: 480/277V

C. Secondary Building Voltage - Low Level: 208/120V

D. All equipment and wiring shall be suitable for the applied voltage.

1.30 DELIVERY, STORAGE AND HANDLING

A. All materials for the work of this section shall be delivered, stored and handled so as to preclude damage of any nature. Manufactured materials shall be delivered and stored in their original containers, plainly marked with the products' and manufacturer's name. Materials in broken containers or in packages showing watermarks or other evidence of damage, shall not be used and shall be removed from the site.

1.31 TEMPORARY POWER AND LIGHTING

A. The Electrical Subcontractor shall furnish and install feeders of sufficient size from the Utility Company's power transformer and meter for the electric light and power requirements for the building while under construction and until the permanent feeders and related equipment have been installed and are in operation. Temporary lighting shall be based on a minimum of one watt per square foot covering each and every square foot of floor area in the building. Sufficient wiring, lamps, and outlets shall be installed to insure proper lighting in all rooms, space, stairwells, and corridors. Minimum sized lamp used shall be 100 watt. Where higher lighting intensities are required by Federal or State Standards of Laws or otherwise specified, the above specified wattage shall be increased to provide these increased intensities.

B. All necessary transformers, meters, cables, panelboards, switches, temporary lamp replacements and accessories required for the temporary light and power installation shall be provided by the Electrical Subcontractor.

C. The Electrical Subcontractor shall provide and maintain on each floor of the building, a feeder or feeders of sufficient capacity for the requirements of the entire floor and he shall provide a sufficient number of outlets, located at convenient points, so that extension cords of not over 50 ft. in length will reach all work requiring temporary light or power.

D. The Electrical Subcontractor shall provide temporary connection to the elevator. Refer to Section 142424 “Holeless Hydraulic Elevators”.

E. The Electrical Subcontractor shall install and maintain the wiring and accessories for the offices of the General Contractor and the Owner as specified in Section 015000 “Temporary Facilities and Controls”.

F. All temporary electrical work shall meet the requirements of the National Electrical Code, the Local Utility Company, and all Federal Standards and Laws.

G. All temporary wiring and accessories thereto installed by the Electrical Subcontractor shall be removed after their purposes have been served.

H. The General Contractor will pay for the cost of electric energy consumed by himself and by all of his Subcontractors, unless otherwise indicated.

I. All lamps installed in permanent lighting fixtures and used for lighting during construction shall be replaced by the Electrical Subcontractor just prior to date of Use and Occupancy or Final Acceptance.

J. Provide and maintain, to the satisfaction of the local authorities having jurisdiction, all temporary lighting and power that may be required for safety purposes. The Electrical Subcontractor will be compensated by the General Contractor for any additional standby time, materials or equipment required by the General Contractor or other Subcontractors beyond the normal working hours, as defined above.

1.32 COMMISSIONING

A. Comply with requirements specified in Division 1.

1.33 TRAINING AND SERVICE

A. The Owner shall be thoroughly instructed in the use of for each type of system installed, as defined in the specifications by the system vendor.

B. The Owner shall be thoroughly instructed in the use and upkeep of the system, the training shall include routine maintenance and operational adjustments.

C. Final “as built” documentation must be available at the job site for all training sessions.

D. The Electrical Subcontractor shall provide training materials free from any copyright restrictions, and upon request from the Owner, furnish a reproducible set of these materials.

E. Instruction and training for the operation and routine maintenance of the system shall be provided at site, after final completion acceptance of the system, at a time mutually satisfactory to the Electrical Subcontractor and Owner.

F. The training shall include system(s) functional description and the proper adjustment procedure for every adjustment in the system(s).

G. The equipment will be made available by the Owner, after delivery and acceptance, for use in the instruction and training program. The Owner will provide space for the instruction and training. The Electrical Subcontractor shall provide the instructor(s) and all training materials.

H. The Electrical Subcontractor shall engage a qualified videographer to record each training module separately on digital, window's compatible DVD media. Include instructions and demonstrations, diagrams, and other visual aids. At the beginning of each training module, record chart containing learning objective and lesson outline.

1.34 WARRANTY

A. The Electrical Trade Contractor shall warranty that all materials furnished shall be free from defects of material for a period of one year from the date of Substantial Completion.

B. The warranty shall repair or replace defective materials, equipment, workmanship and installation that develop within this period, promptly and to Owner's satisfaction and correct damage caused in making necessary repairs and replacements under warranty within Contract Price.

C. In addition to warranty requirements of Division 1 and of Subparagraph A above, obtain written equipment and material warranties offered in manufacturer's published data without exclusion or limitation, in Owner's name.

1. Upon receipt of notice from the Owner of failure of any part of the systems or equipment during the warranty period, the affected part or parts shall be replaced by this Contractor without any reimbursement.

2. Replace material and equipment that require excessive service during warranty period as defined and as directed by Designer.

3. Provide 24-hour service beginning on the date the project is accepted by the Owner, whether or not fully occupied, and lasting until the termination of the warranty period. Service shall be at no cost to the Owner. Service can be provided by this contractor or a separate service organization. Choice of service organization shall be subject to the Owner's approval. Submit name and a phone number that will be answered on a 24-hour basis each day of the week, for the duration of the service.

4. Submit copies of equipment and material warranties to the Owner before final payment.

5. At end of warranty period, transfer manufacturers' equipment and material warranties still in force to the Owner.

6. This Paragraph shall not be interpreted to limit the Owner's rights under applicable codes and laws and under this Contract.

7. Parts of this Specification may specify warranty requirements that exceed those of this Paragraph. Those paragraphs will govern.

8. Use of systems provided under this Section for temporary services and facilities shall not constitute Final Acceptance of work by the Owner, and shall not initiate the warranty period.

9. Non-durable items, such as electric lamps, shall be replaced up to the date of acceptance, such that they shall have had no more than 100 hours use prior to this date.

10. Provide manufacturer's engineering and technical staff at site to analyze and rectify problems that develop during warranty period immediately. If problems cannot be rectified immediately to the Owner's satisfaction, advise the Owner in writing, describe efforts to rectify situation, and provide analysis of cause of problem. Designer will direct course of action.

PART 2 - PRODUCTS

2.1 SEQUENCING

A. Phasing: Refer to Section 01 10 00 - Summary, and Drawings for phasing and milestone completion requirements which affect the General Contractor's Work and the Work of this Filed Subcontract.

B. Coordinate work of this Filed Subcontract with that of other trades, affecting or affected by this work, and cooperate with the other trades as is necessary to assure the steady progress of work.

C. Do not order or deliver any materials until all submittals, required in the listed Specification Sections included as part of this Filed Subcontract, have been received and approved by the Architect.

D. Before proceeding with installation work, inspect all project conditions and all work of other trades to assure that all such conditions and work are suitable to satisfactorily receive the work of this Section and notify the Architect in writing of any which are not. Do not proceed further until corrective work has been completed or waived.

2.2 SCAFFOLDS, STAGING, AND OTHER SIMILAR RAISED PLATFORMS

A. General: Filed Subcontractors shall obtain required permits for, and provide scaffolds, staging, and other similar raised platforms, required to access their Work as specified in Section 01 50 00 - Temporary Facilities and Controls and herein.

1. Scaffolding and staging required for use by this Filed Subcontractor pursuant to requirements of Section 01 50 00 - Temporary Facilities and Controls shall be furnished, erected, maintained in a safe condition, and dismantled when no longer required, by this Filed Sub-Trade requiring such scaffolding.

2. Each Filed Subcontractor is responsible to provide, maintain and remove at dismantling, all tarpaulins and similar protective measures necessary to cover scaffolding for inclement weather conditions other than those required to be provided, maintained and removed by the General Contractor pursuant to MGL (Refer to Section 01 50 00 - Temporary Facilities and Controls and as additionally required for dust control).

3. Furnishing portable ladders and mobile platforms of all required heights, which may be necessary to perform the work of this trade, are the responsibility this Filed Subcontractor.

4. Enclose all exterior scaffolding outside of the construction fence with 8-foot high plywood enclosure at end of each workday to prohibit access to the scaffolding by unauthorized individuals.

PART 3 - EXECUTION

NOT USED

End of Section

Section 26 05 00

COMMON WORK RESULTS FOR ELECTRICAL

(TRADE CONTRACT REQUIRED AS PART OF SECTION 26 00 01)

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. PUBLICLY BID TRADE CONTRACT REQUIREMENTS: As provided under Section 26 00 01 - ELECTRICAL and supplemented under the Bidding Requirements, Contract Forms, and Conditions of the Contract, and applicable parts of Division 1 - GENERAL REQUIREMENTS.

1. Work of this Trade Contract includes all individual specification sections listed in Section 26 00 01.

1.2 RELATED DOCUMENTS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.

1.3 SUMMARY

A. Section Includes:

1. Sleeves for raceways and cables.
2. Sleeve seals.
3. Grout.
4. Common electrical installation requirements.

1.4 SUBMITTALS

A. Product Data: For sleeve seals.

PART 2 - PRODUCTS

2.1 SLEEVES FOR RACEWAYS AND CABLES

A. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.

B. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.

C. Sleeves for Rectangular Openings: Galvanized sheet steel.

1. Minimum Metal Thickness:

a. For sleeve cross-section rectangle perimeter less than 50 inches (1270 mm) and no side more than 16 inches (400 mm), thickness shall be 0.052 inch (1.3 mm).

b. For sleeve cross-section rectangle perimeter equal to, or more than, 50 inches (1270 mm) and 1 or more sides equal to, or more than, 16 inches (400 mm), thickness shall be 0.138 inch (3.5 mm).

2.2 SLEEVE SEALS

A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and raceway or cable.

1. Manufacturers

a. Advance Products & Systems, Inc.

b. Calpico, Inc.

c. Metraflex Co.

d. Or approved equal.

2. Sealing Elements: EPDM interlocking links shaped to fit surface of cable or conduit. Include type and number required for material and size of raceway or cable.

3. Pressure Plates: Carbon steel Include two for each sealing element.

4. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating of length required to secure pressure plates to sealing elements. Include one for each sealing element.

2.3 GROUT

A. Nonmetallic, Shrinkage-Resistant Grout: ASTM C 1107, factory-packaged, nonmetallic aggregate grout, noncorrosive, non-staining, mixed with water to consistency suitable for application and a 30-minute working time.

PART 3 - EXECUTION

3.1 COMMON REQUIREMENTS FOR ELECTRICAL INSTALLATION

A. Comply with NECA 1.

B. Measure indicated mounting heights to bottom of unit for suspended items and to center of unit for wall-mounting items.

C. Headroom Maintenance: If mounting heights or other location criteria are not indicated, arrange and install components and equipment to provide maximum possible headroom consistent with these requirements.

D. Equipment: Install to facilitate service, maintenance, and repair or replacement of components of both electrical equipment and other nearby installations. Connect in such a way as to facilitate future disconnecting with minimum interference with other items in the vicinity.

E. Right of Way: Give to piping systems installed at a required slope.

3.2 SLEEVE INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Electrical penetrations occur when raceways, cables, wireways, cable trays, or busways penetrate concrete slabs, concrete or masonry walls, or fire-rated floor and wall assemblies.

B. Concrete Slabs and Walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of slabs and walls.

C. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.

D. Fire-Rated Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies unless openings compatible with firestop system used are fabricated during construction of floor or wall.

E. Cut sleeves to length for mounting flush with both surfaces of walls.

F. Extend sleeves installed in floors 2 inches (50 mm) above finished floor level.

G. Size pipe sleeves to provide 1/4-inch (6.4-mm) annular clear space between sleeve and raceway or cable, unless indicated otherwise.

H. Seal space outside of sleeves with grout for penetrations of concrete and masonry.

1. Promptly pack grout solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect grout while curing.

I. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Division 07 Section "Joint Sealants".

J. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.

K. Aboveground, Exterior-Wall Penetrations: Seal penetrations using steel pipe sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch (25-mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals.

L. Underground, Exterior-Wall Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for 1-inch (25-mm) annular clear space between raceway or cable and sleeve for installing mechanical sleeve seals.

3.3 SLEEVE-SEAL INSTALLATION

A. Install to seal exterior wall penetrations.

B. Use type and number of sealing elements recommended by manufacturer for raceway or cable material and size. Position raceway or cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway or cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

End of Section

DO NOT REMOVE
THIS PAGE INTENTIONALLY LEFT BLANK

Section 26 05 19

ELECTRICAL POWER CONDUCTORS AND CABLES

(TRADE CONTRACT REQUIRED AS PART OF SECTION 26 00 01)

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. PUBLICLY BID TRADE CONTRACT REQUIREMENTS: As provided under Section 26 00 01 - ELECTRICAL and supplemented under the Bidding Requirements, Contract Forms, and Conditions of the Contract, and applicable parts of Division 1 - GENERAL REQUIREMENTS.

1. Work of this Trade Contract includes all individual specification sections listed in Section 26 00 01.

1.2 RELATED DOCUMENTS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications

1.3 SUMMARY

A. This Section includes the following:

1. Building wires and cables rated 600 V and less.
2. Connectors, splices, and terminations rated 600 V and less.
3. Sleeves and sleeve seals for cables.

1.4 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Field quality-control test reports.

1.5 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.6 WARRANTY

A. Comply with Section 260001.

B. The Electrical Trade Contractor shall warranty that all materials furnished shall be free from defects of material for a period of one year from the date of Substantial Completion.

PART 2 - PRODUCTS

2.1 CONDUCTORS AND CABLES

A. Copper Conductors: Comply with NEMA WC 70.

B. Conductor Insulation: 90 degree rated; Comply with NEMA WC 70 for THHN, THWN-2 and XHHW-2.

C. Multiconductor Cable: Comply with NEMA WC 70 for metal-clad cable, Type MC with ground wire.

D. Emergency System Feeders: Emergency System Feeders: Mineral-insulated, metal-sheathed cable, Type MI.

2.2 CONNECTORS AND SPLICES

A. Manufacturers

1. AFC Cable Systems, Inc.
2. 3M; Electrical Products Division.
3. Tyco Electronics Corp.
4. Or approved equal.

B. Description: Factory-fabricated connectors and splices of size, ampacity rating, material, type, and class for application and service indicated.

2.3 SLEEVES FOR CABLES

A. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.

B. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.

C. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Penetration Firestopping."

2.4 SLEEVE SEALS

A. Manufacturers

1. Advance Products & Systems, Inc.
2. Calpico, Inc.
3. Metraflex Co.
4. Or approved equal.

B. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and cable.

1. Sealing Elements: EPDM or NBR interlocking links suitable for the application shaped to fit surface of cable or conduit. Include type and number required for material and size of raceway or cable.
2. Pressure Plates: Carbon steel. Include two for each sealing element.

3. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating of length required to secure pressure plates to sealing elements. Include one for each sealing element.

PART 3 - EXECUTION

3.1 CONDUCTOR MATERIAL APPLICATIONS

A. Feeders: Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

B. Branch Circuits: Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

3.2 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

A. Service Entrance: Type XHHW-2, single conductors in raceway.

B. Exposed Feeders: Type THHN-THWN-2, single conductors in raceway.

C. Emergency System Feeders in non-corrosive copper or brass environments: Mineral-insulated, metal-sheathed cable, Type MI.

D. Emergency System Feeders direct-buried: Mineral-insulated, metal-sheathed cable, Type MI with an extruded outer polyolefin jacket to provide additional protection.

E. Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspaces: Type THHN-THWN-2, single conductors in raceway.

F. Feeders Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN-THWN-2, single conductors in raceway.

G. Exposed Branch Circuits, Including in Crawlspaces: Type THHN-THWN-2, single conductors in raceway.

H. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN-THWN-2, single conductors in raceway; Metal-clad cable, Type MC.

I. Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN-THWN-2, single conductors in raceway.

J. Cord Drops and Portable Appliance Connections: Type SO, hard service cord with stainless-steel, wire-mesh, strain relief device at terminations to suit application.

K. Class 1 Control Circuits: Type THHN-THWN-2, in raceway.

L. Class 2 Control Circuits: Type THHN-THWN-2, in raceway; Metal-clad cable, Type MC.

3.3 INSTALLATION OF CONDUCTORS AND CABLES

A. Conceal cables in finished walls, ceilings, and floors, unless otherwise indicated.

B. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.

C. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.

D. Install exposed cables parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.

E. Support cables according to Division 26 Sections "Hangers and Supports for Electrical Systems."

F. Identify and color-code conductors and cables according to Division 26 Section "Identification for Electrical Systems."

G. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

H. Make splices and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.

1. Use oxide inhibitor in each splice and tap conductor for aluminum conductors.

I. Wiring at Outlets: Install conductor at each outlet, with at least 12 inches (300 mm) of slack.

3.4 SLEEVE INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Penetration Firestopping."

B. Concrete Slabs and Walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of slabs and walls.

C. Fire-Rated Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies unless openings compatible with firestop system used are fabricated during construction of floor or wall.

D. Cut sleeves to length for mounting flush with both wall surfaces.

E. Extend sleeves installed in floors 2 inches (50 mm) above finished floor level.

F. Size pipe sleeves to provide 1/4-inch (6.4-mm) annular clear space between sleeve and cable unless sleeve seal is to be installed or unless seismic criteria require different clearance.

G. Seal space outside of sleeves with grout for penetrations of concrete and masonry and with approved joint compound for gypsum board assemblies.

H. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and cable, using joint sealant appropriate for size, depth, and location of joint according to Division 07 Section "Joint Sealants."

I. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at cable penetrations. Install sleeves and seal with firestop materials according to Division 07 Section "Penetration Firestopping."

J. Roof-Penetration Sleeves: Seal penetration of individual cables with flexible boot-type flashing units applied in coordination with roofing work.

K. Aboveground Exterior-Wall Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Size sleeves to allow for 1-inch (25-mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals.

L. Underground Exterior-Wall Penetrations: Install cast-iron "wall pipes" for sleeves. Size sleeves to allow for 1-inch (25-mm) annular clear space between cable and sleeve for installing mechanical sleeve seals.

3.5 SLEEVE-SEAL INSTALLATION

A. Install to seal underground exterior-wall penetrations.

B. Use type and number of sealing elements recommended by manufacturer for cable material and size. Position cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.6 FIRESTOPPING

A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly according to Division 07.

3.7 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.

B. Tests and Inspections:

1. After installing conductors and cables and before electrical circuitry has been energized, test service entrance and feeder conductors for compliance with requirements.

2. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.

3. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each splice in cables and conductors No. 3 AWG and larger. Remove box and equipment covers so splices are accessible to portable scanner.

C. Test Reports: Prepare a written report to record the following:

1. Test procedures used.

2. Test results that comply with requirements.

3. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.

D. Remove and replace malfunctioning units and retest as specified above.

End of Section

DO NOT REMOVE
THIS PAGE INTENTIONALLY LEFT BLANK

Section 26 05 26

GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

(TRADE CONTRACT REQUIRED AS PART OF SECTION 26 00 01)

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. PUBLICLY BID TRADE CONTRACT REQUIREMENTS: As provided under Section 26 00 01 - ELECTRICAL and supplemented under the Bidding Requirements, Contract Forms, and Conditions of the Contract, and applicable parts of Division 1 - GENERAL REQUIREMENTS.

1. Work of this Trade Contract includes all individual specification sections listed in Section 26 00 01.

1.2 RELATED DOCUMENTS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications

1.3 SUMMARY

A. This Section includes methods and materials for grounding systems and equipment.

1.4 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Field quality-control test reports.

1.5 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. Comply with UL 467 for grounding and bonding materials and equipment.

1.6 WARRANTY

A. Comply with Section 260001.

B. The Electrical Trade Contractor shall warranty that all materials furnished shall be free from defects of material for a period of one year from the date of Substantial Completion.

PART 2 - PRODUCTS

2.1 CONDUCTORS

A. Insulated Conductors: Copper wire or cable insulated for 600 V unless otherwise required by applicable Code or authorities having jurisdiction.

B. Bare Copper Conductors:

1. Solid Conductors: ASTM B 3.
2. Stranded Conductors: ASTM B 8.
3. Tinned Conductors: ASTM B 33.
4. Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG conductor, 1/4 inch (6 mm) in diameter.
5. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.
6. Bonding Jumper: Copper tape, braided conductors, terminated with copper ferrules; 1-5/8 inches (41 mm) wide and 1/16 inch (1.6 mm) thick.
7. Tinned Bonding Jumper: Tinned-copper tape, braided conductors, terminated with copper ferrules; 1-5/8 inches (41 mm) wide and 1/16 inch (1.6 mm) thick.

2.2 CONNECTORS

A. Listed and labeled by a nationally recognized testing laboratory acceptable to authorities having jurisdiction for applications in which used, and for specific types, sizes, and combinations of conductors and other items connected.

B. Bolted Connectors for Conductors and Pipes: Copper or copper alloy, bolted pressure-type, with at least two bolts.

1. Pipe Connectors: Clamp type, sized for pipe.

C. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.

2.3 GROUNDING ELECTRODES

A. Ground Rods: Copper-clad; 3/4-inch by10 feet (19 mm by 3 m) in diameter.

PART 3 - EXECUTION

3.1 APPLICATIONS

A. Conductors: Install solid conductor for No. 8 AWG and smaller, and stranded conductors for No. 6 AWG and larger, unless otherwise indicated.

B. Underground Grounding Conductors: Install bare copper conductor, No. 2/0 AWG minimum. Bury at least 24 inches (600 mm) below grade.

C. Conductor Terminations and Connections:

1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
2. Underground Connections: Welded connectors, except at test wells and as otherwise indicated.
3. Connections to Ground Rods at Test Wells: Bolted connectors.
4. Connections to Structural Steel: Welded connectors.

3.2 EQUIPMENT GROUNDING

A. Install insulated equipment grounding conductors with the following items, in addition to those required by NFPA 70:

1. Feeders and branch circuits.
2. Lighting circuits.
3. Receptacle circuits.
4. Single-phase motor and appliance branch circuits.
5. Three-phase motor and appliance branch circuits.
6. Flexible raceway runs.
7. Armored and metal-clad cable runs.
8. Computer and Rack-Mounted Electronic Equipment Circuits: Install insulated equipment grounding conductor in branch-circuit runs from equipment-area power panels and power-distribution units.

B. Air-Duct Equipment Circuits: Install insulated equipment grounding conductor to duct-mounted electrical devices operating at 120 V and more, including air cleaners, heaters, dampers, humidifiers, and other duct electrical equipment. Bond conductor to each unit and to air duct and connected metallic piping.

C. Water Heater, Heat-Tracing, and Antifrost Heating Cables: Install a separate insulated equipment grounding conductor to each electric water heater and heat-tracing cable. Bond conductor to heater units, piping, connected equipment, and components.

D. Signal and Communication Equipment: For telephone, alarm, voice and data, and other communication equipment, provide No. 4 AWG minimum insulated grounding conductor in raceway from grounding electrode system to each service location, terminal cabinet, wiring closet, and central equipment location.

1. Service and Central Equipment Locations and Wiring Closets: Terminate grounding conductor on a 1/4-by-2-by-12-inch (6-by-50-by-300-mm) grounding bus.
2. Terminal Cabinets: Terminate grounding conductor on cabinet grounding terminal.

3.3 INSTALLATION

A. Grounding Conductors: Route along shortest and straightest paths possible, unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.

B. Ground Rods: Drive rods until tops are 2 inches (50 mm) below finished floor or final grade, unless otherwise indicated.

1. Interconnect ground rods with grounding electrode conductor below grade and as otherwise indicated. Make connections without exposing steel or damaging coating, if any.
2. For grounding electrode system, install at least three rods spaced at least one-rod length from each other and located at least the same distance from other grounding electrodes, and connect to the service grounding electrode conductor.

C. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance, except where routed through short lengths of conduit.

1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install so vibration is not transmitted to rigidly mounted equipment.
3. Use exothermic-welded connectors for outdoor locations, but if a disconnect-type connection is required, use a bolted clamp.

D. Grounding and Bonding for Piping:

1. Metal Water Service Pipe: Install insulated copper grounding conductors, in conduit, from building's main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes, using a bolted clamp connector or by bolting a lug-type connector to a pipe flange, using one of the lug bolts of the flange. Where a dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.
2. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with a bolted connector.
3. Bond each aboveground portion of gas piping system downstream from equipment shutoff valve.

E. Bonding Interior Metal Ducts: Bond metal air ducts to equipment grounding conductors of associated fans, blowers, electric heaters, and air cleaners. Install bonding jumper to bond across flexible duct connections to achieve continuity.

F. Grounding for Lightning Protection System: Install 3/0 AWG copper grounding conductor, in conduit, to the building's main service ground busbar.

3.4 FIELD QUALITY CONTROL

A. Perform the following tests and inspections and prepare test reports:

1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.
2. Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal, and at ground test wells.
    a. Measure ground resistance not less than two full days after last trace of precipitation and without soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance.
    b. Perform tests by fall-of-potential method according to IEEE 81.

B. Report measured ground resistances that exceed the following values:

1. Power and Lighting Equipment or System with Capacity 500 kVA and Less: 10 ohms.
2. Power and Lighting Equipment or System with Capacity 500 to 1000 kVA: 5 ohms.
3. Power and Lighting Equipment or System with Capacity More Than 1000 kVA: 3 ohms.
4. Power Distribution Units or Panelboards Serving Electronic Equipment: 3 ohms.

C. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Architect promptly and include recommendations to reduce ground resistance.

End of Section

DO NOT REMOVE
THIS PAGE INTENTIONALLY LEFT BLANK

Section 26 05 29

HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

(TRADE CONTRACT REQUIRED AS PART OF SECTION 26 00 01)

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. PUBLICLY BID TRADE CONTRACT REQUIREMENTS: As provided under Section 26 00 01 - ELECTRICAL and supplemented under the Bidding Requirements, Contract Forms, and Conditions of the Contract, and applicable parts of Division 1 - GENERAL REQUIREMENTS.

1. Work of this Trade Contract includes all individual specification sections listed in Section 26 00 01.

1.2 RELATED DOCUMENTS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications

1.3 SUMMARY

A. Section includes:

1. Hangers and supports for electrical equipment and systems.
2. Construction requirements for concrete bases.

1.4 PERFORMANCE REQUIREMENTS

A. Delegated Design: Design supports for multiple raceways, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

B. Design supports for multiple raceways capable of supporting combined weight of supported systems and its contents.

C. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.

D. Rated Strength: Adequate in tension, shear, and pullout force to resist maximum loads calculated or imposed for this Project, with a minimum structural safety factor of five times the applied force.

1.5 SUBMITTALS

A. Product Data: For steel slotted support systems.

B. Shop Drawings: Signed and sealed by a qualified professional engineer. Show fabrication and installation details and include calculations for the following:

1. Trapeze hangers. Include Product Data for components.
2. Steel slotted channel systems. Include Product Data for components.

3. Equipment supports.

C. Welding certificates.

1.6 QUALITY ASSURANCE

A. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

B. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

A. Steel Slotted Support Systems: Comply with MFMA-4, factory-fabricated components for field assembly.

1. Manufacturers

a. Cooper B-Line, Inc.; a division of Cooper Industries.

b. Thomas & Betts Corporation.

c. Unistrut; Tyco International, Ltd.

d. Or approved equal.

2. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.

3. Nonmetallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating applied according to MFMA-4.

4. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.

5. Channel Dimensions: Selected for applicable load criteria.

B. Raceway and Cable Supports: As described in NECA 1 and NECA 101.

C. Conduit and Cable Support Devices: Steel hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.

D. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for non-armored electrical conductors or cables in riser conduits. Plugs shall have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body shall be malleable iron.

E. Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.

F. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:

1. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete, steel, or wood, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.

a. Manufacturers

1) Hilti Inc.

2) ITW Ramset/Red Head; a division of Illinois Tool Works, Inc.

3) MKT Fastening, LLC.

4) Or approved equal.

2. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated steel, for use in hardened portland cement concrete with tension, shear, and pullout capacities appropriate for supported loads and building materials in which used.

a. Manufacturers

1) Cooper B-Line, Inc.; a division of Cooper Industries.

2) Empire Tool and Manufacturing Co., Inc.

3) Hilti Inc.

4) Or approved equal.

3. Concrete Inserts: Steel or malleable-iron, slotted support system units similar to MSS Type 18; complying with MFMA-4 or MSS SP-58.

4. Clamps for Attachment to Steel Structural Elements: MSS SP-58, type suitable for attached structural element.

5. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.

6. Toggle Bolts: All-steel springhead type.

7. Hanger Rods: Threaded steel.

2.2 FABRICATED METAL EQUIPMENT SUPPORT ASSEMBLIES

A. Description: Welded or bolted, structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.

B. Materials: Comply with requirements in Division 05 Section "Metal Fabrications" for steel shapes and plates.

PART 3 - EXECUTION

3.1 APPLICATION

A. Comply with NECA 1 and NECA 101 for application of hangers and supports for electrical equipment and systems except if requirements in this Section are stricter.

B. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for EMT, IMC, and RMC as required by NFPA 70. Minimum rod size shall be 1/4 inch (6 mm) in diameter.

C. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted or other support system, sized so capacity can be increased by at least 25 percent in future without exceeding specified design load limits.

1. Secure raceways and cables to these supports with two-bolt conduit clamps.

D. Spring-steel clamps designed for supporting single conduits without bolts may be used for 1-1/2-inch (38-mm) and smaller raceways serving branch circuits and communication systems above suspended ceilings and for fastening raceways to trapeze supports.

3.2 SUPPORT INSTALLATION

A. Comply with NECA 1 and NECA 101 for installation requirements except as specified in this Article.

B. Raceway Support Methods: In addition to methods described in NECA 1, EMT and RMC may be supported by openings through structure members, as permitted in NFPA 70.

C. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb (90 kg).

D. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:

1. To Wood: Fasten with lag screws or through bolts.
2. To New Concrete: Bolt to concrete inserts.
3. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
4. To Existing Concrete: Expansion anchor fasteners.
5. Instead of expansion anchors, powder-actuated driven threaded studs provided with lock washers and nuts may be used in existing standard-weight concrete 4 inches (100 mm) thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 4 inches (100 mm) thick.
6. To Steel: Beam clamps (MSS Type 19, 21, 23, 25, or 27) complying with MSS SP-69.
7. To Light Steel: Sheet metal screws.
8. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate by means that meet seismic-restraint strength and anchorage requirements.

E. Drill holes for expansion anchors in concrete at locations and to depths that avoid reinforcing bars.

F. The Electrical Subcontractor shall install all hangers and supports for electrical systems prior to fireproofing.

3.3 INSTALLATION OF FABRICATED METAL SUPPORTS

A. Comply with installation requirements in Division 05 Section "Metal Fabrications" for site-fabricated metal supports.

B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.

C. Field Welding: Comply with AWS D1.1/D1.1M.

3.4 CONCRETE BASES

A. Concrete bases shall be provided by the general contractor.

B. The Electrical Subcontractor shall provide the anchor-bolt pattern to the General Contractor for installation of anchor bolts.

C. The Electrical Subcontractor shall provide to the General Contractor the layout of conduit and other materials that penetrate the equipment pads.

3.5 PAINTING

A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.

1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils (0.05 mm).

B. Touchup: Comply with requirements in Division 09 painting Sections for cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal.

C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

End of Section

DO NOT REMOVE
THIS PAGE INTENTIONALLY LEFT BLANK

Section 26 05 33

RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS

(TRADE CONTRACT REQUIRED AS PART OF SECTION 26 00 01)

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. PUBLICLY BID TRADE CONTRACT REQUIREMENTS: As provided under Section 26 00 01 - ELECTRICAL and supplemented under the Bidding Requirements, Contract Forms, and Conditions of the Contract, and applicable parts of Division 1 - GENERAL REQUIREMENTS.

1. Work of this Trade Contract includes all individual specification sections listed in Section 26 00 01.

1.2 RELATED DOCUMENTS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications

1.3 SUMMARY

A. This Section includes raceways, fittings, boxes, enclosures, and cabinets for electrical wiring.

B. See Division 26 for exterior duct banks and manholes, and underground handholes, boxes, and utility construction.

1.4 SUBMITTALS

A. Product Data: For surface raceways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.

B. Shop Drawings: For custom enclosures and cabinets. Include plans, elevations, sections, details, and attachments to other work.

1.5 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. Comply with NFPA 70.

1.6 WARRANTY

A. Comply with Section 260001.

B. The Electrical Trade Contractor shall warranty that all materials furnished shall be free from defects of material for a period of one year from the date of Substantial Completion.

PART 2 - PRODUCTS

2.1 METAL CONDUIT AND TUBING

A. Rigid Steel Conduit: ANSI C80.1.

B. EMT: ANSI C80.3.

C. FMC: Zinc-coated steel.

D. LFMC: Flexible steel conduit with PVC jacket.

E. Fittings for Conduit (Including all Types and Flexible and Liquid tight), EMT, and Cable: NEMA FB 1; listed for type and size raceway with which used, and for application and environment in which installed.

1. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 886.
2. Fittings for EMT: Steel, set-screw or compression type.

2.2 NONMETALLIC CONDUIT AND TUBING

A. RNC: NEMA TC 2, Type EPC-40-PVC, unless otherwise indicated.

B. LFNC: UL 1660.

C. Fittings for RNC: NEMA TC 3; match to conduit or tubing type and material.

D. Fittings for LFNC: UL 514B.

2.3 METAL WIREWAYS

A. Manufacturers

1. Cooper B-Line, Inc.
2. Hoffman.
3. Square D; Schneider Electric.
4. Or approved equal.

B. Description: Sheet metal sized and shaped as indicated, NEMA 250, Type 1 and Type 3R (exterior) unless otherwise indicated.

C. Fittings and Accessories: Include couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.

D. Wireway Covers: Hinged type.

E. Finish: Manufacturer's standard enamel finish.

2.4 NONMETALLIC WIREWAYS

A. Manufacturers

1. Hoffman.
2. Lamson & Sessions.
3. Carlon Electrical Products.

4. Or approved equal.

B. Description: PVC plastic, extruded and fabricated to size and shape indicated, with Snap-On cover and mechanically coupled connections with plastic fasteners.

C. Fittings and Accessories: Include couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.

2.5 SURFACE RACEWAYS

A. Surface Metal Raceways: Galvanized steel with Snap-On covers. Manufacturer's standard enamel finish in color selected by Architect.

1. Manufacturers

a. Thomas & Betts Corporation.

b. Walker Systems, Inc.; Wiremold Company (The).

c. Wiremold Company (The); Electrical Sales Division.

d. Or approved equal.

B. Surface Nonmetallic Raceways: Two-piece construction, manufactured of rigid PVC with texture and color selected by Architect from manufacturer's standard colors.

1. Manufacturers

a. Panduit Corp.

b. Walker Systems, Inc.; Wiremold Company (The).

c. Wiremold Company (The); Electrical Sales Division.

d. Or approved equal.

2.6 BOXES, ENCLOSURES, AND CABINETS

A. Sheet Metal Outlet and Device Boxes: NEMA OS 1.

B. Cast-Metal Outlet and Device Boxes: NEMA FB 1, ferrous alloy, Type FD, with gasketed cover.

C. Nonmetallic Outlet and Device Boxes: NEMA OS 2.

D. Metal Floor Boxes: Cast or sheet metal, fully adjustable, rectangular.

E. Nonmetallic Floor Boxes: Nonadjustable, round.

F. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.

G. Cast-Metal Access, Pull, and Junction Boxes: NEMA FB 1, cast aluminum with gasketed cover.

H. Hinged-Cover Enclosures: NEMA 250, Type 1, with continuous-hinge cover with flush latch, unless otherwise indicated.

1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.

2. Nonmetallic Enclosures: Plastic, finished inside with radio-frequency-resistant paint.

I. Cabinets:

1. NEMA 250, Type 1, galvanized-steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel.
2. Hinged door in front cover with flush latch and concealed hinge.
3. Key latch to match panelboards.
4. Metal barriers to separate wiring of different systems and voltage.
5. Accessory feet where required for freestanding equipment.

PART 3 - EXECUTION

3.1 RACEWAY APPLICATION

A. Outdoors: Apply raceway products as specified below, unless otherwise indicated:

1. Exposed Conduit: Rigid steel conduit.
2. Concealed Conduit, Above ground: Rigid steel conduit; EMT.
3. Underground Conduit outside the foundation wall: RNC, Schedule 80 PVC, direct buried. Convert nonmetallic conduit to rigid steel conduit before rising through earth.
4. Underground Conduit within building confines: RMC, direct buried or RNC, Schedule 80 PVC, direct buried. Convert nonmetallic conduit to rigid steel conduit before rising through earth.
5. Exposed or underground conduit to sewage ejector pump chamber: PVC coated rigid steel conduit.
6. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.
7. Boxes and Enclosures, Aboveground: NEMA 250, Type 3R.

B. Comply with the following indoor applications, unless otherwise indicated:

1. Exposed, Not Subject to Physical Damage: EMT.
2. Exposed, Not Subject to Severe Physical Damage: EMT.
3. Exposed and Subject to Severe Physical Damage: Rigid steel conduit. Includes raceways in the following locations:
   a. Loading dock.
   b. Corridors used for traffic of mechanized carts, forklifts, and pallet-handling units.
   c. Mechanical rooms.
   d. Fire pump room.
4. Concealed in Ceilings and Interior Walls and Partitions: EMT.
5. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC, except use LFMC in damp or wet locations.
6. Damp or Wet Locations: Rigid steel conduit.

7. Raceways for Optical Fiber or Communications Cable: EMT or plenum rated inner duct.

8. Boxes and Enclosures: NEMA 250, Type 1, except use NEMA 250, Type 4, stainless steel in damp or wet locations.

9. Exposed or underground conduit to sewage ejector pump chamber: PVC coated rigid steel conduit.

10. Exposed or underground conduit to acid neutralization chamber: PVC coated rigid steel conduit.

C. Minimum Raceway Size: 1/2-inch (16-mm) trade size.

D. Raceway Fittings: Compatible with raceways and suitable for use and location.

1. Rigid and Intermediate Steel Conduit: Use threaded rigid steel conduit fittings, unless otherwise indicated.

3.2 INSTALLATION

A. Comply with NECA 1 for installation requirements applicable to products specified in Part 2 except where requirements on Drawings or in this Article are stricter.

B. Keep raceways at least 6 inches (150 mm) away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.

C. Complete raceway installation before starting conductor installation.

D. Support raceways as specified in Division 26 Section "Hangers and Supports for Electrical Systems."

E. Arrange stub-ups so curved portions of bends are not visible above the finished slab.

F. Install no more than the equivalent of three 90-degree bends in any conduit run except for communications conduits, for which fewer bends are allowed.

G. Conceal conduit and EMT within finished walls, ceilings, and floors, unless otherwise indicated.

H. Unless indicated otherwise, conceal conduit under floor slabs and within finished walls, ceilings, and floors. Keep conduit minimum 6 inches away from parallel runs of flues and steam or hot water pipes. Install conduit parallel with or at right angles to ceilings, walls, and structural members where located above accessible ceilings and where conduit will be visible after completion of project. Run conduits under floor slab as if exposed.

I. Restrictions Applicable to EMT

1. Do not install underground.

2. Do not encase in concrete, mortar, grout, or other cementitious materials.

3. Do not use in areas subject to severe physical damage including but not limited to equipment rooms where moving or replacing equipment could physically damage the EMT.

4. Do not use in hazardous areas.

5. Do not use outdoors.

6. Do not use in fire pump rooms.

J. Restrictions Applicable to Nonmetallic Conduit

1. PVC Schedule 40 and PVC Schedule 80

a. Do not use in areas where subject to severe physical damage, including but not limited to, mechanical equipment rooms, electrical equipment rooms, and other such areas.

b. Do not use in hazardous (classified) areas.

c. Do not use in fire pump rooms.

d. Do not use in penetrating fire-rated walls or partitions, or fire-rated floors.

e. Do not use above grade.

f. Convert nonmetallic conduit, to rigid steel conduit before rising through floor slab.

K. Restrictions Applicable to Flexible Conduit

1. Use only as specified in paragraph FLEXIBLE CONNECTIONS. Do not use when the enclosed conductors must be shielded from the effects of High-altitude Electromagnetic Pulse (HEMP).

L. Service Entrance Conduit, Underground

1. PVC, Type-EPC 40, galvanized rigid steel.

2. Convert nonmetallic conduit to rigid steel conduit before rising through floor slab.

M. Underground Conduit Other Than Service Entrance

1. Tape Wrapped rigid steel; PVC, Type EPC-40. Convert nonmetallic conduit to rigid steel conduit before rising through floor slab. Ten mil tape shall be 1/2 lapped and extend a minimum of 6 inches above floor.

2. Convert nonmetallic conduit to rigid steel conduit before rising through floor slab.

N. Conduit Installed Under Floor Slabs

1. Conduit run under floor slab shall be located a minimum of 12 inches below the vapor barrier. Seal around conduits at penetrations thru vapor barrier.

2. The Electrical Subcontractor will provide and pay for excavations and backfill for under grade slab conduit runs and coordinate the same with other utilities.

3. All structural fill/bedding material must be installed in accordance with the earthwork specifications, including compaction.

O. Conduit Through Floor Slabs

1. Where conduits rise through floor slabs, curved portion of bends shall not be visible above finished slab.

2. Convert nonmetallic conduit to rigid steel conduit before rising through floor slab.

P. Conduit Installed in Concrete Floor Slabs

1. Rigid steel; PVC, Type EPC-40. Locate so as not to adversely affect structural strength of slabs. Install conduit within middle one-third of concrete slab. Do not stack conduits.

2. Space conduits horizontally not closer than three diameters, except at cabinet locations. Curved portions of bends shall not be visible above finish slab.

3. Increase slab thickness as necessary to provide minimum one inch cover over conduit.

4. Where embedded conduits cross building and/or expansion joints, provide suitable watertight expansion/deflection fittings and bonding jumpers. Expansion/deflection fittings shall allow horizontal and vertical movement of raceway.

5. Conduit larger than one inch trade size shall be parallel with or at right angles to main reinforcement; when at right angles to reinforcement, conduit shall be close to one of supports of slab.

6. Where nonmetallic conduit is used, raceway shall be converted to rigid steel before rising above floor, unless specifically indicated.

Q. Stub-Ups

1. Provide conduits stubbed up through concrete floor for connection to free-standing equipment with adjustable top or coupling threaded inside for plugs, set flush with finished floor. Extend conductors to equipment in rigid steel conduit, except that flexible metal conduit may be used 6 inches above floor. Where no equipment connections are made, install screwdriver-operated threaded flush plugs in conduit end.

2. Convert nonmetallic conduit to rigid steel conduit before rising through floor slab.

R. Conduit Support

1. Support conduit by pipe straps, wall brackets, hangers, or ceiling trapeze. Fasten by wood screws to wood; by toggle bolts on hollow masonry units; by concrete inserts or expansion bolts on concrete or brick; and by machine screws, welded threaded studs, or spring-tension clamps on steel work.

2. Threaded C-clamps may be used on rigid steel conduit only. Do not weld conduits or pipe straps to steel structures. Load applied to fasteners shall not exceed one-fourth proof test load.

3. Fasteners attached to concrete ceiling shall be vibration resistant and shock-resistant.

4. Holes cut to depth of more than 1 1/2 inches in reinforced concrete beams or to depth of more than 3/4 inch in concrete joints shall not cut main reinforcing bars. Fill unused holes.

5. In partitions of light steel construction, use sheet metal screws. In suspended-ceiling construction, run conduit above ceiling. Do not support conduit by ceiling support system.

6. Conduit and box systems shall be supported independently of both (a) tie wires supporting ceiling grid system, and (b) ceiling grid system into which ceiling panels are placed. Supporting means shall not be shared between electrical raceways and mechanical piping or ducts.

7. Installation shall be coordinated with above-ceiling mechanical systems to assure maximum accessibility to all systems.

8. Spring-steel fasteners may be used for lighting branch circuit conduit supports in suspended ceilings in dry locations. Support exposed risers in wire shafts of multistory buildings by U-clamp hangers at each floor level and at 10 foot maximum intervals.

9. Where conduit crosses building expansion joints, provide suitable watertight expansion fitting that maintains conduit electrical continuity by bonding jumpers or other means.

10. For conduits greater than 2 1/2 inches inside diameter, provide supports to resist forces of 0.5 times the equipment weight in any direction and 1.5 times the equipment weight in the downward direction.

S. Directional Changes in Conduit Runs

1. Make changes in direction of runs with symmetrical bends or cast-metal fittings. Make field-made bends and offsets with hickey or conduit-bending machine. Do not install crushed or deformed conduits. Avoid trapped conduits. Prevent plaster, dirt, or trash from lodging in conduits, boxes, fittings, and equipment during construction. Free clogged conduits of obstructions.

T. Locknuts and Bushings

1. Fasten conduits to sheet metal boxes and cabinets with two locknuts where required by NFPA 70, where insulated bushings are used, and where bushings cannot be brought into firm contact with the box; otherwise, use at least minimum single locknut and bushing. Locknuts shall have sharp edges for digging into wall of metal enclosures. Install bushings on ends of conduits, and provide insulating type where required by NFPA 70.

U. Flexible Connections

1. Provide flexible steel conduit between 3 and 6 feet in length for recessed and semi-recessed lighting fixtures; for equipment subject to vibration, noise transmission, or movement; and for motors. Install flexible conduit to allow 20 percent slack. Minimum flexible steel conduit size shall be 1/2 inch diameter. Provide liquidtight flexible conduit in wet and damp locations and in fire pump rooms for equipment subject to vibration, noise transmission, movement or motors. Provide separate ground conductor across flexible connections.

V. Raceway Terminations at Locations Subject to Moisture or Vibration: Use insulating bushings to protect conductors, including conductors smaller than No. 4 AWG.

W. Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than 200-lb (90-kg) tensile strength. Leave at least 12 inches (300 mm) of slack at each end of pull wire.

X. Raceways for Optical Fiber and Communications Cable: Install as follows:

1. 3/4-Inch (19-mm) Trade Size and Smaller: Install raceways in maximum lengths of 50 feet (15 m).

2. 1-Inch (25-mm) Trade Size and Larger: Install raceways in maximum lengths of 75 feet (23 m).

3. Install with a maximum of two 90-degree bends or equivalent for each length of raceway unless Drawings show stricter requirements. Separate lengths with pull or junction boxes or terminations at distribution frames or cabinets where necessary to comply with these requirements.

Y. Install raceway sealing fittings at suitable, approved, and accessible locations and fill them with listed sealing compound. For concealed raceways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings at the following points:

1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
2. Where otherwise required by NFPA 70.

Z. Expansion-Joint Fittings for RNC: Install in each run of aboveground conduit that is located where environmental temperature change may exceed 30 deg F (17 deg C), and that has straight-run length that exceeds 25 feet (7.6 m).

1. Install expansion-joint fittings for each of the following locations, and provide type and quantity of fittings that accommodate temperature change listed for location:
   a. Outdoor Locations Not Exposed to Direct Sunlight: 125 deg F (70 deg C) change.
   b. Outdoor Locations Exposed to Direct Sunlight: 155 deg F (86 deg C) temperature change.
   c. Indoor Spaces: Connected with the Outdoors without Physical Separation: 125 deg F (70 deg C) temperature change.
   d. Attics: 135 deg F (75 deg C) temperature change.
2. Install fitting(s) that provide expansion and contraction for at least 0.00041 inch per foot of length of straight run per deg F (0.06 mm per meter of length of straight run per deg C) of temperature change.
3. Install each expansion-joint fitting with position, mounting, and piston setting selected according to manufacturer's written instructions for conditions at specific location at the time of installation.

AA. Flexible Conduit Connections: Use maximum of 72 inches (1830 mm) of flexible conduit for recessed and semi recessed lighting fixtures,]equipment subject to vibration, noise transmission, or movement; and for transformers and motors.

1. Use LFMC in damp or wet locations subject to severe physical damage.
2. Use LFMC or LFNC in damp or wet locations not subject to severe physical damage.

BB. Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block, and install box flush with surface of wall.

CC. Set metal floor boxes level and flush with finished floor surface.

DD. Set nonmetallic floor boxes level. Trim after installation to fit flush with finished floor surface.

3.3 INSTALLATION OF UNDERGROUND CONDUIT

A. Direct-Buried Conduit:

1. Excavate trench bottom to provide firm and uniform support for conduit. Prepare trench bottom as specified in Division 31 Section "Earth Moving" for pipe less than 6 inches (150 mm) in nominal diameter.
2. Install backfill as specified in Division 31 Section "Earth Moving."
3. After installing conduit, backfill and compact. Start at tie-in point, and work toward end of conduit run, leaving conduit at end of run free to move with expansion and contraction as temperature changes during this process. Firmly hand tamp backfill around conduit to provide maximum supporting strength. After placing controlled

backfill to within 12 inches (300 mm) of finished grade, make final conduit connection at end of run and complete backfilling with normal compaction as specified in Division 31 Section "Earth Moving."

4. Install manufactured duct elbows for stub-ups at poles and equipment and at building entrances through the floor, unless otherwise indicated. Encase elbows for stub-up ducts throughout the length of the elbow.

5. Install manufactured rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through the floor.

    a. Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with 3 inches (75 mm) of concrete.

    b. For stub-ups at equipment mounted on outdoor concrete bases, extend steel conduit horizontally a minimum of 60 inches (1500 mm) from edge of equipment pad or foundation. Install insulated grounding bushings on terminations at equipment.

6. Warning Planks: Bury warning planks approximately 12 inches (300 mm) above direct-buried conduits, placing them 24 inches (600 mm) O.C. Align planks along the width and along the centerline of conduit.

End of Section

Section 26 05 48

VIBRATION AND SEISMIC CONTROLS FOR ELECTRICAL SYSTEMS

(TRADE CONTRACT REQUIRED AS PART OF SECTION 26 00 01)

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. PUBLICLY BID TRADE CONTRACT REQUIREMENTS: As provided under Section 26 00 01 - ELECTRICAL and supplemented under the Bidding Requirements, Contract Forms, and Conditions of the Contract, and applicable parts of Division 1 - GENERAL REQUIREMENTS.

1. Work of this Trade Contract includes all individual specification sections listed in Section 26 00 01.

1.2 RELATED DOCUMENTS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications

1.3 SUMMARY

A. Section includes:

1. Isolation pads.
2. Spring isolators.
3. Restrained spring isolators.
4. Channel support systems.
5. Restraint cables.
6. Hanger rod stiffeners.
7. Anchorage bushings and washers.

1.4 PERFORMANCE REQUIREMENTS

A. Seismic-Restraint Loading:

1. Site Class as Defined in the State Building Code.
2. Assigned Seismic Use Group or Building Category as Defined in the State Building Code.

1.5 SUBMITTALS

A. Product Data: For the following.

1. Include rated load, rated deflection, and overload capacity for each vibration isolation device.
2. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of seismic-restraint component used.

a. Tabulate types and sizes of seismic restraints, complete with report numbers and rated strength in tension and shear as evaluated by an agency acceptable to authorities having jurisdiction.

b. Annotate to indicate application of each product submitted and compliance with requirements.

3. Restrained-Isolation Devices: Include ratings for horizontal, vertical, and combined loads.

B. Delegated-Design Submittal: For vibration isolation and seismic-restraint details indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Design Calculations: Calculate static and dynamic loading due to equipment weight and operation, seismic forces required to select vibration isolators and seismic restraints.

a. Coordinate design calculations with wind-load calculations required for equipment mounted outdoors. Comply with requirements in other Division 26 Sections for equipment mounted outdoors.

2. Indicate materials and dimensions and identify hardware, including attachment and anchorage devices.

3. Field-fabricated supports.

4. Seismic-Restraint Details:

a. Design Analysis: To support selection and arrangement of seismic restraints. Include calculations of combined tensile and shear loads.

b. Details: Indicate fabrication and arrangement. Detail attachments of restraints to the restrained items and to the structure. Show attachment locations, methods, and spacings. Identify components, list their strengths, and indicate directions and values of forces transmitted to the structure during seismic events. Indicate association with vibration isolation devices.

c. Preapproval and Evaluation Documentation: By an agency acceptable to authorities having jurisdiction, showing maximum ratings of restraint items and the basis for approval (tests or calculations).

C. Welding certificates.

D. Field quality-control reports.

1.6 QUALITY ASSURANCE

A. Comply with seismic-restraint requirements in the IBC unless requirements in this Section are more stringent.

B. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

C. Seismic-restraint devices shall have horizontal and vertical load testing and analysis and shall bear anchorage preapproval OPA number from OSHPD, preapproval by ICC-ES, or preapproval by another agency acceptable to authorities having jurisdiction, showing maximum seismic-restraint ratings. Ratings based on independent testing are preferred to ratings based on calculations. If preapproved ratings are not available, submittals based on independent testing are preferred. Calculations (including combining shear and tensile

loads) to support seismic-restraint designs must be signed and sealed by a qualified professional engineer.

D. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 VIBRATION ISOLATORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Ace Mountings Co., Inc.
2. Amber/Booth Company, Inc.
3. California Dynamics Corporation.
4. Or approved equal.

B. Pads: Arrange in single or multiple layers of sufficient stiffness for uniform loading over pad area, molded with a nonslip pattern and galvanized-steel baseplates, and factory cut to sizes that match requirements of supported equipment.

1. Resilient Material: Oil- and water-resistant neoprene.

C. Spring Isolators: Freestanding, laterally stable, open-spring isolators.

1. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
2. Minimum Additional Travel: 50 percent of the required deflection at rated load.
3. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
4. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
5. Baseplates: Factory drilled for bolting to structure and bonded to 1/4-inch- (6-mm-) thick, rubber isolator pad attached to baseplate underside. Baseplates shall limit floor load to 500 psig (3447 kPa).
6. Top Plate and Adjustment Bolt: Threaded top plate with adjustment bolt and cap screw to fasten and level equipment.

D. Restrained Spring Isolators: Freestanding, steel, open-spring isolators with seismic or limit-stop restraint.

1. Housing: Steel with resilient vertical-limit stops to prevent spring extension due to weight being removed; factory-drilled baseplate bonded to 1/4-inch- (6-mm-) thick, neoprene or rubber isolator pad attached to baseplate underside; and adjustable equipment mounting and leveling bolt that acts as blocking during installation.
2. Restraint: Seismic or limit-stop as required for equipment and authorities having jurisdiction.
3. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
4. Minimum Additional Travel: 50 percent of the required deflection at rated load.
5. Lateral Stiffness: More than 80 percent of rated vertical stiffness.

6. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

2.2 SEISMIC-RESTRAINT DEVICES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Amber/Booth Company, Inc.
2. California Dynamics Corporation.
3. Cooper B-Line, Inc.; a division of Cooper Industries.
4. Or approved equal.

B. General Requirements for Restraint Components: Rated strengths, features, and application requirements shall be as defined in reports by an agency acceptable to authorities having jurisdiction.

1. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least four times the maximum seismic forces to which they will be subjected.

C. Channel Support System: MFMA-3, shop- or field-fabricated support assembly made of slotted steel channels with accessories for attachment to braced component at one end and to building structure at the other end and other matching components and with corrosion-resistant coating; and rated in tension, compression, and torsion forces.

D. Restraint Cables: ASTM A 492 stainless-steel cables with end connections made of steel assemblies with thimbles, brackets, swivels, and bolts designed for restraining cable service; and with a minimum of two clamping bolts for cable engagement.

E. Hanger Rod Stiffener: [Steel tube or steel slotted-support-system sleeve with internally bolted connections] [Reinforcing steel angle clamped] to hanger rod. Do not weld stiffeners to rods.

F. Bushings for Floor-Mounted Equipment Anchor: Neoprene bushings designed for rigid equipment mountings, and matched to type and size of anchors and studs.

G. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for rigid equipment mountings, and matched to type and size of attachment devices.

H. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.

I. Mechanical Anchor: Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchors with strength required for anchor and as tested according to ASTM E 488. Minimum length of eight times diameter.

J. Adhesive Anchor: Drilled-in and capsule anchor system containing polyvinyl or urethane methacrylate-based resin and accelerator, or injected polymer or hybrid mortar adhesive. Provide anchor bolts and hardware with zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

PART 3 - EXECUTION

3.1 APPLICATIONS

A. Multiple Raceways or Cables: Secure raceways and cables to trapeze member with clamps approved for application by an agency acceptable to authorities having jurisdiction.

B. Hanger Rod Stiffeners: Install hanger rod stiffeners where indicated or scheduled on Drawings to receive them and where required to prevent buckling of hanger rods due to seismic forces.

C. Strength of Support and Seismic-Restraint Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static and seismic loads within specified loading limits.

3.2 SEISMIC-RESTRAINT DEVICE INSTALLATION

A. Equipment and Hanger Restraints:

1. Install restrained isolators on electrical equipment.

2. Install resilient, bolt-isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch (3.2 mm).

3. Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction providing required submittals for component.

B. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.

C. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.

D. Drilled-in Anchors:

1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.

2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.

3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.

4. Adhesive Anchors: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.

5. Set anchors to manufacturer's recommended torque, using a torque wrench.

6. Install zinc-coated steel anchors for interior and stainless-steel anchors for exterior applications.

3.3 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

A. Install flexible connections in runs of raceways, cables, wireways, cable trays, and busways where they cross seismic joints, where adjacent sections or branches are supported by different structural elements, and where they terminate with connection to equipment that is anchored to a different structural element from the one supporting them as they approach equipment.

3.4 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Obtain Architect's approval before transmitting test loads to structure. Provide temporary load-spreading members.
2. Test at least four of each type and size of installed anchors and fasteners selected by Architect.
3. Test to 90 percent of rated proof load of device.
4. Measure isolator restraint clearance.
5. Measure isolator deflection.
6. Verify snubber minimum clearances.
7. If a device fails test, modify all installations of same type and retest until satisfactory results are achieved.

B. Remove and replace malfunctioning units and retest as specified above.

C. Prepare test and inspection reports.

3.5 ADJUSTING

A. Adjust isolators after isolated equipment is at operating weight.

B. Adjust limit stops on restrained spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.

C. Adjust active height of spring isolators.

D. Adjust restraints to permit free movement of equipment within normal mode of operation.

End of Section

Section 26 05 53

IDENTIFICATION FOR ELECTRICAL SYSTEMS

(TRADE CONTRACT REQUIRED AS PART OF SECTION 26 00 01)

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. PUBLICLY BID TRADE CONTRACT REQUIREMENTS: As provided under Section 26 00 01 - ELECTRICAL and supplemented under the Bidding Requirements, Contract Forms, and Conditions of the Contract, and applicable parts of Division 1 - GENERAL REQUIREMENTS.

1. Work of this Trade Contract includes all individual specification sections listed in Section 26 00 01.

1.2 RELATED DOCUMENTS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications

1.3 SUMMARY

A. This Section includes the following:

1. Identification for conductors and communication and control cable.
2. Warning labels and signs.
3. Equipment identification labels.

1.4 SUBMITTALS

A. Product Data: For each electrical identification product indicated.

1.5 QUALITY ASSURANCE

A. Comply with ANSI A13.1.

1.6 COORDINATION

A. Coordinate identification names, abbreviations, colors, and other features with requirements in the Contract Documents, Shop Drawings, manufacturer's wiring diagrams, and the Operation and Maintenance Manual, and with those required by codes, standards, and 29 CFR 1910.145. Use consistent designations throughout Project.

PART 2 - PRODUCTS

2.1 WARNING LABELS AND SIGNS

A. Comply with NFPA 70 and 29 CFR 1910.145.

B. Warning Signs: Provide warning signs where there is hazardous exposure associated with access to or operation of electrical facilities. Provide text of sufficient clarity and lettering of

sufficient size to convey adequate information at each location; mount permanently in an appropriate and effective location. Comply with recognized industry standards for color and design.

C. Operational Tags: Where needed for proper and adequate information on operation and maintenance of electrical systems, provide tags of plasticized card stock, preprinted.

D. Self-Adhesive Warning Labels: Factory printed, multicolor, pressure-sensitive adhesive labels, configured for display on front cover, door, or other access to equipment, unless otherwise indicated.

E. Baked-Enamel Warning Signs: Preprinted aluminum signs, punched or drilled for fasteners, with colors, legend, and size required for application. 1/4-inch (6.4-mm) grommets in corners for mounting. Nominal size, 7 by 10 inches (180 by 250 mm).

F. Metal-Backed, Butyrate Warning Signs: Weather-resistant, nonfading, preprinted, cellulose-acetate butyrate signs with 0.0396-inch (1-mm) galvanized-steel backing; and with colors, legend, and size required for application. 1/4-inch (6.4-mm) grommets in corners for mounting. Nominal size, 10 by 14 inches (250 by 360 mm).

G. Fasteners for Signs: Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat and lock washers.

H. Warning label and sign shall include, but are not limited to, the following legends:

1. Multiple Power Source Warning: "DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES."

2. Workspace Clearance Warning: "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 36 INCHES (915 mm)."

2.2 ELECTRICAL SYSTEM IDENTIFICATION

A. Manufacturers:

1. T&B.

2. 3M

3. EMED Co.

4. Or approved equal.

B. Identification of Equipment:

1. All pieces of major electrical equipment shall have a manufacturer's label identifying the manufacturer's address, equipment model and serial numbers, equipment size, and other pertinent data. Care shall be taken not to obliterate this nameplate in any way.

2. The Contractor shall make it possible for the personnel operating and maintaining the equipment and systems in this project to readily identify the various pieces of equipment, junction boxes, etc., by marking them. All items of equipment, pull boxes, junction boxes, etc., shall be clearly marked using engraved nameplates as hereinafter specified. The item of equipment shall indicate the same number as shown on the Drawings, where applicable.

3. White background and black letters equipment nameplates shall be three ply laminated plastic, a minimum of 3/32" thick, black background, white letters for

normal power, red background, white letters for emergency power, and blue-white-blue for UPS power. Letters shall be similar to Roman Gothic of a size that is legible (1/2" minimum for main nameplates and 3/8" minimum for branch device nameplates) and appropriate to the application. Attachment of nameplates shall be by stainless steel screws. Rivets or adhesives are not acceptable.

a. Electrical equipment to be identified includes: All switchgear, switchboards, unit substations, distribution panels, transformers, motor control centers, panelboards, automatic transfer switches, busway plugs, disconnect switches, motor controller/starters, lighting control panels, pull boxes, junction boxes, and similar equipment.

b. Nameplates on switchgear, switchboards, unit substations, automatic transfer switches, transformers, distribution panels, motor control centers, disconnect switches, motor controller/starters, variable frequency drives and panelboards shall give voltage and current characteristics and the source feeding the panel. Current characteristics shall indicate the size of the overcurrent devices serving the equipment and not the equipment current rating.

1) Provide panel and circuit designation on disconnect switches, motor controllers/starters, variable frequency drives, etc.

Example:

PANEL PP2
120/208V, 3PH, 4 W, 225 A
Fed from DPA-3
Room 1.102

c. Individual overcurrent devices and pilot lights in switchgear, switchboards, unit substations, distribution panels, motor control centers, and similar equipment shall have nameplates showing the load served and its location, where remote. Nameplates on motor starters shall indicate variable speed, time delay operation, etc., where applicable.

d. Blank nameplates shall be mounted on each spare or bussed space in motor control centers, and on each spare or space in distribution panels.

e. Branch circuit panelboards shall have neatly typed circuit directories behind clear plastic. Identify circuits by room numbers. Room numbers shall be those finally selected by the Owner; not necessarily those given on contract Drawings. Spares and spaces shall be indicated with erasable pencil; not typed. Circuit numbers shall be provided in the directory and at each circuit breaker.

C. Conduit Systems: Provide adequate marking of major conduit which is exposed or concealed in accessible spaces, to distinguish each run as either a normal power, emergency power, fire alarm, control wiring or voice/data conduit. Except as otherwise indicated, use white banding with black lettering except that emergency power orange and white, fire alarm conduit markers shall use red banding. Provide self-adhesive or snap-on type plastic markers. Indicate voltage ratings of conductors exceeding 250 volts. Locate markers at ends of conduit runs, near switches and other control devices, near items of equipment served by the conductors, at points where conduit passes through walls or floors, or enters non-accessible construction and at spacings of not more than 30' along each run of exposed conduit.

D. Cable Tray Systems: Provide engraved nameplates identifying cable tray systems as to use, on maximum 50' centers on all tray systems and whenever a tray enters a room or

concealed accessible location. Nameplate text shall be submitted to the Engineer for review.

E. Underground Cable Identification: Bury a continuous, preprinted, red and silver metallic ribbon cable marker, Brady No. 91600 Series or an approved equal with each underground cable (or group of cables), regardless of whether conductors are in conduit or direct buried. Locate each directly over cables, 12" above cable below finished grade. Ribbons shall be detectable from above grade using a pipe or cable locator.

F. Cable/Conductor Identification: Coordinate a uniform and consistent scheme of color identification of power wiring throughout the building system. Identification shall be by the permanent color of the selected covering. On large conductors, secure identification by means of painted color banding or plastic tape.

1. Color scheme shall be as follows, [or as required to match the existing color coding in the building for 120/240 V systems with high leg provide Orange for phase B]

	208/120 Volt	480/277 Volt	5kV/15kV
Phase A	Black	Brown	Black
Phase B	Red	Purple	Red
Phase C	Blue	Yellow	Blue
Neutral	White	Gray	White
Ground	Green	Green	

2. Wiring for switches shall be same color as phase wire.

3. Colored insulation in sizes up through #4. Conductors #3 and larger may have black insulation, but color coded with 1/2" wide band of colored tape, at accessible locations. Rap conductor minimum 6" width.

4. Feeder cables shall be tagged in pull boxes, wireways, wiring gutters of panels, and at other accessible locations. Tags shall be fireproof, nonconductive material, approved by Architect.

5. Maintain same conductor color from service entrance to last device.

G. Phase Rotation: Phase rotation shall be maintained throughout the project.

1. Phase rotation shall be clockwise or counterclockwise, per serving power company standards, A-B-C, and identified as such left-to-night, top-to-bottom, and front-to-back with color coding as specified above at switchboards, panelboards, substations, transformers, motor control centers, motor starters, and similar locations.

2. Motor phase reversal, if necessary, shall be made at motor controller.

H. Branch Circuit and Control Wiring Tags: All branch circuit and control wiring conductors shall be tagged using self-sticking vinyl cloth or mylar cloth wire markers. Embossed pressure sensitive plastic or metal ribbon markers will not be accepted. Tags shall be installed at all wiring splice, tap and termination points and shall correspond to the designations shown on the control wiring diagrams or panel schedules.

I. Branch Circuit Pull Boxes and Junction Boxes: Branch circuit pull boxes shall be neatly stenciled with a black permanent marker indicating the panel name and branch circuit number. Boxes on emergency power systems shall be painted orange prior to marking. Boxes on fire alarm power systems shall be painted red prior to marking.

J. Miscellaneous Switch Plates or Device Plates: Adhesive Film Label with Clear Protective Overlay for interior use: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8 inch (10 mm).

1. Nomenclature shall include the panel and circuit of the outlet or switch, or the indication of the pilot, or the area of control, or equipment served.

2. Switched and non-switched device plates shall be engraved. Engraving shall be 3/16" condensed Gothic and shall be filled with black enamel.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Verify identity of each item before installing identification products.

B. Location: Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment.

C. Apply identification devices to surfaces that require finish after completing finish work.

D. Self-Adhesive Identification Products: Clean surfaces before application, using materials and methods recommended by manufacturer of identification device.

E. Attach non-adhesive signs and plastic labels with screws and auxiliary hardware appropriate to the location and substrate.

3.2 CLEANING AND PAINTING OF ELECTRICAL WORK

A. Prime, protective and touch-up painting is included in the Work of this Division. Finish painting in equipment spaces, concealed locations, and other locations not exposed to the view of building occupants is included in the work of this Division. Finished painting in areas exposed to the view of building occupants is specified under Division 9.

B. All equipment and materials furnished by the electrical subcontractor shall be delivered to the job with suitable factory protective finish.

C. Electrical switchgear, disconnect switches, contactors, etc., with suitable factory-applied finishes shall not be repainted; except for aesthetic reasons where located in finished areas as directed by the Architect and in a color selected by the Architect. Where factory-applied finishes are damaged in transit, storage or installation, or before final acceptance, they shall be restored to factory-fresh condition by competent refinishers using the spray process.

D. All equipment not finished at the factory shall be given a prime coat and then finish painted with two coats of enamel in a color as directed by the Architect/Engineer. No nameplates on equipment shall be painted, and suitable protection shall be afforded such plates to prevent their being rendered illegible during the painting operations.

E. The surfaces to be finish-painted shall first be prepared as follows:

1. Galvanized and black steel surfaces shall first be painted with one coat of galvanized metal primer.

2. Aluminum surfaces shall first be painted with one coat of zinc chromate primer.

F. All ferrous metal surfaces without a protective finish and not galvanized in exposed and concealed areas including chases, under floor and above ceilings shall be painted with two

coats of zinc chromate primer as the construction progresses to protect against deterioration.

G. All junction and pull boxes and covers which are part of raceway systems distributing emergency power shall be painted orange. Where a multiple branch emergency power system is installed, the branch designation (LS, CB or EQ) shall be stenciled on the box cover in minimum one inch (1") high white letters.

H. All junction and pull boxes and covers and terminal cabinets which are part of the raceway/wiring system for emergency alarm wiring shall be painted orange and fire alarm wiring shall be painted red. A system designation (FA) shall be stenciled on the box or cabinet cover in minimum one inch (1") high white letters.

I. All conduit exposed to view shall be finish painted as directed by the Architect.

J. Before painting, all surfaces to be painted shall be suitably prepared. This shall include removing all oil, rust, scale, dirt, and other foreign material. Surfaces shall be made smooth by grinding, filing, brushing, or other approved method. In the painting operations, the primer for metal surfaces shall be of the zinc dust type unless specified otherwise, and where finish painting is specified, it shall be painted using materials and colors selected and approved by the Architect. Refer to Division 9 for additional requirements.

End of Section

Section 26 05 73

OVERCURRENT PROTECTIVE DEVICE COORDINATION STUDY

(TRADE CONTRACT REQUIRED AS PART OF SECTION 26 00 01)

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. PUBLICLY BID TRADE CONTRACT REQUIREMENTS: As provided under Section 26 00 01 - ELECTRICAL and supplemented under the Bidding Requirements, Contract Forms, and Conditions of the Contract, and applicable parts of Division 1 - GENERAL REQUIREMENTS.

1. Work of this Trade Contract includes all individual specification sections listed in Section 26 00 01.

1.2 RELATED DOCUMENTS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications

1.3 SCOPE OF WORK

A. This Section includes requirements for computer-based fault-current, overcurrent protective device coordination and arc flash protection studies. Protective devices shall be set based on Engineer's review of submitted results of the protective device coordination study.

1. Coordination of series–rated devices is not permitted.

1.4 PERFORMANCE REQUIREMENTS

A. Fault Current Study: Prepare computer-based, fault current study to calculate the maximum available short-circuit current in amperes RMS symmetrical at circuit-breaker positions of the electrical power distribution system based on proposed feeder routing.

B. Overcurrent Protective Device Coordination: Prepare computer-based, selective coordination study such that all overcurrent protective devices proposed for inclusion in the Work shall be selected to be selectively coordinated for total selective coordination with the overcurrent protective devices installed on their supply side such that an overcurrent event (overload, short-circuit, or ground-fault) occurring at the lowest level in the system (branch circuit) cannot cause the feeder protective device supplying the branch circuit panelboard to open.

1. Total selective coordination shall be carried through each level of distribution for all branches of emergency power system. Emergency power systems shall include life safety, legally required standby systems, critical operations power systems, and fire pumps.

2. The normal power system and standby power system shall be coordinate to 0.01s.

C. Arc Flash Hazard Analysis: Prepare computer-based, arc-flash study to determine the arc-flash hazard distance and the incident energy to which personnel could be exposed during work on or near electrical equipment.

1.5 DEFINITIONS

A. One-Line Diagram: A diagram which shows, by means of single lines and graphic symbols, the course of an electric circuit or system of circuits and the component devices or parts used therein.

B. Protective Device: A device that senses when an abnormal current flow exists and then removes the affected portion from the system.

C. SCCR: Short-circuit current rating.

D. Service: The conductors and equipment for delivering electric energy from the serving utility to the wiring system of the premises served.

1.6 SUBMITTALS

A. The release of electrical equipment submittals (panelboards, engine generators, switchgear, etc.) is dependent on the receipt of a complete and accurate overcurrent protective device coordination study. The following submittals shall be in digital form:

1. Coordination-study input data, including completed computer program input data sheets. Provide editable electronic media including all files and breaker TCC's.

2. Study and Equipment Evaluation Reports.

3. Coordination-Study Report; signed, dated, and sealed by a qualified professional engineer.

4. Arc-flash study input data, including completed computer program input data sheets.

5. Arc Flash Hazard Analysis Report; signed, dated, and sealed by a qualified professional engineer.

B. Product Data: For computer software program to be used for studies.

C. Qualification Data: For Coordination Study Specialist and Arc-Flash Hazard Analysis Specialist.

D. Product Certificates: For coordination-study and fault-current-study computer software programs, certifying compliance with IEEE 399. For arc-flash hazard analysis software, certifying compliance with IEEE 1584 and NFPA 70E.

E. Maintenance procedures according to requirements in NFPA 70E shall be provided in the equipment manuals.

1.7 QUALITY ASSURANCE

A. Studies shall use computer programs that are distributed nationally and are in wide use. Software algorithms shall comply with requirements of standards and guides specified in this Section. Manual calculations are not acceptable.

B. Qualifications: Comprehensive engineering analysis by qualified Professional Engineer or personnel trained and employed by the equipment manufacturer in required calculation methodology.

1. Analysis to be performed by Professional Engineer or personnel trained, employed, and supervised by a registered Professional Engineer.

2. Registered professional engineer shall be a full-time employee of the electrical equipment manufacturer or a professional engineering firm.

3. Report shall be signed and sealed by a Professional Engineer with current registration.

C. Comply with IEEE 242 for short-circuit currents and coordination time intervals.

D. Comply with IEEE 399 for general study procedures.

E. Comply with IEEE 1584 for performing Arc Flash Hazard Calculations.

PART 2 - PRODUCTS

2.1 COMPUTER SOFTWARE PROGRAM REQUIREMENTS

A. Comply with IEEE 399 for fault-current and overcurrent protective device coordination studies.

B. Comply with IEEE 1584 and NFPA 70E for arc-flash hazard analysis.

C. Analytical features of fault-current-study computer software program shall include "mandatory," "very desirable," and "desirable" features as listed in IEEE 399.

D. Computer software program shall be capable of plotting and diagramming time-current-characteristic curves as part of its output. Computer software program shall report device settings and ratings of all overcurrent protective devices and shall demonstrate coordination by computer-generated, time-current coordination plots.

2.2 POWER SYSTEM STUDIES

A. The Electrical Trade Contractor shall request information required to complete the power system studies from the Utility Company. This information shall be provided to the manufacturer upon request.

B. The manufacturer shall make all necessary modifications to the circuit breaker types for a fully coordinate electrical system to comply with the specifications.

C. Short Circuits Studies, Protective Device Evaluation Studies, and Protective Device Coordination Studies shall be provided by the Manufacturer. The studies shall be submitted to the Engineer prior to receiving final approval of the distribution equipment shop drawings and/or prior to release of equipment for manufacture. If formal completion of the studies may cause delay in equipment manufacture, approval may be obtained for a preliminary submittal of sufficient study data to ensure that the selection of device ratings and characteristics will be satisfactory.

2.3 POWER SYSTEM DATA

A. The Design System Analyst performing the short-circuit, protective device coordination study, and arc flash hazard analysis shall furnish the Contractor with a list of required data immediately after award of the contract. Contractor shall expedite collection of the data to ensure completion of the study and analysis as required.

B. For new equipment, use characteristics submitted under the provisions of action submittals and information submittals for this Project.

C. Source combination shall include present and future motors and generators indicated in the documents.

D. If applicable, include fault contribution of existing motors in the study and analysis.

E. Gather and tabulate the following input data to support coordination study:

1. Product Data for overcurrent protective devices specified in other Division 26 Sections and involved in overcurrent protective device coordination studies. Use equipment designation tags that are consistent with electrical distribution system diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.
2. Impedance of utility service entrance.
3. Electrical Distribution System Diagram: In hard-copy and electronic-copy formats, showing the following:
    a. Circuit breakers and fuses ratings and types.
    b. Relays and associated power and current transformer ratings and ratios.
    c. Transformer kilovolt amperes, primary and secondary voltages, connection type, impedance, X/R ratios, taps measured in per cent, and phase shift.
    d. Generator short-circuit current contribution data, including short-circuit reactance, rated kilovolt amperes, size, rated voltage, and X/R ratio.
    e. Cables: Indicate conduit material, sizes of conductors, conductor material, insulation, and length.
    f. Busway ampacity, impedance, lengths, and conductor material.
    g. Motor horsepower and code letter designation according to NEMA MG 1.
    h. Low-voltage cable sizes, lengths, number, conductor material and conduit material (magnetic or nonmagnetic).
    i. Medium-voltage cable sizes, lengths, conductor material, and cable construction and metallic shield performance parameters.
4. Data sheets to supplement electrical distribution system diagram, cross-referenced with tag numbers on diagram, showing the following:
    a. Special load considerations, including starting inrush currents and frequent starting and stopping.
    b. Transformer characteristics, including primary protective device, magnetic inrush current, and overload capability.
    c. Motor full-load current, locked rotor current, service factor, starting time, type of start, and thermal-damage curve.
    d. Generator thermal-damage curve.
    e. Ratings, types, and settings of utility company's overcurrent protective devices.
    f. Special overcurrent protective device settings or types stipulated by utility company.
    g. Time-current-characteristic curves of devices.
    h. Manufacturer, frame size, interrupting rating in amperes rms symmetrical, ampere or current sensor rating, long-time adjustment range, short-time adjustment range, and instantaneous adjustment range for circuit breakers.
    i. Manufacturer and type, ampere-tap adjustment range, time-delay adjustment range, instantaneous attachment adjustment range, and current transformer ratio for overcurrent relays.
    j. Panelboards, switchboards, motor-control center ampacity, and interrupting rating in amperes rms symmetrical.

2.4 SHORT-CIRCUIT STUDY REPORT CONTENT

A. Executive Summary

B. Study descriptions, purpose, basis and scope of the study.

C. One-line diagram, showing the following:

1. Protective device designations and ampere ratings.
2. Cable size and lengths.
3. Transformer kilovolt ampere (kVA) and voltage ratings.
4. Motor and generator designations and kVA ratings.
5. Switchgear, switchboard, motor-control center and panelboard designations.

D. Study Input Data: As described in "Power System Data" Article.

E. Short-Circuit Study Output:

1. Interrupting Duty Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:
   a. Voltage.
   b. Calculated symmetrical fault-current magnitude and angle.
   c. Fault-point X/R ratio.
   d. No AC Decrement (NACD) ratio.
   e. Equivalent impedance.
   f. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a symmetrical basis.
   g. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a total basis.

F. Incident Energy and Flash Protection Boundary:

1. Calculations:
   a. Arcing fault magnitude.
   b. Protective device clearing time.
   c. Duration of arc.
   d. Arc-flash boundary.
   e. Working distance.
   f. Incident energy.
   g. Hazard risk category.
   h. Recommendations for arc-flash energy reduction.
2. Circuit breakers rated 1200A and higher shall be provided with an Arc flash Reduction Maintenance System for accelerated instantaneous trip to reduce arc flash. The setting shall be determined by the arc flash study and set in the field by the manufacturer’s representative.
   a. The pickup setting is chosen using the following steps:

1) Calculate the arcing fault current that could flow through the circuit breaker associated with the Arc flash Reduction Maintenance System. Formulas from IEEE STD 1584TM-2002 are used to calculate the arcing current.

2) Determine the total transient load current that can flow to loads fed by the circuit breaker equipped with the Arc flash Reduction Maintenance System. These can include motor inrush and transformer inrush.

3) Choose a pickup setting for the Arc flash Reduction Maintenance System that is:

a) Below 75% of calculated arcing current.

b) Above the total transient load current.

G. Fault study input data, case descriptions, and fault-current calculations including a definition of terms and guide for interpretation of the computer printout.

H. Equipment specific Arc Flash Warning Labels.

I. Recommendations for system improvements, where needed.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine Project overcurrent protective device submittals for compliance with electrical distribution system coordination requirements and other conditions affecting performance.

1. Proceed with coordination study and arc-flash study only after relevant equipment submittals have been assembled, but prior to their submission to the Architect.

2. Coordination study shall accompany submission of relevant equipment submittals.

3.2 FAULT-CURRENT STUDY

A. A short-circuit current ratings indicated in the Contract Documents are based on Fault-Current study prepared by the Engineer during design and are based on available information and anticipated feeder lengths. Calculate the maximum available short-circuit current in amperes rms symmetrical at circuit-breaker positions of the electrical power distribution system based on proposed feeder routing. The calculation shall be for a current immediately after initiation and for a three-phase bolted short circuit at each of the following:

1. Electric Utility’s supply termination point.

2. Switchgear and switchboard bus.

3. Motor-control center.

4. Distribution panelboard.

5. Branch circuit panelboard.

6. Standby Generators and Transfer Switches.

7. Enclosed Fused Switch.

8. Enclosed Circuit Breaker.

B. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for Project. Include studies of system-switching configurations and alternate operations that could result in maximum fault conditions.

C. Calculate momentary and interrupting duties on the basis of maximum available fault current.

D. Calculate short-circuit currents according to IEEE 551.

E. Calculations to verify interrupting ratings of overcurrent protective devices shall comply with IEEE 241 and IEEE 242.

1. Transformers, as appropriate for transformers included in the Work:

a. ANSI C57.12.10.

b. ANSI C57.12.22.

c. ANSI C57.12.40.

d. IEEE C57.12.00.

e. IEEE C57.96.

2. Medium-Voltage Circuit Breakers: IEEE C37.010.

3. Low-Voltage Circuit Breakers: IEEE 1015 and IEEE C37.20.1.

4. Low-Voltage Fuses: IEEE C37.46.

F. Study Report:

1. Show calculated X/R ratios and equipment interrupting rating (1/2-cycle) fault currents on electrical distribution system diagram.

G. Equipment Evaluation Report:

1. For 600-V overcurrent protective devices, ensure that interrupting ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.

2. For devices and equipment rated for asymmetrical fault current, apply multiplication factors listed in the standards to 1/2-cycle symmetrical fault current.

3. Verify adequacy of phase conductors at maximum three-phase bolted fault currents; verify adequacy of equipment grounding conductors and grounding electrode conductors at maximum ground-fault currents. Ensure that short-circuit withstand ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.

4. Notify Engineer, in writing, of any existing circuit protective devices improperly rated for the calculated available fault current.

3.3 COORDINATION STUDY

A. Coordination (Selective): Localization of an overcurrent condition to restrict outages to the circuit or equipment affected, accomplished by the selection and installation of overcurrent protective devices and their ratings or settings for the full range of available overcurrents, from overload to the maximum available fault current, and for the full range of overcurrent protective device opening times associated with those overcurrents.

1. Emergency system (Life Safety) overcurrent devices shall be fully selectively coordinated with all supply side overcurrent protective devices (emergency and normal).

B. Perform coordination study using approved computer software program. Prepare a written report using results of fault-current study. Comply with IEEE 399.

1. Calculate the maximum and minimum 1/2-cycle short-circuit currents.

2. Calculate the maximum and minimum ground-fault currents.

C. Comply with IEEE 241 and IEEE 242 recommendations for fault currents and time intervals.

D. The studies shall include all portions of the electrical distribution system from the normal power source and emergency/standby power sources down to and including the 120/208V distribution system. Normal/emergency/standby system connections and those which result in maximum fault conditions shall be adequately covered in the study.

E. All emergency system overcurrent devices shall be selectively coordinated with the overcurrent devices installed on their supply side per Section 700.27 of the National Electrical Code. The generator circuit breakers shall be of the same manufacturer as the switchboard. Provide a letter from the manufacturer stating that the overcurrent devices have been selectively coordinated.

F. Perform coordination study using approved computer software program. Prepare a written report using results of fault-current study. Comply with IEEE 399.

1. Calculate the maximum and minimum 1/2-cycle short-circuit currents.

2. Calculate the maximum and minimum ground-fault currents.

G. Comply with IEEE 241 and IEEE 242 recommendations for fault currents and time intervals.

H. Transformer Primary Overcurrent Protective Devices:

1. Device shall not operate in response to the following:

a. Inrush current when first energized.

b. Self-cooled, full-load current or forced-air-cooled, full-load current, whichever is specified for that transformer.

c. Permissible transformer overloads according to IEEE C57.96 if required by unusual loading or emergency conditions.

2. Device settings shall protect transformers according to IEEE C57.12.00, for fault currents.

I. Conductor Protection: Protect cables against damage from fault currents according to ICEA P-32-382, ICEA P-45-482, and conductor melting curves in IEEE 242. Demonstrate that equipment withstands the maximum short-circuit current for a time equivalent to the tripping time of the primary relay protection or total clearing time of the fuse. To determine temperatures that damage insulation, use curves from cable manufacturers or from listed standards indicating conductor size and short-circuit current.

J. Coordination-Study Report: Prepare a written report indicating the following results of coordination study:

1. Tabular Format of Settings Selected for Overcurrent Protective Devices:

a. Device tag.

b. Relay-current transformer ratios; and tap, time-dial, and instantaneous-pickup values.

c. Circuit-breaker sensor rating; and long-time, short-time, and instantaneous settings.

d. Fuse-current rating and type.

e. Ground-fault relay-pickup and time-delay settings.

2. Coordination Curves: Prepared to determine settings of overcurrent protective devices to achieve selective coordination. Graphically illustrate that adequate time separation

exists between devices installed in series, including power utility company's upstream devices. Prepare separate sets of curves for the switching schemes and for emergency periods where the power source is local generation. Show the following information:

a. Device tag.

b. Voltage and current ratio for curves.

c. Three-phase and single-phase damage points for each transformer.

d. No damage, melting, and clearing curves for fuses.

e. Cable damage curves.

f. Transformer inrush points.

g. Maximum fault-current cutoff point.

h. Motor starting characteristics, damage points and overload relay.

i. Thermal damage curve for motors larger than 100 HP.

j. Generator short-circuit decrement curve and damage point, and thermal damage curve.

K. Completed data sheets for setting of overcurrent protective devices.

L. Complete Schedule of breaker settings to summarize information contained on data sheets. Sample schedule has been included at the end of this section for preferred format.

3.4 ARC FLASH HAZARD ANALYSIS

A. Comply with IEEE 1584 for arc flash hazard analysis.

B. Comply with NFPA 70E and its Annex D for hazard analysis study.

C. The flash protection boundary and the incident energy shall be calculated at all significant locations in the electrical distribution system where work could be performed on energized parts including, but not limited to, the following:

1. Disconnect switches.
2. Electrical substations.
3. Electrical switchgear and switchboards.
4. Emergency system boxes and enclosures.
5. Enclosed circuit breakers.
6. Meter Sockets and assemblies.
7. Motor starter.
8. Motor-control centers.
9. Panelboards.
10. Power transfer equipment. (ATS)
11. Transformers.
12. Uninterruptible power supply equipment.

D. When appropriate, the short circuit calculations and the clearing times of the phase overcurrent devices will be retrieved from the short-circuit and coordination study model. Ground

overcurrent protection relays should not be taken into consideration when determining the clearing time when performing incident energy calculations.

E. Calculate the arc-flash protection boundary and the corresponding incident energy calculations for multiple system scenarios to be compared and the greatest incident energy to be uniquely reported for each equipment location. Calculations to be performed to represent the maximum and minimum contributions of fault current magnitude for all normal and emergency operating conditions.

1. The minimum calculation will assume that the utility contribution is at a minimum and will assume a minimum motor contribution (all motors off).

2. The maximum calculation will assume a maximum contribution from the utility and will assume the maximum amount of motors to be operating. Calculations shall take into consideration the parallel operation of synchronous generators with the electric utility, where applicable.

F. Incident energy calculations shall consider the accumulation of energy over time when performing arc flash calculations on buses with multiple sources. Iterative calculations must take into account the changing current contributions, as the sources are interrupted or decremented with time. Fault contribution from motors and generators to be decremented as follows:

1. Fault contribution from induction motors should not be considered beyond 3-5 cycles.

2. Fault contribution from synchronous motors and generators should be decayed to match the actual decrement of each as closely as possible.

G. For each equipment location with a separately enclosed main device, calculations for incident energy and flash protection boundary shall include both the line and load side of the main breaker.

1. When performing incident energy calculations on the line side of a main breaker, the line side and load side contributions must be included in the fault calculation.

H. Mis-coordination should be checked amongst all devices within the branch containing the immediate protective device to compute the incident energy for the corresponding location.

I. Arc Flash calculations shall be based on actual overcurrent protective device clearing time. Maximum clearing time will be capped at 2 seconds based on IEEE 1584 section B.1.2. Where it is not physically possible to move outside of the flash protection boundary in less than 2 seconds during an arc flash even, a maximum clearing time based on the specific location shall be utilized.

J. Complete Arc Flash report to be used for the preparation of Arc Flash Warning labels for electrical equipment. Refer to Division 26 Section “Identification for Electrical Systems” for requirements of Arc Flash Study and labels.

3.5 CORRECT DEFICIENCIES, RE-CALCULATE AND REPORT

A. After Engineer’s initial review, correct unsatisfactory conditions and recalculate to demonstrate compliance; resubmit overcurrent protective devices as required to bring system into compliance.

B. Revise and Resubmit report multiple times as necessary to demonstrate compliance with requirements.

3.6 APPLICATION OF WARNING LABELS

A. Install arc-flash warning labels as specified in Division 26 Section “Identification for Electrical Systems”. Install labels under the direct supervision and control of the Arc-Flash Hazard Study Specialist.

3.7 ARC-FLASH WARNING LABELS

A. Comply with requirements in Division 26 Section "Identification for Electrical Systems." Produce a 3.5-by-5-inch (76-by-127-mm) thermal transfer label of high-adhesion polyester for each work location included in the analysis.

B. The label shall have an orange header with the wording, "WARNING, ARC-FLASH HAZARD," and shall include the following information taken directly from the arc-flash hazard analysis:

1. Flash Hazard Boundary
2. Short Circuit Current Available
3. Shock Hazard when Cover is Removed
4. Limited Approach Boundary
5. Restricted Approach Boundary
6. Prohibited Approach Boundary
7. PPE Requirements, including the following:
    a. Hazard Risk Category
    b. Required Minimum Arc Rating of PPE in cal/cm^2
    c. Clothing Description
8. Engineering report number, revision number, and issue date.

C. Labels shall be machine printed, with no field-applied markings.

End of Section

DO NOT REMOVE
THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 26 08 00

COMMISSIONING OF ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this section.

1.02 SUMMARY

A. This section includes commissioning process requirements for Electrical systems, assemblies, and equipment.

B. Related Sections:

1. Division 01 Section "General Commissioning Requirements" for general commissioning process requirements.

1.03 DESCRIPTION

A. Refer to Division 01 Section “General Commissioning Requirements” for the description of commissioning.

1.04 DEFINITIONS

A. Refer to Division 01 Section “General Commissioning Requirements” for definitions.

1.05 SUBMITTALS

A. Refer to Division 01 Section “General Commissioning Requirements” for CxA’s role.

B. Refer to Division 01 Section “Submittals” for specific requirements. In addition, provide the following:

C. Certificates of readiness

D. Certificates of completion of installation, pre-start, and startup activities.

E. O&M manuals

F. Test reports

1.06 QUALITY ASSURANCE

A. Test Equipment Calibration Requirements: Electrical Subcontractors will comply with test manufacturer’s calibration procedures and intervals. Recalibrate test instruments immediately after instruments have been repaired resulting from being dropped or damaged. Affix calibration tags to test instruments. Furnish calibration records to CxA upon request.

1.07 COORDINATION

A. Refer to Division 01 Section “General Commissioning Requirements” for requirements pertaining to coordination during the commissioning process.

PART 2 - PRODUCTS

2.01 TEST EQUIPMENT

A. All standard testing equipment required to perform startup, initial checkout and functional performance testing shall be provided by the Electrical Subcontractor for the equipment being tested. For example, the Electrical Subcontractor of Division 26 shall ultimately be responsible for all standard testing equipment for the electrical systems and controls systems in Division 26.

B. Special equipment, tools and instruments (specific to a piece of equipment and only available from vendor) required for testing shall be included in the base bid price to the Owner and left on site, except for stand-alone data logging equipment that may be used by the CxA.

C. Proprietary test equipment and software required by any equipment manufacturer for programming and/or start-up, whether specified or not, shall be provided by the manufacturer of the equipment. Manufacturer shall provide the test equipment, demonstrate its use, and assist in the commissioning process as needed. Proprietary test equipment (and software) shall become the property of the Owner upon completion of the commissioning process.

D. All testing equipment shall be of sufficient quality and accuracy to test and/or measure system performance with the tolerances specified in the Specifications. If not otherwise noted, the following minimum requirements apply: Temperature sensors and digital thermometers shall have a certified calibration within the past year to an accuracy of 0.5°F and a resolution of + or - 0.1°F. Pressure sensors shall have an accuracy of + or - 2.0% of the value range being measured (not full range of meter) and have been calibrated within the last year.

PART 3 - EXECUTION

3.01 GENERAL DOCUMENTATION REQUIREMENTS

A. With assistance from the installing Electrical Subcontractors, the CxA will prepare Pre-Functional Checklists for all commissioned components, equipment, and systems

B. Red-lined Drawings: The Electrical Subcontractor will verify all equipment, systems, instrumentation, wiring and components are shown correctly on red-lined drawings. Preliminary red-lined drawings must be made available to the Commissioning Team for use prior to the start of Functional Performance Testing. Changes, as a result of Functional Testing, must be incorporated into the final as-built drawings, which will be created from the red-lined drawings. The contracted party, as defined in the Contract Documents will create the as-built drawings.

C. Operation and Maintenance Data: Electrical Subcontractor will provide a copy of O&M literature within 45 days of each submittal acceptance for use during the commissioning process for all commissioned equipment and systems. The CxA will review the O&M literature once for conformance to project requirements. The CxA will receive a copy of the final approved O&M literature once corrections have been mad by the Electrical Subcontractor.

D. Demonstration and Training: Electrical Subcontractor will provide demonstration and training as required by the specifications. A complete training plan and schedule must be submitted by the Electrical Subcontractor to the CxA four weeks (4) prior to any training. A training agenda for each training session must be submitted to the CxA one (1) week prior the training session

3.02 ELECTRICAL SUBCONTRACTOR'S RESPONSIBILITIES

A. Perform tests as required by Division 26.

B. Attend construction phase controls coordination meetings.

C. Participate in Electrical systems, assemblies, equipment, and component maintenance orientation and inspection as directed by the CA.

D. Provide information requested by the CxA for final commissioning documentation.

E. Include requirements for submittal data, operation and maintenance data, and training in each purchase order or sub-contract written.

F. Prepare preliminary schedule for Electrical system orientations and inspections, operation and maintenance manual submissions, training sessions, equipment start-up and task completion for owner. Distribute preliminary schedule to commissioning team members.

G. Update schedule as required throughout the construction period.

H. Assist the CxA in all verification and functional performance tests.

I. Provide measuring instruments and logging devices to record test data, and provide data acquisition equipment to record data for the complete range of testing for the test period.

J. Gather operation and maintenance literature on all equipment, and assemble in binders as required by the specifications. Submit to CxA 45 days after submittal acceptance.

K. Coordinate with the CxA to provide 48-hour advance notice so that the witnessing of equipment and system start-up and testing can begin.

L. Notify the CxA a minimum of two weeks in advance of the time for start of the testing and balancing work. Attend the initial testing and balancing meeting for review of the official testing and balancing procedures.

M. Participate in, and schedule vendors and Electrical Subcontractors to participate in the training sessions.

N. Provide written notification to the CM/GC and CxA that the following work has been completed in accordance with the contract documents, and that the equipment, systems, and sub-system are operating as required.
   1. Electrical equipment including but not limited to switchgear, panel boards, lighting, receptacles, lighting control and all other equipment furnished under this Division.
   2. Emergency generators, ATS switches and emergency power systems.
   3. Fire alarm system
   4. Grounding

O. The equipment supplier shall document the performance of his equipment.

P. Provide a complete set of red-lined drawings to the CxA prior to the start of Functional Performance Testing.

Q. Equipment Suppliers
   1. Provide all requested submittal data, including detailed start-up procedures and specific responsibilities of the Owner, to keep warranties in force.
   2. Assist in equipment testing per agreements with Electrical Subcontractors.
   3. Provide information requested by CxA regarding equipment sequence of operation and testing procedures.

R. Refer to Division 01 Section “General Commissioning Requirements” for additional Electrical Subcontractor responsibilities.

3.03 CxA'S RESPONSIBILITIES

A. Refer to Division 01 Section “General Commissioning Requirements” for CxA’s Responsibilities.

3.04 TESTING PREPARATION

A. Certify in writing to the CxA that Electrical systems, subsystems, and equipment have been installed, calibrated, and started and are operating according to the Contract Documents.

B. Certify in writing to the CxA that Electrical instrumentation and control systems have been completed and calibrated, that they are operating according to the Contract Documents, and that pre-test set points have been recorded.

C. Certify in writing that testing procedures have been completed and that testing reports have been submitted, discrepancies corrected, and corrective work approved.

D. Place systems, subsystems, and equipment into operating mode to be tested (e.g., normal shut-down, normal auto position, normal manual position, unoccupied cycle, emergency power, and alarm conditions).

E. Inspect and verify the position of each device and interlock identified on checklists.

F. Check safety cutouts, alarms, and interlocks with smoke control and life-safety systems during each mode of operation.

G. Testing Instrumentation: Install measuring instruments and logging devices to record test data as directed by the CxA.

3.05 GENERAL TESTING REQUIREMENTS

A. Provide technicians, instrumentation, and tools to perform commissioning test at the direction of the CxA.

B. Scope of Electrical testing shall include the entire Electrical installation, from the incoming power equipment throughout the distribution system. Testing shall include measuring, but not limited to resistance, voltage, and amperage of system(s) and devices.

C. Test all operating modes, interlocks, control responses, and responses to abnormal or emergency conditions, and verify proper response of building automation system controllers and sensors.

D. The CxA along with the Electrical Subcontractor and other contracted subcontractors, including the fire alarm Subcontractor shall prepare detailed testing plans, procedures, and checklists for Electrical systems, subsystems, and equipment.

E. Tests will be performed using design conditions whenever possible.

F. Simulated conditions may need to be imposed using an artificial load when it is not practical to test under design conditions. Before simulating conditions, calibrate testing instruments. Provide equipment to simulate loads. Set simulated conditions as directed by the CxA and document simulated conditions and methods of simulation. After tests, return settings to normal operating conditions.

G. The CxA may direct that set points be altered when simulating conditions is not practical.

H. The CxA may direct that sensor values be altered with a signal generator when design or simulating conditions and altering set points are not practical.

I. If tests cannot be completed because of a deficiency outside the scope of the Electrical system, document the deficiency and report it to the Owner. After deficiencies are resolved, reschedule tests.

J. If the testing plan indicates specific seasonal testing, complete appropriate initial performance tests and documentation and schedule seasonal tests.

3.06 ELECTRICAL SYSTEMS, SUBSYSTEMS, AND EQUIPMENT TESTING PROCEDURES

A. Equipment Testing and Acceptance Procedures: Testing requirements are specified in individual Division 26 sections. Provide submittals, test data, inspector record, infrared camera and certifications to the CA.

B. Electrical Instrumentation and Control System Testing: Field testing plans and testing requirements are specified in Division 26 Sections "Instrumentation and Control" and "Sequence of Operations" Assist the CxA with preparation of testing plans.

C. Emergency Generator Testing and Acceptance Procedures: Provide technicians, load banks, infrared cameras, instrumentation, tools and equipment to test performance of designated systems and devices at the direction of the CxA. The CxA shall determine the sequence of testing and testing procedures for each equipment item and pipe section to be tested.

D. Fire Detection and Alarm System Testing: Provide technicians, instrumentation, tools and equipment to test performance of designated systems and devices at the direction of the CxA. The CxA shall determine the sequence of testing and testing procedures for each equipment item and pipe section to be tested.

E. Electrical Distribution System Testing: Provide technicians, load banks, infrared cameras, instrumentation, tools and equipment to test performance of designated systems and devices at the direction of the CxA. The CxA shall determine the sequence of testing and testing procedures for each equipment item to be tested

F. The work included in the commissioning process involves a complete and thorough evaluation of the operation and performance of all components, systems and sub-systems. The following equipment and systems shall be evaluated:

Electrical Power Systems
Electrical service and switchgear
Transformers
Electrical distribution systems
Emergency and standby power systems including automatic transfer switching systems
Lighting and lighting control systems (associated with interior lighting, which also includes the theatre and TV Studio lighting)
Low voltage systems (lighting controls and transformers)
Grounding and bonding systems
Interfaces to automated temperature/building automation control systems
Life Safety Systems
Fire alarm systems
Egress lighting

3.07 DEFICIENCIES/NON-CONFORMANCE, COST OF RETESTING, FAILURE DUE TO MANUFACTURER DEFECT

A. Refer to Division 01 Section “General Commissioning Requirements” for requirements pertaining to deficiencies/non-conformance, cost of retesting, or failure due to manufacturer defect.

3.08 APPROVAL

A. Refer to Division 01 Section “General Commissioning Requirements” for approval procedures.

3.09 DEFERRED TESTING

A. Refer to Division 01 Section “General Commissioning Requirements” for requirements pertaining to deferred testing.

3.10 OPERATION AND MAINTENANCE MANUALS

A. The Operation and Maintenance Manuals shall conform to Contract Documents requirements as stated in Division 01.

B. Refer to Division 01 Section “General Commissioning Requirements” for the AE and CxA roles in the Operation and Maintenance Manual contribution, review and approval process.

3.11 TRAINING OF OWNER PERSONNEL

A. Refer to Division 01 Section “General Commissioning Requirements” for requirements pertaining to training.

END OF SECTION

Section 26 09 13

ELECTRICAL POWER MONITORING AND CONTROL

(TRADE CONTRACT REQUIRED AS PART OF SECTION 26 00 01)

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. PUBLICLY BID TRADE CONTRACT REQUIREMENTS: As provided under Section 26 00 01 - ELECTRICAL and supplemented under the Bidding Requirements, Contract Forms, and Conditions of the Contract, and applicable parts of Division 1 - GENERAL REQUIREMENTS.

1. Work of this Trade Contract includes all individual specification sections listed in Section 26 00 01.

1.2 RELATED DOCUMENTS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications

1.3 SCOPE OF WORK

A. It is the intent of these specifications that this Subcontractor, Manufacturer and/or its Authorized System Integrator expeditiously furnishes and installs a system complete in every respect and ready to operate. All miscellaneous items and accessories required for such installation, whether or not each such item or accessory as shown on the plans or mentioned in these specifications, shall be furnished and installed.

B. Application software for personal computer workstations shall be provided as described in this specification.

C. All products shall not violate any U. S. patents.

1.4 REFERENCES

A. The system shall comply with the applicable portions of NEMA standards. In addition, the control unit shall comply with FCC Emission Standards specified in Part 15, Sub-part J for Class A application.

1.5 SUBMITTALS

A. Drawings: Drawings shall show all field monitoring devices, key networking components, and cabling required to complete the system. Drawings shall identify device room location and recommended installation notations. Specific locations and mounting details are subject to the discretion and responsibilities of the installing Subcontractor.

B. Product Data: Provide catalog sheets to indicate physical data and electrical performance, electrical characteristics, and connection requirements of each device supplied under the scope of work.

1.6 QUALITY ASSURANCE

A. Manufacturer Requirements

1. Provide factory-direct technical support hotline.
2. Components included within the power equipment lineups shall be factory installed, wired and tested prior to shipment to the job site.

1.7 DELIVERY, STORAGE & HANDLING

A. Ordering: Comply with manufacturer's ordering instructions and lead-time requirements to avoid construction delays.

B. Delivery

1. Deliver materials in manufacturer's original, unopened, undamaged packages with intact identification labels.
2. Deliver to other trades in a timely manner.

C. Storage and Protection: Store materials away from exposure to harmful weather conditions and at temperature and humidity conditions recommended by manufacturer.

1.8 PROJECT CONDITIONS

A. Do not install equipment until the following conditions can be maintained in spaces to receive equipment:

1. Ambient temperature: 0° to 50° C (32° to 122° F).
2. Relative humidity: Maximum 90 percent, non-condensing.
3. Must be protected from dust during installation.

1.9 MAINTENANCE

A. Enable the end user to order new equipment for system expansion, replacements, and spare parts.

B. Make new replacement parts available.

C. Provide factory-direct technical support hotline.

D. Offer renewable annual service contracts, to include parts, factory labor, and annual training visits.

1.10 WARRANTY

A. Comply with Section 260001.

B. The Electrical Trade Contractor shall warranty that all materials furnished shall be free from defects of material for a period of one year from the date of Substantial Completion.

C. Provide a 3-year preventive maintenance plan. The plan shall include one site visit per year after the warranty period to verify that the system is working per the specifications and to proactively perform maintenance, repairs, and replacements to prevent failures before they occur.

PART 2 PRODUCTS

2.1 METER TECHNOLOGY

A. Manufacturer

1. National Meter Industries, Inc.
2. Satec.
3. Eaton.
4. Or approved equal.

B. Basis Of Design

1. National Meter Industries, Inc. CVM-C10 Power Quality Analyzer with current transformers (CT's) sized for the application.

C. The meter shall calculate the electrical usage of electrical loads with the use of remote current transformers. The meter shall be microprocessor-based. The meter shall be capable of sampling each power waveform calculating power factor and harmonic content to achieve 0.5% accurate readings. The meter shall save the Kilowatt hour and Max demand readings, indefinitely, in non-volatile RAM during power outages, without the use of batteries until, at such time, the meter is re-energized.

2.2 METER FUNCTION

A. Three Phase Values:

1. Active Energy (kWh) Generated & Consumed
2. kVarhC Generated & Consumed
3. kVarhl Generated 8 Consumed
4. Max kW Demand
5. Max Kva Demand
6. kVAR
7. Power Factor
8. kWh Cost
9. kWh C02 Emissions
10. Two Tariffs
11. LCD Display Shows Correct / Incorrect Field Wiring
12. Total Harmonic Distortion; Voltage & Amperage

B. Values Per Phase:

1. Voltage: Ph/N. Ph/Ph
2. Amperage
3. kW/kVA
4. Reactive Power - Capacrtive & Inductive
5. Power Factor

C. Output:

1. Two Digital Out
2. Pulse / Alarm
3. NPN Transistor - 50 mA @ 24 VDC
4. Closure Time-100 mS

D. Compliance:

1. Accuracy: ANSI C12.20
2. FCC: Class A Part 15
3. CE/IEC: 61010:2010/61000-6-4:2007/60664
4. Current Transformers Remote CT Operated 1 Amp or 5 Amp Secondary Up To 10.000 Amps Primary

E. Current Transformers:

1. Remote CT Operated
2. 1 Amp or 5 Amp Secondary
3. Up To 10.000 Amps Primary

F. Features:

1. Enclosure - NEMA 1 ABS V0 Rated Plastic
2. Energy Displayed: kWh. kVarLh, kVarCh
3. Field Programmable
4. Measuring Range: 120V-480V (depending on type)
5. Minimum & Maximum Values for Each Parameter
6. Hard Wired Modbus Data - (up to 255 meters on one two wire circuit)
7. Microprocessor/RAM Based - No Batteries

G. Communications:

1. ModBus / Bacnet RS485 RTU (MSTP)

H. Technical Characteristics:

1. Power Supply: 85 - 265 VAC, 95 - 300 VDC (-15%,+ 10%)
2. Consumption: 3.5 VA (AC), 2 W (DC)
3. Frequency: 45-65 Hz

I. Measuring Circuit:

1. 300V Ph/N, 520V Ph / Ph
2. Frequency: 45-65 Hz
3. Rated Current: /n… 1A or 5A
4. Permanent Overload: 1.2/n
5. Operating Temperature: 23 - 113 Degrees F
6. Relative Humidity: 5-95% Non-Condensing

7. CAT III 600 Volt

J. Accuracy Class:

1. Voltage: 0.5%
2. Current: 0.5%
3. Power: 1.0%

2.3 COMMUNICATIONS

A. The meter shall contain Modbus RS485 RTU communications as a standard feature. The meters' communication wires to be Daisy Chain, Parallel, Star wired together.

B. Provide Modbus RS485 output and cabling to the building BMS system.

2.4 ENCLOSURE

A. All meters shall be installed in Standard NEMA 1 surface mount enclosures sized to accommodate the quantity of the meters.

B. Wiring between meter enclosures shall be in minimum 3/4" EMT.

2.5 SOFTWARE

A. Furnish and install latest versions of Powerstudio Software on the client workstation (PC for BMS). This is a Windows based software package that allows the end-user to automatically read National meters having RS485 Modbus communications. This system shall have unlimited / unabused telephone support and unlimited downloads, from an FTP site, in case of PC upgrade or hard drive corruption.

B. Powerstudio software is a Windows based system used to trend National meters (having Modbus communications) energy usage and power quality parameters (depending on type) with the ability to display real time values and historical usage, by either graph or text data. Meter files can be exported to ".txt" format which can be opened and manipulated by Excel, for customized reporting. Meters can communicate with Powerstudio via hard wire or TCPIP communications through the use of virtual comm. ports either directly or through Ethernet converters. Powerstudio can be turned into a PC based web server for off-site communications.

C. Setup the software to display measurements for each load being monitored by a single meter.

D. The software shall provide a link that can be accessed via a web browser to display real time values and historical usage, by graph and text data.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Coordinate, receive, mount, connect, [and place into operation] all equipment.

B. Install equipment in accordance with manufacturer's installation instructions.

1. Install relay cabinets in locations where audible noise is acceptable.
2. Use only with 75° C (167° F) copper wire at 75% ampacity.

C. Provide complete installation of system in accordance with Contract Documents.

D. Maintain performance criteria stated by the manufacturer without defects, damage, or failure.

E. Provide equipment at locations and in quantities indicated on Drawings. Provide any additional equipment required to provide control intent.

F. Furnish all conduit, wire, connectors, hardware, and other incidental items necessary for a properly functioning system as described herein and shown on the plans. The Electrical Subcontractor shall maintain performance criteria stated by the manufacturer without defects, damage, or failure.

G. Compliance: the Electrical Subcontractor shall comply with manufacturer's product data, including shop drawings, technical bulletins, product catalog installation instructions, and product carton instructions for installation.

H. Application of Power: Power shall not be applied to the system during construction and prior to turn-on unless specifically authorized by written instructions from the manufacturer.

3.2 SITE VERIFICATION

A. Verify that wiring conditions, which have been previously installed under other sections or at a previous time, are acceptable for product installation in accordance with manufacturer's instructions.

3.3 FIELD MEASUREMENTS

A. The Electrical Subcontractor shall be responsible for field measurements and coordinating the physical size of all equipment with the architectural requirements of the spaces into which they are to be installed.

3.4 INSPECTION

A. Inspect all material included in this contract prior to installation. Manufacturer shall be notified of unacceptable material prior to installation.

3.5 SITE PROTECTION

A. The Electrical Subcontractor shall protect installed product and finished surfaces from damage during all phases of installation including storage, preparation, testing, and cleanup.

3.6 COMMISSIONING

A. Comply with requirements specified in Division 1.

B. Engage a factory-authorized service representative to supervise and assist with startup service. Complete installation and startup checks according to the approved manufacturer's written instructions.

3.7 TRAINING AND SERVICE

A. Comply with Section 26 00 01.

B. Conduct one 4-hour training session. Train the Owner's maintenance personnel on procedures and schedules related to start up and shutdown, troubleshooting, servicing, and preventive maintenance.

C. Conduct one 4-hour training sessions. Train the Owner's personnel on procedures and schedules related to monitoring the metering system, manipulation and interpretation of the data.

3.8 EXTRA MATERIALS

A. Furnish the following component at the end of the project to the Owner:

1. 480V Meters: 2
2. 208V Meters: 2

End of Section

DO NOT REMOVE
THIS PAGE INTENTIONALLY LEFT BLANK

Section 26 09 43

NETWORK LIGHTING CONTROLS

(TRADE CONTRACT REQUIRED AS PART OF SECTION 26 00 01)

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. PUBLICLY BID TRADE CONTRACT REQUIREMENTS: As provided under Section 26 00 01 - ELECTRICAL and supplemented under the Bidding Requirements, Contract Forms, and Conditions of the Contract, and applicable parts of Division 1 - GENERAL REQUIREMENTS.

1. Work of this Trade Contract includes all individual specification sections listed in Section 26 00 01.

1.2 RELATED DOCUMENTS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications

1.3 SUSTAINABLE DESIGN REQUIREMENTS

A. Comply with Section 01 81 13.

B. Sustainable Design Intent: Comply with project requirements intended to achieve sustainable design, measured and documented according to the MA-CHPS 2009 rating system.

C. Contractor is responsible for compliance with and completion of all required documentation for all of the following MA-CHPS Credits:

1. Indoor Environmental Quality EQ.P8: Eliminate Glare.

a. Daylight Responsive Lighting Controls. Requirement EQ.P8.1 (direct sunlight penetration) shall be verified by one of the following methods:

1) For photosensor based systems; documentation showing location of sensors and lighting zones, and setpoint and commissioning information for the system.

2) For timer based systems; documentation of astronomical clock schedule and narrative of why a time based system is adequate for the daylit space.

3) For occupant education approach; a manual to be provided to the building occupants describing the daylighting intent of the space and function of all daylighting, lighting and shading devices.

2. Indoor Environmental Quality EQ.C8: Controllability of Systems.

a. Provide a narrative description of how occupants may control light levels in each classroom.

3. Indoor Environmental Quality EQ.C10: Electric Lighting.

a. Intent: Provide high quality and flexible classroom lighting.

1) EQ.C10.1 Provide multi-scene indirect/direct lighting systems for all classrooms, with the exception for specialty classrooms where direct lighting only is required for educational purposes.

2) EQ.C10.2 The lighting system shall operate in two modes: general illumination and A/V. When general illumination is required, daylighting harvesting should take precedent, if daylight controls are installed.

3) EQ.C10.3 In general illumination mode, achieve an average illumination at the desk level of 35 to 50 footcandles with a minimum of 25 footcandles at any point more than 3 ft. from any wall.

4) EQ.C10.4 In A/V mode, not including contribution from the teaching wall light, achieve an average illumination at the desk level of between 10 and 20 footcandles for any point in the room greater than 3 ft. from the side walls, 10 ft. from the front wall and 6 ft. from the back wall, while limiting vertical illumination on the projection screen to no more than 7 footcandles at any point on the screen.

5) EQ.C10.5 In indirect mode, controls shall provide at least two levels of uniform lighting both at night and when daylight is available.

4. Energy EE.C4: Plug Load Reduction and ENERGY STAR® Equipment

a. Provide a narrative description of how devices turn off when not in use. The design intent is to turn off 50% of the plug loads in classrooms and offices through relay panels via occupancy sensors and time schedule.

1.4 SCOPE OF WORK

A. It is the intent of these specifications that the Electrical Subcontractor, Manufacturer and/or its Authorized System Integrator expeditiously furnishes and installs a system complete in every respect and ready to operate. All miscellaneous items and accessories required for such installation, whether or not each such item or accessory as shown on the plans or mentioned in these specifications, shall be furnished and installed.

B. The term ‘Lighting Control System (LCS)’ is defined as the interconnected set of hardware and software components that collectively serve to regulate the illumination levels of an interior and/or exterior space. The components that comprise the LCS are sub categorized into three groups: LCS Input Devices, LCS End Devices and LCS Control devices. The Digital Addressable Lighting Interface (DALI) shall be used to transmit data to and from LCS Input Devices and LCS End Devices.

1. LCS Input Devices

a. Occupancy sensors

b. Daylight sensors

c. Multi sensors (combined daylight, occupancy and temperature)

d. Wall mount switches and dimmers

2. LCS End Devices

a. DALI LED drivers

b. DALI field addressable relays

c. DALI relay panels

d. DALI dimming modules

3. LCS Control Equipment

a. Lighting control panels

b. LCS server with database and end-user application(s)

C. Requirements are indicated elsewhere in these specifications for work including, but not limited to, raceways and electrical boxes and fittings required for installation of control equipment and wiring:

1. Not work of this section

1.5 PROGRAMMING

A. Coordinate and obtain a written approval of system functionality from the Owner prior to programming.

B. Perform a walk-through with the Owner and demonstrate the system functionality.

C. Make any adjustments to system functionality after initial programming if necessary to achieve the desired functionality requested by the Owner.

D. Obtain a written final letter of acceptance from the Owner upon completion of system functionality programming and demonstration.

1.6 QUALITY ASSURANCE

A. All products shall meet all applicable CSA/UL regulations.

B. All products shall meet all applicable ANSI requirements.

C. All products shall meet all applicable FCC regulations.

D. All DALI products shall comply with the IEC Standard 60929 Annexes E and G.

E. All products shall be installed in accordance to all applicable national electrical and local building codes.

F. All products shall be subjected to a complete functional test at the factory prior to shipment.

G. All products shall meet the DALI Controls Standard and function under non-proprietary communication protocols.

H. All control products shall be provided by the same company as the Fixture Manufacturer.

1.7 SUBMITTALS

A. Comply with requirements specified in Division 01 and the following:

1. The vendor shall submit a copy of a letter from the manufacturer of submitted equipment certifying that the installer is an authorized and certified installer of the submitted equipment.

2. Only an authorized and certified installer of the submitted equipment shall install all equipment including hardware, software and cabling; shall make all connections at all field devices and at the head-end; and shall make all necessary field adjustments for a fully functional system.

3. Only a qualified Vendor holding licenses required by legally constituted authorities having jurisdiction over the work, shall do the work.

4. The vendor shall submit a letter signed by a corporate officer, partner, or owner of the contracting company stating that they shall install all equipment including hardware, software and cabling; shall make all connections at all field devices and at the head-end; and shall make all necessary field adjustments for a fully functional system.

5. The vendor shall submit a letter signed by a corporate officer, partner, or owner of the contracting company describing the service capability of the company and stating the company's commitment to maintain that service capability through the warranty period.

6. Preliminary Plans: Submit documentation including a preliminary installation schedule, architecture and design plan, and call flow patterns to the Owner for review prior to the start of work. Installation Work shall not commence before installation Electrical Subcontractor receives Owner approval of design and architecture.

7. The vendor shall submit shall provide a migration and integration plan that details the Vendor's implementation strategy to complete the system. This plan shall be prepared by the Vendor and approved by the Owner.

B. Shop Drawings

1. Prior to assembling or installing the system, the Electrical Subcontractor shall provide complete shop drawings which include the following:

   a. Architectural floor plans indicating all system device locations.

   b. Full schematic wiring information for all devices. Wiring information shall include cable type, cable length, conductor routings, quantities, and point-to-point termination schedules.

   c. Complete system one-line block diagram.

   d. Statement of the system sequence of operation.

   e. Riser diagrams showing interconnections.

   f. Detail drawings showing installation and mounting.

   g. Calculations detailing 25% spare capacity of each circuit.

2. All drawings shall be fully dimensioned.

3. Operating License: Submit evidence of application for FCC Radio Station Authorization prior to installing equipment. Furnish the license or a copy of the application for the license, to the Owner/End User prior to operating the equipment. The original license must be delivered to the Owner/End User.

C. As-Built Drawings

1. At the conclusion of the project, the Electrical Subcontractor shall provide "as built" drawings. The "as built" drawings shall be a continuation of the Electrical Subcontractor's shop drawings as modified, augmented, and reviewed during the installation, check out and acceptance phases of the project. All drawings shall be fully dimensioned and prepared in DWG format using the latest version of AutoCAD.

2. The as-built drawings shall incorporate all updated system riser diagrams prepared in DWG format using the latest version of AutoCAD.

D. Manuals

1. At the conclusion of the project, the Electrical Subcontractor shall provide copies of the manuals as described herein. Each manual's contents shall be identified on the cover. The manual shall include names, addresses, and telephone numbers of each system integrator installing equipment and systems and the nearest service representatives for each item of equipment for each system. The manuals shall have a table of contents and labeled sections. The manuals shall include all modifications made during installation, checkout, and acceptance. The manuals shall contain the following:

    a. Functional Design Manual

        1) The functional design manual shall identify the operational requirements for the system and explain the theory of operation, design philosophy, and specific functions. A description of hardware and software functions, interfaces, and requirements shall be included for all system operating modes.

    b. Hardware Manual

        1) The hardware manual shall describe all equipment furnished including:

            a) General description and specifications

            b) Installation and check out procedures

            c) Equipment layout and electrical schematics to the component level

            d) System layout drawings and schematics

            e) Alignment and calibration procedures

            f) Manufacturers repair parts list indicating sources of supply

    c. Software Manual

        1) The software manual shall describe the functions of all software and shall include all other information necessary to enable proper loading, testing, and operation. The manual shall include:

            a) Definition of terms and functions

            b) Use of system and applications software

            c) Initialization, start up, and shut down

            d) Alarm reports

            e) Reports generation

            f) Data base format and data entry requirements

            g) Directory of all disk files

2. Operators Manual

    a. The operator's manual shall fully explain all procedures and instructions for the operation of the system including:

        1) Computers and peripherals

        2) System start up and shut down procedures

        3) Use of system, command, and applications software

        4) Recovery and restart procedures

5) Graphic alarm presentation
6) Use of report generator and generation of reports
7) Data entry
8) Operator commands
9) Alarm messages and reprinting formats
10) System access requirements

3. Maintenance Manual
   a. The maintenance manual shall include descriptions of maintenance for all equipment including inspection, periodic preventive maintenance, fault diagnosis, and repair or replacement of defective components.

1.8 WARRANTY

A. Comply with Section 260001.

B. The Electrical Trade Contractor shall warranty that all materials furnished shall be free from defects of material for a period of one year from the date of Substantial Completion.

C. Provide a 3-year preventive maintenance plan. The plan shall include one site visit per year after the warranty period to verify that the system is working per the specifications and to proactively perform maintenance, repairs, and replacements to prevent failures before they occur.

D. Cooper Controls Fifth Light: The manufacturer shall supply a five (5) year warranty on LED Drivers and a two (2) year warranty on all other components of the lighting control system.

PART 2 - PRODUCTS

2.1 LIGHTING CONTROL SYSTEM

A. Manufacturers
   1. Cooper Controls, Fifth Light.
   2. Lutron, Echo.
   3. Osram Sylvania, Encelium.
   4. Or approved equal.

B. Basis Of Design
   1. Cooper Controls - Fifth Light for building low voltage lighting controls.

C. General Requirements
   1. The Lighting Control System shall meet all of the general criteria, operating characteristics and performance parameters specified herein.
   2. The deployment team, defined as the electrical installer and commissioning agent, shall provide, connect and furnish all equipment necessary for the proper and complete operation and service of the Lighting Control System as indicated in the engineering drawings and specified herein.

2.2 SYSTEM REQUIREMENTS

A. Emergency Default:

1. The lighting control system and lighting end devices must revert to a safe and acceptable default state in the event of a loss of power situation. In order for the default state to be considered safe and acceptable it must meet the following specifications:

a. Loss of Power to Lighting Relays: All relays being used for lighting control must default to the closed (on) position the instant that power is lost to their corresponding lighting circuit. Relays must remain in the closed (on) state until the supply of power is resumed, at which point all relays are to continue to remain in the closed (on) position until commanded otherwise.

b. Loss of Power to the Lighting Control Panels: All lighting control panels are to be supplied with power from non-emergency circuits. In the event that power is lost to the lighting control panel, all of the lighting relays and Drivers that are connected to it shall revert to the full power (on) state and remain in this state until power is restored and they are commanded to otherwise.

c. Loss of Power to Emergency Circuits: In the event that power is lost to the emergency circuits, all lighting relays that are supplied by emergency fixtures shall automatically revert to the default closed (on) position. When back up power is activated, all relays that are supplied by emergency fixtures shall be in the closed (on) state and are to remain in this state until commanded otherwise. All Drivers that are supplied by emergency circuits shall revert to the full power state and remain in this state the instant that back up power is activated until commanded otherwise.

d. Tamper Proof Settings: The default settings (or any other settings that pertain to the operation of the lighting control system during emergency conditions) of all lighting control equipment, DALI Drivers and lighting relays shall not be capable of being modified through either a manual or software provision by the user of the lighting control system.

B. Central Control: All operating parameters of the lighting control system shall be configured from central point of access through a secure internet connection.

C. Remote Access: All operating parameters of the lighting control system shall be configurable from any internet enabled computer through a web-browser. Building Owner to provide a secure VPN connection into the Lighting Server for a minimum of two years to allow for the Manufacturer to support the end user with original system set up and necessary system monitoring.

D. User Access: The end user shall be capable of applying administrative rules to restrict the access privileges of each user. Access restrictions shall be applicable to the set of fixtures as well as the feature set available for those fixtures.

E. System Clock: The time clock of the lighting control system shall be synchronized to internet standard time.

F. Power Failure: The lighting system shall resume operation after a power outage to the state that it would have been in if the power outage had never occurred.

G. Loss of Communication: DALI devices shall operate at a user specified level in the event that communication is lost to the control panel.

H. Time Scheduling: The daily power consumption cycle of each fixture shall be regulated by a programmable scheduling routine.

I. Daylight Harvesting: The lighting system shall adjust fluorescent light levels in response to varying ambient light levels in order to maintain a constant, user-specified light level at desk height. Ambient light levels shall be read from a network of daylight sensors that are distributed throughout areas that are candidates for daylight harvesting. Intelligent algorithms shall be used to minimize the number of sensors required.

1. Daylight Sensor Groupings: The set of light fixtures that are controlled by a given Daylight Sensor can span multiple DALI communication busses, shall be configurable through software and shall not require any manual wiring to modify. The system shall allow for light fixtures to be added or removed from given Daylight Sensor group through web software.

2. Daylight Sensor Settings: All settings that govern the behavior of a given Daylight Sensor shall be adjustable through web software and shall not require any physical adjustment to the sensor itself.

3. Gradient Dimming: A single daylight sensor working in conjunction with lighting software shall be capable of providing separate control for up to 16 groups of light fixtures. Each group of light fixtures can have unique settings, including the lighting set point, so that location specific conditions can be accommodated by a single sensor. Gradient diming will allow for the row of light fixtures closest to the window to dim more than the next closest row of light fixtures (the third closest row dims more than the second closest row and so on for the 4th,5th…16th rows) even though all rows are controlled by the same single sensor.

4. Electronic Enable/Disable: The daylight sensor shall be enabled and disabled through software in order to manage its operational on a scheduled daily basis.

J. Personal Control: Users shall customize the lighting levels in their own workspace. Building Management can apply restrictions to the range of lighting levels that can be programmed by each occupant to ensure conservation targets are met. Access is provided from any computer or hand-held device that is connected to the internet. The light level of each fixture shall be controllable in increments from 0-100% in increments of 1% for a specified duration of time.

1. Number of Simultaneous Users: The system shall accommodate a minimum of five hundred (500) simultaneous web users.

2. Browser access: Safari, Internet Explorer, Google Chrome, Mozilla Firefox.

3. The vendor shall setup personal control for each classroom, office or similar area. Personal control shall be available from personal computer, tablet or phone.

K. Occupancy Detection: The system shall reduce the power consumption in vacant areas by reading the status of a network of low voltage occupancy sensors.

1. Occupancy Sensor Wiring: Occupancy sensors shall not be wired to switch the AC power line nor shall be wired directly to any lighting Drivers or any other lighting end device. Occupancy sensors shall be wired directly to the low voltage lighting control panel.

2. Occupancy Sensor Groupings: The set of light fixtures that are controlled by a given occupancy sensor can span multiple DALI communication busses, shall be configurable through software and shall not require any manual wiring. The system shall allow for light fixtures to be added or removed from given occupancy sensor group through web software.

3. Occupancy Sensor Settings: All settings that govern the behavior of a given occupancy sensor shall be adjustable through web software and shall not require any physical adjustment to the sensor itself.

4. Occupancy Sensor Levels: Each occupancy sensor shall have a total of five (5) programmable lighting levels. These levels are defined as follows:

   a. Occupied Level: The Occupied Level represents the light level that fixtures will be commanded to when occupancy is detected. Light levels will remain at the Occupied Level until occupancy is no longer detected.

   b. Transition Levels: Transition Levels provide a gradual change in light levels when occupancy is no longer detected. Three (3) Transition Levels, each of which can be programmed with different light levels and timer values shall be provided.

   c. Vacancy Level: The Vacancy Level represents the light level that fixtures will be commanded to when occupancy is no longer being detected and all Transition Levels have expired.

   d. Electronic Enable/Disable: The occupancy sensor shall be enabled and disabled through software in order to manage its operation on a scheduled daily basis.

L. Monitoring: The operational status of all system hardware and software components shall be routinely checked. Faults with tubes, Drivers and every other components of the system shall be automatically detected and electronic notifications shall be distributed. These notifications clearly illustrate the location of the device on the floor plan and the time that the fault was detected.

M. Reporting: The energy consumption of the lighting system shall be viewed, tracked and recorded. Data shall be charted according to user-defined zones, which can be as small as an individual fixture or as large as a portfolio of buildings. Savings shall be presented in terms of energy, dollars and greenhouse gas emissions (if requested). The data presented is a computed value and does not require the installation of additional hardware. Alternatively, this software can be integrated with a physical metering system to present revenue grade energy measurements.

N. Demand Response: The system shall be capable of linking a portfolio of facilities together so that their operating policy can be centrally managed in response to a load shedding event. Electrical demand shall be reduced on a priority basis; with low traffic areas being dimmed first while the illumination levels of high use areas is maintained. A transaction record of all demand response activities shall be created and distributed according to user specifications.

O. Off Hour Access: The system shall only activate the set of lights required by an occupant to perform their work during the off-hour time period. The system shall avoid turning on an entire quadrant or floor for when only an office, hallway and washroom are required. These lights can be activated in several ways including, a pass card, phone system or web software. Cleaning staff are accommodated by a programmed turn-on and shut-down sequence, which illuminates their work area in successive fashion.

P. Zoning: The system shall be capable of configuring zones via software and avert the need to re-wire certain power distribution circuitry and lighting equipment as tenancy patterns change.

Q. Multi-Building Control: The lighting control system shall be capable of connecting to an offsite datacenter so that it can be operated as part of a multiple building control network.

1. Data Consolidation: Buildings operating on the multiple building networks shall have all information consolidated to a single report and view on the web interface. This allows for the total energy consumed by all buildings to be displayed in a single graph rather than one graph for each building. Information relating to the all reporting and monitoring functions (as described in this specification) shall be consolidated in this manner.

R. Override Management: The system shall be capable of handling several different commands targeted at the same fixture in a manner that is logical, pre-defined and acceptable to the end customer.

S. Graphical User Interface: The visual interface of the software shall import the floor plan design file in DXF or DWG format. All lighting fixtures, sensors and other components of the lighting system contained in the floor plan design file shall be automatically recognized by the software and rendered into interactive objects on the graphical user interface.

2.3 CONTROL EQUIPMENT

A. Momentary Switches

1. Momentary Switches shall provide continuous dimming control via a low voltage connection to a Lighting Control Panel.

2. Momentary Switch Wiring: Momentary Switches shall not be wired to switch the AC power line nor shall be wired directly to any lighting Drivers or any other lighting end device. Momentary Switches shall only be wired to a low voltage lighting control panel through a three (3) conductor low voltage cable that meets the following specifications: 16AWG/3, plenum rated, FT6.

3. Momentary Switch Groupings: The set of light fixtures that are controlled by a given Momentary Switch shall be configurable through software and shall not require any manual wiring. The system shall allow for light fixtures to be added or removed from given Momentary Switch group through web software.

4. Momentary Switch Settings: All settings that govern the behavior of a given Momentary Switch shall be adjustable through web software and shall not require any physical adjustment to the Momentary Switch itself.

5. Dynamic Duration: All commands sent from the Momentary Switch shall expire after a specified time period. The duration of this time period shall be programmable, based on the time of day that the Momentary Switch is activated. This will allow for the time duration to differ at various times of day. Each momentary switch can have a different dynamic duration.

6. Momentary Switch Functionality: Momentary Switches shall provide one touch on/off functionality as well as press and hold dimming.

B. Low Voltage Keypads

1. Low Voltage Keypads shall provide continuous dimming control via a low voltage connection to a Lighting Control Panel.

2. Low Voltage Keypads Wiring: Low Voltage Keypads shall not be wired to switch the AC power line nor shall be wired directly to any lighting Drivers or any other lighting end device. Low Voltage Keypads shall only be wired to a low voltage lighting control panel through a multi (X) conductor low voltage cable that meets the following specifications: 16AWG/X, plenum rated, FT6; where X is the number of buttons on the keypad plus one (1).

3. Low Voltage Keypad Groupings: The set of light fixtures that are controlled by a given Keypad button shall be configurable through software and shall not require any manual wiring. The system shall allow for light fixtures to be added or removed from given Keypad groups through web software.

4. Low Voltage Keypad Settings: All settings that govern the behavior of a given Keypad shall be adjustable through web software and shall not require any physical adjustment to the device itself.

5. Dynamic Duration: All commands sent from the Keypad shall expire after a specified time period. The duration of this time period shall be programmable, based on the time of day that the Keypad is activated. This will allow for the time duration to differ at various times of day. Each Keypad can have a different dynamic duration.

6. Low Voltage Keypad Functionality: Low Voltage Keypads shall provide one touch on/off functionality as well as press and hold dimming. Different groups of lights shall be assigned to different buttons on each Keypad.

C. Addressable Field Relays

1. Manufacturer: Cooper Controls Fifth Light

2. Communication: DALI protocol

3. Power: from the DALI bus

4. Maximum current draw: 3.75 milli-Amps

5. Communication connections: two wires (16/18AWG, FT6, non-twisted, non-shielded, non-polarized and plenum rated) connected to the DALI communication bus.

6. Power ratings: up to 20 Amps/347 VAC.

7. Mounting: junction box

D. Addressable Dimming Modules

1. Manufacturer: Cooper Controls Fifth Light

2. Communication: DALI protocol

3. Power: from the DALI bus

4. Maximum current draw: 3.75 milli-Amps

5. Communication connections: two wires (16/18AWG, FT6, non-twisted, non-shielded, non-polarized and plenum rated) connected to the DALI communication bus.

6. Power ratings: up to 20 Amps/120 VAC.

7. Dimming control: forward phase dimming control for incandescent and magnetic low voltage loads

8. Mounting: junction box

E. Relay Panels

1. Manufacturer: Cooper Controls Fifth Light

2. Communication: DALI protocol

3. Power: from the DALI bus

4. Maximum current draw: 3.75 milli-Amps (per relay)

5. Communication connections: two wires (16/18AWG, FT6, non-twisted, non-shielded, non-polarized and plenum rated) connected to the DALI communication bus.
6. Power ratings: up to 20 Amps/347 VAC (per relay)
7. Number of relays: up to 24 or 48.

F. Addressable Multi Sensors

1. Manufacturer: Cooper Controls Fifth Light
2. Communication: DALI protocol
3. Power: from the DALI bus
4. Maximum current draw: 3.75 milli-Amps
5. Connections: two wires (16/18AWG, FT6, non-twisted, non-shielded, non-polarized and plenum rated) connected to the DALI communication bus.
6. Sensing technologies: occupancy, daylight and temperature
7. Daylight sensing range: 0-400 lux
8. Daylight sensing coverage: light input within 60° cone
9. Occupancy detection technology: passive infrared
10. Occupancy detection coverage area: 600 ft2 or 1,200 ft2.
11. Occupancy detection angle: 360°
12. Temperature detection range: -19.25°C to 44.5°C (-2.65°F to 112.1°F)
13. Mounting: junction box or ceiling tile
14. Groups: The set of fixtures controlled by a given multi sensor shall be completely configurable through software and can span multiple DALI communication busses.
15. Timers: All times shall be configurable through the web software and shall not require any manual configuration of settings prior to installation. Timer values can range from 1second to 24 hours.

G. Low Voltage Occupancy Sensors

1. Manufacturer: Cooper Controls Greengate
2. Communication: Low voltage signal
3. Power: from lighting control panel
4. Connections: three wires (16/18AWG, FT6, non-twisted, non-shielded, non-polarized and plenum rated) connected to the lighting control panel
5. Occupancy sensing technologies: passive infrared and/or ultrasonic technology.
6. Occupancy detection coverage area: options available from 500 ft2 or 2,000 ft2.
7. Occupancy detection angle: 360° or linear
8. Mounting: junction box or ceiling tile
9. Groups: The set of fixtures controlled by a given multi sensor shall be completely configurable through software and can span multiple DALI communication busses.
10. Timers: All times shall be configurable through the web software and shall not require any manual configuration of settings prior to installation. Timer values can range from 1second to 24 hours.

H. Lighting Control Panels

1. Internal circuitry shall be protected by a fused receptacle.
2. Shall provide Class I/II NEC separation
3. Lighting Control Panel shall provide the interface between the software application and lighting Drivers, sensors, keypads and low-voltage switches.
4. Lighting Control Panel shall provide 2-way communication to software application via an Ethernet protocol.
5. Lighting Control Panel shall provide 2-way communication to lighting Drivers via the DALI protocol.
6. The control hardware shall provide a general purpose interface to low voltage analog and digital inputs and outputs.
7. Lighting Control Panel shall be mounted in a tamper-proof electrical cabinet.
8. The Lighting Control Panel shall allow remote diagnosis of its operational status.

2.4 DALI DIMMABLE ELECTRONIC DRIVERS

A. Physical Characteristics

1. The cross sectional dimensions of the Driver shall not exceed 1.2” in height and 1.5” in width.
2. The Driver shall be equipped with 18 AWG flying leads that are 2 feet long for power, DALI, red and blue wires and 4 feet long for yellow wires.

B. Performance Specifications

1. Driver shall provide continuous dimming that is free of flicker despite poor power quality. Dimming range shall be from 1% to 100% (in increments of 1%) using a dimming curve that is optimized for eye sensitivity.
2. The Driver shall abide by the DALI protocol as outlined in the IEC 60929 specification.
3. Driver shall have the following programmable settings:
    a. Individual addresses: 64
    b. Group address: 16
    c. Scenes: 16
4. Bi-directional digital communication
5. Driver shall return the following programmable parameters
    a. Power on level
    b. Short, search and random addresses
    c. Groups 0-7 and 8-15
    d. Scenes 0-15
    e. Minimum and maximum dimming levels
    f. Fade time and fade rate
    g. System and power failure levels
    h. Physical minimum level

i. Device type

j. Version number

k. Returns the following status parameters:

l. Actual dim level

m. Driver status and tube status

n. Lamp power on

o. Limit error

p. Reset state

q. Missing short address

r. Contents of volatile memory

6. Driver communication wires shall be polarity insensitive and shall not require shielding, twisting. Plenum rated 18 AWG 2 conductor cable shall be sufficient.

7. Driver control wires shall be rated for the voltage of the power supply in order to be capable of being run in the same conduit as power wires.

8. Driver communication wires shall be capable of withstanding connection to the line voltage for an indefinite period of time without incurring any damage.

9. All control and communication operations of the Driver shall be immune to noise and power disturbances.

10. Driver shall meet the following operating parameters:

a. Operating Voltage: 120VAC, 277 VAC or 347 VAC (+5%/-10%) as per application requirements.

b. Protection: End of lamp life and inrush current limiting circuitry.

c. Warranty: 5 years

d. Dimming range: T8: 1% - 100%, T5/T5HO: 3%-100% (in increments of 1%)

e. Driver Factor: Field programmable (T8: 0.01-1.0, T5/T5HO: 0.03-1.0)

f. Power Factor: > 0.95 at all dimming levels while operating within rated voltage range

g. Total Harmonic Distortion: <10% at all dimming levels while operating within rated voltage range (3rd harmonic <8%)

h. Peak Inrush Current < 7 Amps

i. Lamp Operating Frequency: > 40KHz

j. Lamp Current Crest Factor: < 1.7

k. Maximum Enclosure Temperature: 167 F/75 C

l. Maximum Output Voltage: < 600Vrms

m. Standby Power consumption: <2W

n. Lamp Start: Programmed rapid start

o. Lamps Start Time: 1.5 Seconds

p. Lamp Start Power: Directly at any dimming level without flash to higher level.

q. Number of lamp starts: 200,000

C. Driver Regulatory Requirements

1. CSA C22.2 / UL 935
2. ANSI C82.11 High Frequency Fluorescent Lamp Driver Standard
3. ANSI/IEEE C62.41 Category A Surge Protection
4. FCC Part 15
5. Rated for Class I or Class II control applications

2.5 DEPLOYMENT

A. Testing DALI Loop

1. Ensure standby voltage across the DALI lines (VDALI) is within the following range: 9.5VDC < VDALI <22.5 VDC, as specified in the DALI protocol.
2. Ensure that there is no continuity from one DALI communication line to the other.
3. Ensure that there is no continuity from the DALI loop to ground.

B. DALI Device Addresses

1. Ensure that there is no continuity from the DALI loop to ground.

2.6 SWITCHES AND FACEPLATES

A. All switch buttons shall be engraved as denoted on the drawings. Stick on labels shall not be acceptable.

B. All faceplates shall be stainless steel.

2.7 SUPPORT

A. On Site Support: Shall be available within 24 hours of a service call anywhere in Canada and the U.S.A.

B. Phone Support: Toll free technical support shall be available 24 hours a day, 7 days a week.

C. Internet Support: The operational status of tubes, Drivers, critical programs, control hardware and computers can be monitored and diagnosed remotely. Building owner shall provide the Manufacturer with a secure VPN connection to the Lighting Server in order to establish this level of support. Manufacturer to adhere to the necessary security requirements set forth by the building owner. This connection must be maintained for a minimum of two years in order to support the specified warranty.

2.8 INTEGRATION

A. Network Convergence

1. The LCS shall transmit data on the same Ethernet communication network used for computers, VOIP telephones and other IP devices running in the facility.
2. The LCS shall not incur noticeable latencies by running on the unified network
3. The LCS shall operate with the same network hardware used for routing standard TCP/IP data packets.

B. BAS Integration

1. The integration of the LCS and Building Automation Systems (BAS) shall meet the objectives listed as follows.
2. Consolidated Device Status: The operational status of all system devices (BAS components and LCS end devices including DALI Drivers, DALI relays and LCS control panels) shall be consolidated to a central repository.
3. Consolidated Energy Reporting: The energy consumption of all system devices shall be published to a consolidated central repository.
4. Asset Tracking: The bill of materials of each system shall be consolidated to a central repository.
5. Event calendar: The maintenance schedule for each system shall be consolidated to a central repository.
6. Shared Hardware: Devices common to multiple systems shall be shared in order to reduce overall part quantity. (Occupancy sensors in the lighting system shall be used to signal room/space occupancy status to the HVAC system by sharing data among both systems).
7. Automated Response: Events in any system shall automatically trigger a programmed, user defined response in appropriate other systems. (For example, a demand response event in the HVAC system shall automatically initiate a demand response routine in the LCS).
8. Central Access: The user interface shall be consolidated into a single window to perform major daily operator functions.
9. Coordinate with the BAS vendor to enable the control of the parking lot lighting through the BAS.
10. ***The LCS integration with the BAS shall allow the BAS to control the exterior site lighting fixtures. The LCS vendor shall provide interconnection points and programming to allow the BAS to turn the site lighting ON/OFF*** (Add #4)

C. BACnet Interface

1. Bi-directional transmission of data between the LCS and the BAS shall be performed through a BACnet compliant interface.
2. The BACnet interface shall publish all key operating parameters of the LCS for the read and write operations required to implement intelligent integration strategies.
3. Demand Response: The BACnet interface shall publish the amount of load in the LCS available for shedding. The LCS shall also publish the amount of load currently being shed for previous demand response events.
4. Monitoring: The BACnet interface shall publish the operational status of all LCS devices, including lamps driven by DALI Drivers.
5. Reporting: The LCS shall publish the energy consumption for each DALI device for a given time interval. The instantaneous power shall also be published through the BACnet interface.
6. Control: The BACnet interface shall provide read/write access to all LCS end devices.
7. Device Attributes: The x-y coordinates and orientation of all LCS end devices shall be published through the BACnet interface in order to display LCS end devices in the visual interface other systems.

2.9 LIGHT LEVEL PROGRAMMING

A. General,

1. All dimmable light fixtures shall be programmed for a maximum 80% light output unless higher output is needed to meet footcandle levels.

2. All occupancy sensors shall be programmed for vacancy mode (requires manual activation of wall switch to turn ON light fixtures).

B. Classroom

1. Occupied Level: 80% LPD (Light Power Density). Achieve average illumination at desk level of between 35-50 footcandles with minimum of 25 footcandles at any point more than three feet from any wall.

2. AV Mode: Achieve an average illumination at the desk level of between 10-20 footcandles for any point in the room greater than three feet from the side walls, 10 feet from the front wall and six feet from the back wall, while limiting vertical illumination on the projection screen to no more than seven footcandles at any point on the screen.

3. Quite Time: override the multi sensor and achieve average illumination at desk level of between 35-50 footcandles with minimum of 25 footcandles at any point more than three feet from any wall for a preset time of one hour.

4. Transition Levels: Provide a gradual change in light levels when occupancy is no longer detected (50%, 25%, 10% LPD)

5. Vacancy Level: 0% LPD

C. Common Area

1. Occupied Level: 80% LPD (Light Power Density). Achieve average illumination at desk level of between 35-50 footcandles with minimum of 25 footcandles at any point more than three feet from any wall.

2. AV Mode: Achieve an average illumination at the desk level of between 10-20 footcandles for any point in the room greater than three feet from the side walls, 10 feet from the front wall and six feet from the back wall, while limiting vertical illumination on the projection screen to no more than seven footcandles at any point on the screen.

3. Quite Time: override the multi sensor and achieve average illumination at desk level of between 35-50 footcandles with minimum of 25 footcandles at any point more than three feet from any wall for a preset time of one hour.

4. Transition Levels: Provide a gradual change in light levels when occupancy is no longer detected (50%, 25%, 10% LPD)

5. Vacancy Level (Normal Business Hours): 50% LPD

6. Vacancy Level (Non-Business Hours): 0% LPD

D. Office/Conference

1. Occupied Level: 80% LPD

2. Transition Levels: Provide a gradual change in light levels when occupancy is no longer detected (50%, 25%, 10% LPD)

3. Vacancy Level: 0% LPD

E. Bathroom

1. Occupied Level: 80% LPD
2. Transition Levels: Provide a gradual change in light levels when occupancy is no longer detected (50%, 25%, 10% LPD)
3. Vacancy Level (Normal Business Hours): 10% LPD
4. Vacancy Level (Non-Business Hours): 0% LPD

F. Utility/Storage/Maintenance

1. Occupied Level: 80% LPD
2. Transition Levels: Provide a gradual change in light levels when occupancy is no longer detected (50%, 25%, 10% LPD)
3. Vacancy Level: 0% LPD

G. Cafeteria

1. Occupied Level: 80% LPD
2. Transition Levels: Provide a gradual change in light levels when occupancy is no longer detected (50%, 25%, 10% LPD)
3. Vacancy Level (Normal Business Hours): 50% LPD
4. Vacancy Level (Non-Business Hours): 0% LPD

H. Gym

1. Occupied Level: 80% LPD
2. Transition Levels: Provide a gradual change in light levels when occupancy is no longer detected (50%, 25%, 10% LPD)
3. Vacancy Level (Normal Business Hours): 10% LPD
4. Vacancy Level (Non-Business Hours): 0% LPD

I. Media Center

1. Occupied Level: 80% LPD
2. Transition Levels: Provide a gradual change in light levels when occupancy is no longer detected (50%, 25%, 10% LPD)
3. Vacancy Level (Normal Business Hours): 50% LPD
4. Vacancy Level (Non-Business Hours): 0% LPD

J. Science

1. Occupied Level: 80% LPD (Light Power Density)
2. Transition Levels: Provide a gradual change in light levels when occupancy is no longer detected (50%, 25%, 10% LPD)
3. Vacancy Level: 0% LPD

2.10 LIGHTING RELAY PANEL PROGRAMMING

A. Classroom

1. Occupied Level (Normal Business Hours): ON

2. Vacancy Level (Normal Business Hours): ON
3. Occupied Level (Non-Business Hours): ON
4. Vacancy Level (Non-Business Hours): OFF

B. Common Area

1. Occupied Level (Normal Business Hours): ON
2. Vacancy Level (Normal Business Hours): ON
3. Occupied Level (Non-Business Hours): ON
4. Vacancy Level (Non-Business Hours): OFF

C. Office/Conference

1. Occupied Level (Normal Business Hours): ON
2. Vacancy Level (Normal Business Hours): ON
3. Occupied Level (Non-Business Hours): ON
4. Vacancy Level (Non-Business Hours): OFF

D. Fire alarm integration:

1. In the event of a fire alarm all relays controlling the projector circuits shall turn OFF after the receipt of a contact closure from the fire alarm panel. Once the fire alarm panel is reset, the relays controlling the projector circuits shall turn ON.

E. Generator

1. In the event of a power failure or when the generator is running the system will turn ON all the light fixtures and override all switches/programming. When the power is restored or the generator is turned off the system will resume normal operation.

F. Programmed timed OFF

1. The system will turn off all light fixtures except for the night lights at a prescribed time designated by the Owner. However, if the system senses occupancy in the building it will override the scheduled time off until 15 minutes after building vacancy is detected through a gradual change in light levels when occupancy is no longer detected.

PART 3 - EXECUTION

3.1 INSTALLATION

A. The control system shall be installed and fully wired as shown on the plans by the installing Subcontractor. The Electrical Subcontractor shall complete all electrical connections to all control circuits.

B. Install the work of this Section in accordance with manufacturer’s printed instructions unless otherwise indicated.

C. Provide computer-generated documentation on the commissioning of the system including room by room description including:

1. Sensor parameters, time delays, sensitivities and daylighting set-points.

2. Sequence of operation, (e.g. manual ON, Auto OFF. etc.).

3. Load parameters (e.g. blink warning, etc.).

3.2 PRODUCT SUPPORT AND SERVICE

A. Factory telephone support shall be available at no cost to the owner. Factory assistance shall consist of solving programming or application questions concerning the control equipment.

3.3 COMMISSIONING

A. Comply with requirements specified in Division 1.

B. Engage a factory-authorized service representative to supervise and assist with startup service. Complete installation and startup checks according to the approved manufacturer's written instructions

C. The lighting system shall be commissioned as per system specifications upon installation and completion of the lamp burn-in period. The Manufacturer shall coordinate all commissioning activities through the Electrical Installer and provide detailed status reports to the entire Project Team as key milestones are being achieved. Timelines and objectives for completion shall also be provided by the Manufacturer.

D. The commissioning agent shall visit the site on a scheduled basis as per contract provisions. Work shall be phased so that specific areas can be commissioned over the course of the project and must allow for the capability to have sections of the building running prior to final deployment. Ex: West Wing Lighting Controls functioning and saving energy prior to installation completion on the East Wing of building.

E. The commissioning agent shall perform the following on site activities as part of their deployment requirements.

F. Training of Electrical Subcontractor: All personnel responsible for installing the system shall be trained by the commissioning agent prior to the commencement of the system deployment.

G. Wiring and Hardware Review: All wiring connections and electrical equipment included in the scope of the lighting control system shall be assessed.

H. Field Testing: All DALI loop communication connections, sensor connections and Ethernet connections shall be verified in accordance to a specified testing procedure.

I. Final Inspection: All of the connections relating to the lighting control system shall be tested and verified.

J. Training: The end customer shall be trained in the usage of the system within 1 month of completion of the commissioning process. A second training session shall be scheduled within 6 months of final commissioning. This training class shall consist of three separate two hour sessions. The first to cover any specifics to the scope of control in the project and a general technology overview, the second would contain an overview of the software manual and the third would cover any frequently asked questions and how and whom to contact for further service and support.

3.4 TRAINING AND SERVICE

A. Comply with Section 26 00 01.

B. Conduct four 4-hour training sessions. Train the Owner's maintenance personnel on procedures and schedules related to start up and shutdown, troubleshooting, servicing, and preventive maintenance.

3.5 EXTRA MATERIALS

A. Furnish the following component at the end of the project to the Owner:

1. Occupancy Sensors: 10
2. Hi-bay occupancy sensor: 5
3. Wall stations: 10 of each type.
4. Field relays: 10
5. Digital Analog Converter (DAC): 5

End of Section

DO NOT REMOVE
THIS PAGE INTENTIONALLY LEFT BLANK

Section 26 22 00

LOW-VOLTAGE TRANSFORMERS

(TRADE CONTRACT REQUIRED AS PART OF SECTION 26 00 01)

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. PUBLICLY BID TRADE CONTRACT REQUIREMENTS: As provided under Section 26 00 01 - ELECTRICAL and supplemented under the Bidding Requirements, Contract Forms, and Conditions of the Contract, and applicable parts of Division 1 - GENERAL REQUIREMENTS.

1. Work of this Trade Contract includes all individual specification sections listed in Section 26 00 01.

1.2 RELATED DOCUMENTS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications

1.3 REFERENCE STANDARDS

A. FEDERAL REGISTER – US Department of Energy, Office of Energy Efficiency and Renewable Energy. 10 CFR Part 430, July 29, 2004. Energy Conservation Program for Commercial and Industrial Equipment: Energy Conservation Standards for Distribution Transformers (Designated C-3).

B. ANSI/NEMA ST 20 - Dry Type Transformers for General Applications.

C. ANSI/NEMA TP-1 – Guide for Determining Energy Efficiency for Distribution Transformers.

D. ANSI/NEMA TP-2 – Standard Test Method for Measuring Energy Consumption of Distribution Transformers.

E. Metering Standards:

1. Computational algorithms per IEEE Std 1459-2000.

2. UL 916, UL 61010C-1 CAT III.

3. IEEE C57.110-1998 – IEEE Recommended Practice for establishing transformer capability when feeding non-sinusoidal load currents.

4. IEEE-1100 – Recommended Practice for Powering and Grounding Sensitive Electronic Equipment.

5. IEEE Standard 1100 documents how typical transformers feeding electronic equipment produce substantially higher losses under electronic equipment load compared to under linear load, requiring derating.

1.4 SUMMARY

A. This Section includes the following types of dry-type transformers rated 600 V and less, with capacities up to 1000 kVA:

1. Distribution transformers.

1.5 SUBMITTALS

A. Submit product data including the following:

1. Insulation system impregnant data sheet as published by supplier.
2. Construction Details including enclosure dimensions, kVA rating, primary & secondary nominal voltages, voltage taps, BIL, unit weight.
3. Basic Performance characteristics including insulation class, temperature rise, core and coil materials, impedances & audible noise level, unit weight.
4. Inrush Current (typical 3 cycle recovery) Short Circuit Current data: Primary (Sym. O/P S/C) & Secondary (L-N/G S/C).
    a. Efficiency Data
        1) No load and full load losses per NEMA ST20.
        2) Linear load Efficiency data @ 1/6 load.
        3) Linear load efficiency data @ 1/4, 1/2, 3/4 & full load .
        4) Linear Load Efficiency @ 35% loading tested per NEMA TP-2.
        5) Efficiency under K7 load profile at 15%, 25%, 50%, 75%, 100% of nameplate rating.
    b. Copy of Factory ISO 9001 documentation describing nonlinear load test program.
        1) Meter and CT details including model, accuracy, serial numbers and calibration information.
    c. Copy of Linear & Nonlinear load test report for a representative 75kVA transformer.
    d. 25 year Product Warranty Certificate.
    e. Packaging method for shipment (meeting specification requirements) including representative picture.
    f. UL approval for non-linear loading greater than 5% and other applicable agency certifications.

B. Description of manufacturer’s factory nonlinear load test program.

1. In light of the significant degradation of transformer performance when feeding nonlinear load compared to linear load, it is mandatory that the manufacturer test the transformers under nonlinear load representative of real world load mix. Transformers that have not been subject to testing under nonlinear load will not be considered for this project due to the uncertainty related to their real world performance.
2. Given the lack of a standard for testing transformers under nonlinear load, the manufacturer must have a nonlinear Load Test Program operating in the production environment that is audited and documented per quality standard ISO 9001.
3. The nonlinear load bank shall consist of a phase-neutral loading with a k7 profile, representative of a mix of typical commercial equipment.
4. Meters and CTs shall both be revenue class accurate. CTs shall be operated within their approved accuracy loading range. Dual meters shall gather simultaneous

primary and secondary energy and harmonic data. Meter and CT details including model, accuracy, serial numbers and calibration information.

5. Efficiency: Measurements shall be taken at multiple load levels and plotted to show compliance with specification and correlation to the designed efficiency curve.

6. Efficiency shall be determined purely by measurements using method and instrumentation per NEMA TP-2 Standard. Other methods are not acceptable.

7. Harmonic data including current and Voltage THD at the different load levels shall be included with the test report.

8. Shop Drawings: Indicate dimensions and weights.

9. Wiring Diagrams: Power, signal, and control wiring.

10. Manufacturer Seismic Qualification Certification: Submit certification that transformers, accessories, and components will withstand seismic forces defined in Division 26.

1.6 DELIVERY, STORAGE AND HANDLING

A. Store and protect products

B. Store in a warm, dry location with uniform temperature. Cover ventilation openings to keep out dust, water and other foreign material.

C. Handle transformers using lifting eyes and/or brackets provided for that purpose. Protect against unfavorable external environment such as rain and snow, during handling.

1.7 COMMERCIAL PRODUCT

A. Transformer shall be a standard item in the manufacturer’s catalog.

1.8 FACTORY PRODUCT PERFORMANCE VALIDATION

A. At time of order, the customer may request that the project engineer or other designated customer representative witness the performance testing of one or more of the transformers on the project at the manufacturer’s facility, along with a demonstration of integrated metering option if specified.

1.9 ON-SITE PERFORMANCE VALIDATION

A. To insure that the products shipped to the job site meet this specification, provide on-site revenue class accurate efficiency and harmonic measurements of transformers once installed and operating at customer’s site. Data shall be collected from primary and secondary sides of the transformer simultaneously on a synchronized cycle by cycle basis. The use of two discrete meters that are not synchronized is not acceptable. Sampling shall be of 10% of transformers on the project once installed and operating, as selected by customer.

1.10 WARRANTY

A. Comply with Section 260001.

B. The Electrical Trade Contractor shall warranty that all materials furnished shall be free from defects of material for a period of one year from the date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers

1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
3. Square D; a brand of Schneider Electric.
4. Or approved equal.

2.2 BASIS OF DESIGN

A. The system specified is based upon products by Eaton Electrical Inc.; and represents the performance standard upon which any equivalent solution shall be based.

2.3 TRANSFORMER SPECIFICATION

A. Provide individually mounted dry type, 3-phase transformers in accordance with the following:

1. They shall be of the indoor ventilated type.
2. They shall be for 60 Hertz operation.
3. They shall be rated DoE 2016 compliant for efficiency.
4. They shall be copper wound.
5. They shall have a delta connected high side rated for 480 volts and a wye connected low side rated for 120/208 volts, 3 phase, 4 wire, grounded neutral or as indicated.
6. They shall have full capacity taps above and below normal as follows:

Transformer Rating	Taps
15 KVA and less	Two-5% - FCBN
30 KVA and above	Two-2-1/2% FCAN and 4-2-1/2% FCBN

7. Up to and including 15 KVA they shall be suitable for wall mounting. Larger than 15 KVA, shall be suitable for platform mounting.
8. They shall have sheet metal casings which are coated inside and out with a rust inhibiting primer and finished with a factory coat of enamel.
9. Floor or wall supported transformers shall be resiliently isolated from the building structure by means of neoprene vibration isolators.
10. Ceiling supported transformers shall be resiliently suspended by means of spring hanger rod isolators providing.
11. They shall be designed so that the full load temperature rise does not exceed 115-degree C, over a 40-degree C ambient. The insulation system shall conform to NEMA ST20 Standards for a 220-degree C UL component recognized insulation system for 15 KVA and above and 185-degree C for below 15 KVA.
12. Submit manufacturer’s certification that 75-degree C operating temperature wires connecting to their terminals will not be damaged under full load conditions if the ambient temperature is maintained at 40-degree C.

13. Submit manufacturers certification that the sound outputs of transformers do not exceed the following levels based on NEMA standard testing procedures:

TRANSFORMER RATING	DECIBEL SOUND OUTPUT
9	40
15	45
30	45
45	45
75	50
112-1/2	50
150	50
300	55

B. The center tap or neutral of the load side transformer windings shall be bonded to a lug and bolt inside the transformer casing. The bolt shall extend outside to serve as a system grounding stud. The bond to the bolt shall have an ampere capacity of no less than 20% of the capacity of a load side phase winding.

C. All dry-type transformers where indicated on the drawings or herein specified shall be electro-statically shielded type, UL listed K factor transformers, rated K-4 minimum. Provide K-13 transformers with 200% neutral bars, lugs and connections.

D. All transformers shall be listed for 115°C average temperature rise. Transformers rated at 150°C rise shall not be acceptable.

E. K rated transformers shall have an impedance range of 3% to 5% and shall have a minimum reactance of 2% in order to help reduce neutral current when supplying loads with large amounts of third harmonic current.

F. Submit manufacturers certification that peak excitation currents do not exceed twelve times full load current for transformers 30KVA and larger or thirty-two times full load for transformers less than 30 KVA.

G. Install transformers in accordance with the following:

1. Wall or floor mount transformers 15 KVA and less. Floor mount transformers larger than 15 KVA unless otherwise noted.

H. Dimensions: The maximum dimensions of the transformers shall be:

1. 15kVA 36.88” H X 24.88” W X 21.13” D
2. 30kVA 36.88” H X 24.88” W X 21.13” D
3. 45kVA 43.00” H X 30.50” W X 24.00” D
4. 75kVA 51.00” H X 34.50” W X 31.50” D
5. 112.5kVA 60.00” H X 38.00” W X 33.70” D
6. 150kVA 60.00” H X 38.00” W X 33.70” D
7. 225kVA 66.18” H X 42.18” W X 33.50” D

I. Transformer Label

1. Provide a permanent label on each transformer with location of its primary disconnect.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Follow all national, state and local codes with respect to transformer installation.

B. Where sound level may be of concern, utilize the services of a recognized and established Acoustical Consultant to provide the proper installation environment to minimize noise and vibration.

C. Check for damage and loose connections.

D. Set the transformer plumb and level.

E. Mount transformer on vibration isolation pads suitable for isolating the transformer.

F. Wall Brackets: Manufacturer's standard brackets

G. Provide Seismic restraints where required.

H. Coordinate all work in this Section with that in other sections.

I. Verify all dimensions in the field.

J. Upon completion of the installation, an infrared scan shall be provided for all bolted connections. Correct any deficiencies.

K. Adjust transformer secondary voltages to provide the required voltage at the loads.

L. Non-compliant products shall be replaced at no cost to the customer.

3.2 COMMISSIONING

A. Comply with requirements specified in Division 1.

B. Engage a factory-authorized service representative to supervise and assist with startup service. Complete installation and startup checks according to the approved manufacturer's written instructions.

3.3 TRAINING AND SERVICE

A. Comply with Section 26 00 01.

B. Conduct two 4-hour training sessions. Train the Owner’s maintenance personnel on procedures and schedules related to start up and shutdown, troubleshooting, servicing, and preventive maintenance.

End of Section

Section 26 24 13

SWITCHBOARDS

(TRADE CONTRACT REQUIRED AS PART OF SECTION 26 00 01)

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. PUBLICLY BID TRADE CONTRACT REQUIREMENTS: As provided under Section 26 00 01 - ELECTRICAL and supplemented under the Bidding Requirements, Contract Forms, and Conditions of the Contract, and applicable parts of Division 1 - GENERAL REQUIREMENTS.

1. Work of this Trade Contract includes all individual specification sections listed in Section 26 00 01.

1.2 RELATED DOCUMENTS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications

1.3 SUMMARY

A. Section Includes:

1. Service and distribution switchboards rated 600 V and less.
2. Transient voltage suppression devices.
3. Disconnecting and overcurrent protective devices.
4. Instrumentation.
5. Control power.
6. Accessory components and features.
7. Identification.

1.4 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Switchboards shall withstand the effects of earthquake motions determined according to SEI/ASCE 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

1.5 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Shop Drawings: For each switchboard and related equipment.

1. Include dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings.

2. Include time-current coordination curves for each type and rating of overcurrent protective device included in switchboards.

3. Include schematic and wiring diagrams for power, signal, and control wiring.

C. Seismic Qualification Certificates: Submit certification that switchboards, overcurrent protective devices, accessories, and components will withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."

D. Field quality-control reports.

E. Operation and maintenance data.

1.6 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with NEMA PB 2.

C. Comply with NFPA 70.

D. Comply with UL 891.

1.7 WARRANTY

A. Comply with Section 260001.

B. The Electrical Trade Contractor shall warranty that all materials furnished shall be free from defects of material for a period of one year from the date of Substantial Completion.

C. Provide a 3-year preventive maintenance plan. The plan shall include one site visit per year after the warranty period to verify that the system is working per the specifications and to proactively perform maintenance, repairs, and replacements to prevent failures before they occur.

D. Transient voltage suppression devices: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers

1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.

2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.

3. Square D; a brand of Schneider Electric.

4. Or approved equal.

2.2 BASIS OF DESIGN

A. The system specified is based upon products by Eaton Electrical Inc.; and represents the performance standard upon which any equivalent solution shall be based.

2.3 MANUFACTURED UNITS

A. Applicable Standards

1. The publications listed below form a part of this specification to the extent referenced. The latest revision of each publication shall be applied.

2. American National Standards Institute (ANSI) Publications:

a. C2 National Electrical Safety Code (NESC)

b. C12 Code for Electricity Metering

c. C39.1 Requirements for Electrical Analog Indicating Instruments

d. C57.12 Requirements for Instrument Transformers

e. Z35.1 Specifications for Accident Prevention Signs

f. Z55.1 Gray Finished for Industrial Apparatus and Equipment

3. National Electrical Manufacturers Association (NEMA) Publications:

a. C2 National Electrical Safety Code (NESC)

b. C12 Code for Electricity Metering

c. C39.1 Requirements for Electrical Analog Indicating Instruments

d. C57.12 Requirements for Instrument Transformers

e. Z35.1 Specifications for Accident Prevention Signs

f. Z55.1 Gray Finished for Industrial Apparatus and Equipment

4. National Electrical Manufacturers Association (NEMA) Publications:

a. AB-1 Molded Circuit Breakers

b. LI-1 Industrial Laminated Thermosetting Plastics

c. PB-2 Dead-Front Distribution Switchboards

d. LI-1 Industrial Laminated Thermosetting Plastics

e. PB-2 Dead-Front Distribution Switchboards

f. PB-2.1 Safe Handling, Installation, Operation and Maintenance of Switchboards

g. 260 Safety Labels for Padmounted Switchgear and Transformers Sited in Public Areas

5. International Electrical Testing Association (NETA)

a. ATS Acceptance Testing Specifications for Electrical Power Distribution Equipment

6. National Fire Protection Association (NFPA) Publications:

a. 70-1987 National Electrical Code

7. Underwriters Laboratories, Inc. (UL) Publications:

a. 467 Grounding and Bonding Equipment

b. 489 Molded-Case Circuit Breakers and Circuit Breaker Enclosures

c. 891 Dead-Front Switchboards

B. Quality Control

1. Design tests required for certification of conformance to ANSI, NEMA or UL requirements may be required for review by the engineer at the option of the owner. Design tests need not be performed on the actual equipment being submitted but must have been performed on a sample or other unit representative of the specific construction techniques which are utilized.

2. The following factory tests shall be made on the secondary switchboard, although not necessarily in the order listed. All tests shall be in accordance with the latest revision NEMA PB-2 and/or UL 891:

   a. A dielectric withstand test of 1000 VDC shall be made between each phase and ground with all switching devices closed and phases not under test grounded.

   b. The grounding of instrument transformer cases or frames, as applicable, shall be checked with a low potential source.

   c. Control wire continuity and correctness shall be verified by actual electrical operation of the control component or individual circuit continuity checks with electrical instruments.

   d. Control wire insulation shall be tested with the application of 1000 VDC after circuit grounds have been disconnected for the test. Sensitive or electronic equipment shall be disconnected for the test.

   e. Polarity tests shall be performed to verify that instrument transformers have been correctly connected.

   f. Results of the above tests shall be submitted with final drawings in the form of certified test reports. Third party certification is not required.

C. Submittals for Approval

1. Manufacturers Data: Submit manufacturers data for the following components:

   a. Low Voltage Circuit Breaker

   b. Instruments and Meters

   c. Instrument Transformers

   d. Control Component Devices

2. Shop Drawings: Submit shop drawings for the secondary unit substation including the following:

   a. Overall dimensions, front view, sectional views, conduit entrance location(s), equipment access requirements and weights.

   b. Bus arrangements including dimensions and ampere ratings of all bus bars, including ground bus.

   c. Type and spacing of bus supports.

   d. Maximum short circuit bracing.

   e. Circuit breaker type, interrupting rating, instrument transformers and meters.

   f. Elementary diagrams and wiring diagrams having their terminals identified and indicating the internal wiring for each item of equipment and the interconnection between the items.

   g. One-line diagram.

h. Details of bus connections.

i. Anchoring instructions to meet UBC Seismic requirements.

j. Instrument transformers and meters.

k. Proposed nameplate schedule.

l. Itemized and coded bill of material.

m. Before shipment, all shop drawings shall be approved by the Engineer. Shipping splits shall be approved in writing.

3. Certified tests reports: Submit certified tests reports for the following:

a. Switchgear Factory Tests

b. Paint qualification test in accordance with ANSI C37.20.3 section 5.2.8

c. Before shipment all certified test reports shall be approved by the Engineer.

4. Operating and Maintenance Instructions: Furnish 3 copies of maintenance, instructional literature and renewal parts data bound in a loose-leaf notebook. Notebook shall contain but not be limited to the following:

a. Instruments and Meters

b. Instrument Transformers

c. Control Component Devices

d. Meters (each type)

e. Circuit Breakers

D. Description

1. Furnish a dead front type, completely metal enclosed, self-supporting structure independent of wall supports. Voltage rating shall be 480Y/277 volts, 3 phase, 4 wire. It shall consist of the required number of vertical sections bolted together to form one rigid switchboard. The sides shall be covered with removable bolt-on plates. All edges of front cover panels shall be formed. Sheet steel shall be 12-gauge minimum thickness unless proof of conformance to UL 891 rigidity requirements can be submitted. Identify any sheet components constructed of less than 12-gauge steel.

2. Equipment shall comply with the latest applicable standards of NEMA PB2 and UL 891, and shall comply with all NEC and UL requirements for service entrance and a UL service entrance label shall be provided. Los Angeles City Test Lab Certification is acceptable in lieu of UL labeling.

E. Construction

1. Switchboard shall be provided with adequate lifting means and shall be capable of being rolled or moved into installation position and bolted directly to the floor without the use of floor sills.

2. All power connections shall be bused from incoming to outgoing line terminals. Use of cable is not allowed. All bus bars shall be copper with silver-plated copper bolted connections at joints. The bus bars shall be of sufficient size to limit the temperature rise to 65°C rise at the ampere rating indicated on the drawing based on UL tests, and rated to withstand thermal stresses and mechanical forces exerted during short circuit conditions when directly connected to a power source having an available

fault current of 65,000 amperes symmetrical at rated voltages. Provide full capacity neutral.

3. A ground bus shall be furnished firmly secured to each vertical section structure and shall extend the entire length of the switchboard. The neutral bus shall be grounded to the ground bus with a bus conductor sized per UL and NEC requirements. An incoming ground lug shall be furnished. One ground lug for each feeder circuit shall also be supplied.

4. All hardware used at bolted connections shall be of high strength, hex head, grade 5 steel with Bellville type spring washers. All bolts and washers shall be plated. Slotted head screws are not allowed.

5. All hardware used on conductors shall be high-tensile strength and plated. All terminals shall be compression type suitable for copper cable of sizes indicated for 75°C cable.

6. The manufacturer shall supply, upon request, test results to confirm that the switchgear has been tested to substantiate designs according to applicable NEMA and UL Standards. The tests shall verify the performance of the short circuit bracing and temperature rise of the bus assembly, the suitability of the enclosure venting and rigidity. In addition, each switchgear assembly shall be factory tested in accordance with the latest revision of NEMA PB-2 and/or UL 891.

7. Small wiring, necessary fuse blocks and terminal blocks within the switchboard shall be furnished as required. All groups of control wires shall be labeled with wire markers and all wires leaving the switchboard shall be provided with terminal blocks having suitable numbering strips. All control devices shall be provided with engraved plastic nameplates black with white core, attached with two screws.

8. Front Accessible Switchboard:

   a. All vertical sections without uniform depths shall align front and rear as shown on the drawings.

   b. All internal devices shall be removable from the front and shall be panel mounted with the necessary line and load connections front accessible. All bus connections shall be accessible from the front. Nuts shall face top or front as applicable to allow access for torquing.

   c. Mount devices so manufacturer type, catalog number, ampere rating and interrupting rating are visible without removing panels or covers.

   d. Provide padlocking provisions for each circuit breaker.

F. Overcurrent Devices

1. Incoming Main Device Section

   a. Main Circuit Breaker: Individually mounted 100% rated and shall be of full LSIG type with mechanical restraint on a common pan or rail assembly.

   b. The interior shall have three flat bus bars stacked and aligned vertically with glass reinforced polyester insulators laminated between phases. The molded polyester insulators shall support and provide phase isolation to the entire length of bus.

   c. Circuit breaker equipped with line terminal jaws shall not require additional external mounting hardware. Circuit breaker shall be held in mounted position by a self-contained bracket secured to the mounting pan by fasteners. Circuit breaker of different frame sizes shall be capable of being mounted across from each other.

d. Line-side circuit breaker connections are to be jaw type.

e. All unused spaces provided, unless otherwise specified, shall be fully equipped for future devices, including all appropriate connectors and mounting hardware.

f. Electronic trip molded case circuit breakers:

1) Electronic circuit breakers shall have the following time/current response adjustments: Long Time Pickup, Long Time Delay, Short Time Pickup, Short Time Delay, and Instantaneous settings. Each adjustment shall have discrete settings (fully adjustable) and shall be independent of all other adjustments.

2) Circuit breaker trip system shall be a microprocessor-based true rms sensing designed with sensing accuracy through the thirteenth (13th) harmonic. Sensor ampere ratings shall be as indicated on the drawing.

3) Local visual trip indication for overload, short circuit and ground fault trip occurrences.

4) Long Time Pickup indication to signal when loading approaches or exceeds the adjustable ampere rating of the circuit breaker shall be provided.

5) Communications capabilities for remote monitoring of circuit breaker trip system, to include phase and ground fault currents, pre-trip alarm indication, switch settings, and trip history information shall be provided.

6) Circuit breaker shall be provided with Zone selective Interlocking (ZSI) communications capabilities on the short-time and ground fault functions compatible with all other electronic trip circuit breakers and external ground fault sensing systems as noted on drawings.

7) Furnish thermal magnetic molded case circuit breakers for 250A frames and below.

2. Distribution Section Devices

a. Circuit breaker(s) shall be group mounted with mechanical restraint on a common pan or rail assembly.

b. The interior shall have three flat bus bars stacked and aligned vertically with glass reinforced polyester insulators laminated between phases. The molded polyester insulators shall support and provide phase isolation to the entire length of bus.

c. Circuit breaker(s) equipped with line terminal jaws shall not require additional external mounting hardware. Circuit breaker(s) shall be held in mounted position by a self-contained bracket secured to the mounting pan by fasteners. Circuit breaker(s) of different frame sizes shall be capable of being mounted across from each other.

d. Line-side circuit breaker connections are to be jaw type.

e. All unused spaces provided, unless otherwise specified, shall be fully equipped for future devices, including all appropriate connectors and mounting hardware.

f. Thermal magnetic molded case circuit breakers:

1) Molded case circuit breakers shall have integral thermal and instantaneous magnetic trip in each pole.

2) Circuit protective devices shall molded case circuit breakers. Circuit breakers shall be high interrupting Ampere ratings shall be as shown on the drawings.

3) Manufacturer shall submit one set of published Ip and Iat let-through curves (as required by UL) to the owner.

3. Circuit breakers shall be operated by a toggle-type handle and shall have a quick-make, quick-break over-center switching mechanism tripping of the breaker shall be clearly indicated by handle position. Contacts shall be non-welding silver alloy and arc extinction shall be accomplished by means of arc chutes.

4. Circuit breakers in the switchboard shall be Standard Micrologic (LSI 310+ Trip Units) with solid-state trip unit and flux transfer shunt trip. Breakers shall have trip rating plugs with ratings as indicated on the drawings Rating plugs shall be interlocked so they are NOT interchangeable between frames and interlocked such that a breaker cannot be latched with the rating plug removed.

5. Circuit breakers feeding motor loads shall have a high instantaneous range.

6. Trip unit shall have adjustable short time setting with a fixed instantaneous override for circuit protection. Main breakers shall be provided with additional short delay trip time adjustment for increased system coordination.

7. Breakers shall have built-in test points for testing long delay, and instantaneous functions of the breaker by means of a 120-volt operated test kit.

8. All circuit breakers in the switchboard shall be UL listed and labeled for 100% application per NEC.

9. All circuit breakers shall be provided with an Arc Flash Reduction Maintenance System for accelerated instantaneous trip to reduce arc flash. Provide:

   a. Zone-selective interlocking – 310+ Trip Units

   b. Energy-reducing maintenance switching with local status indicator – Arcflash Reduction Maintenance Switch (ARMS)

   c. An instantaneous trip setting that is less than the available arcing current – 310+ Trip Units

   d. An instantaneous override that is less than the available arcing current

10. Provide Ground Fault Protection (GFP) type circuit breakers for circuit breakers rated 1000A and above in a 480/277V system.

G. Accessory Components and Features

1. Portable Test Set: For testing functions of solid-state trip devices without removing from switchboard. Include relay and meter test plugs suitable for testing switchboard meters and switchboard class relays.

H. Identification

1. Service Equipment Label: NRTL labeled for use as service equipment for switchboards with one or more service disconnecting and overcurrent protective devices.

I. Nameplates and Signs

1. Provide all safety and warning signs in accordance with ANSI Z35.1 and as required by the NEC, NESC and any local codes.

2. Furnish Master Nameplate giving voltage, ampere rating, short circuit rating, manufacturer's name, general order number and item number.

3. An engraved lamicoid nameplate shall be provided to identify all switches, transformers, circuit breakers, instruments, door mounted devices and control equipment. Construct nameplate of 1/16 inch engraving lamicoid with letters machine engraved through black facing to white opaque core unless otherwise indicated. All nameplates shall have a 1/64-inch bevel on front edges. Nameplates shall be fastened with a minimum of two (2) stainless steel screws, not adhesive. Letter size shall be 1/4-inch high for unit identification and 1/8-inch high for device identification unless otherwise indicated.

4. Provide mimic bus manufactured of anodized red aluminum, 1/4-inch wide, fastened with flat head recessed stainless steel screws on 4 inch centers.

J. Instrumentation

1. Instrument Transformers: IEEE C57.13, NEMA EI 21.1, and the following:

a. Current Transformers: IEEE C57.13; 5 A, 60 Hz, secondary and secondary shorting device. Burden and accuracy shall be consistent with connected metering and relay devices.

b. Control-Power Transformers: Dry type, mounted in separate compartments for units larger than 3 kVA.

c. Current Transformers for Neutral and Ground-Fault Current Sensing: Connect secondary wiring to ground overcurrent relays, via shorting terminals, to provide selective tripping of main and tie circuit breaker. Coordinate with feeder circuit-breaker, ground-fault protection.

K. Control Power

1. Control Circuits: 120-V ac, supplied through secondary disconnecting devices from control-power transformer.

2. Electrically Interlocked Main and Tie Circuit Breakers: Two control-power transformers in separate compartments, with interlocking relays, connected to the primary side of each control-power transformer at the line side of the associated main circuit breaker. 120-V secondary’s connected through automatic transfer relays to ensure a fail-safe automatic transfer scheme.

3. Control-Power Fuses: Primary and secondary fuses for current-limiting and overload protection of transformer and fuses for protection of control circuits.

4. Control Wiring: Factory installed, with bundling, lacing, and protection included. Provide flexible conductors for No. 8 AWG and smaller, for conductors across hinges, and for conductors for interconnections between shipping units.

2.4 SURGE PROTECTION DEVICES (SPD)

A. Provide Type 1 surge protection device at the switchboard.

B. Surge Protection Device Description: IEEE C62.41.1 – 2002, IEEE C62.41.2 – 2002, UL 1449 Third Edition, or most recent edition & NEC Article 285 compliant and test devices according to IEEE C62.45 - 2002, Type 1, integrally mounted, solid-state, parallel-connected, with sine-wave tracking suppression and filtering modules, UL labeled with 200 kA short-circuit current rating (SCCR), and with the following features and accessories:

1. LED indicator lights for power and protection status.
2. Audible alarm, with silencing switch, to indicate when protection has failed.
3. Form-C contacts rated at 5 A and 250-V ac, one normally open and one normally closed, for remote monitoring of system operation. Contacts shall reverse position on failure of any surge diversion module or on opening of any current-limiting device.
4. Transient-event counter set to totalize transient surges.

C. Peak Single-Impulse Surge Current Rating: 150 kA per mode/300 kA per phase.

D. Withstand Capabilities: 5000 IEEE C62.41, Category C3 (10 kA), 8-by-20-mic.sec. surges with less than 5 percent change in clamping voltage.

E. Protection modes and UL 1449, Third Edition or most recent edition, VPR (Voltage Protection Mode) for grounded wye circuits with 480Y/277-V, three-phase, four-wire circuits shall be as follows:

1. Line to Neutral: 1200 V for 480Y/277.
2. Line to Ground: 1200 V for 480Y/277.
3. Neutral to Ground: 1200 V for 480Y/277.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Receive, inspect, handle, store and install switchboards and accessories according to NEMA PB 2.1.

B. Equipment Mounting: Install switchboards on concrete base, 4-inch (100-mm) nominal thickness. Comply with requirements for concrete base specified in Division 03 Section "Cast-in-Place Concrete".

1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
4. Install anchor bolts to elevations required for proper attachment to switchboards.

C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from switchboard units and components.

D. Comply with mounting and anchoring requirements specified in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."

E. Install filler plates in unused spaces of panel-mounted sections.

F. Install overcurrent protective devices, transient voltage suppression devices, and instrumentation.

1. Set field-adjustable switches and circuit-breaker trip ranges.

G. Install spare-fuse cabinet.

H. Comply with NECA 1.

I. Comply with requirements for terminating feeder bus specified in Division 26 Section "Enclosed Bus Assemblies." Drawings indicate general arrangement of bus, fittings, and specialties.

J. Comply with requirements for terminating cable trays specified in Division 26 Section "Cable Trays for Electrical Systems." Drawings indicate general arrangement of cable trays, fittings, and specialties.

3.2 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

B. Switchboard Nameplates: Label each switchboard compartment with a nameplate complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

C. Device Nameplates: Label each disconnecting and overcurrent protective device and each meter and control device mounted in compartment doors with a nameplate complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

3.3 FIELD QUALITY CONTROL

A. Acceptance Testing Preparation:

1. Test insulation resistance for each switchboard bus, component, connecting supply, feeder, and control circuit.

2. Test continuity of each circuit.

B. Tests and Inspections:

1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.

2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

3. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

C. Switchboard will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports, including a certified report that identifies switchboards included and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.4 COMMISSIONING

A. Comply with requirements specified in Division 1.

B. Engage a factory-authorized service representative to supervise and assist with startup service. Complete installation and startup checks according to the approved manufacturer's written instructions.

3.5 TRAINING AND SERVICE

A. Comply with Section 26 00 01.

B. Conduct two 4-hour training sessions. Train the Owner’s maintenance personnel on procedures and schedules related to start up and shutdown, troubleshooting, servicing, and preventive maintenance.

End of Section

Section 26 24 16

PANELBOARDS

(TRADE CONTRACT REQUIRED AS PART OF SECTION 26 00 01)

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. PUBLICLY BID TRADE CONTRACT REQUIREMENTS: As provided under Section 26 00 01 - ELECTRICAL and supplemented under the Bidding Requirements, Contract Forms, and Conditions of the Contract, and applicable parts of Division 1 - GENERAL REQUIREMENTS.

1. Work of this Trade Contract includes all individual specification sections listed in Section 26 00 01.

1.2 RELATED DOCUMENTS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications

1.3 SUMMARY

A. Section includes distribution panelboards and lighting and appliance branch-circuit panelboards.

1.4 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Panelboards shall withstand the effects of earthquake motions determined according to SEI/ASCE 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

1.5 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Shop Drawings: For each panelboard and related equipment.

1. Include dimensioned plans, elevations, sections, and details. Show tabulations of installed devices, equipment features, and ratings.
2. Detail enclosure types and details for types other than NEMA 250, Type 1.
3. Detail bus configuration, current, and voltage ratings.
4. Short-circuit current rating of panelboards and overcurrent protective devices.
5. Include evidence of NRTL listing for series rating of installed devices.
6. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
7. Include wiring diagrams for power, signal, and control wiring.

8. Include time-current coordination curves for each type and rating of overcurrent protective device included in panelboards.

C. Seismic Qualification Certificates: Submit certification that panelboards, overcurrent protective devices, accessories, and components will withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."

D. Field quality-control reports.

E. Panelboard schedules for installation in panelboards.

F. Operation and maintenance data.

1.6 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with NEMA PB 1.

C. Comply with NFPA 70.

1.7 WARRANTY

A. Comply with Section 260001.

B. The Electrical Trade Contractor shall warranty that all materials furnished shall be free from defects of material for a period of one year from the date of Substantial Completion.

C. Transient voltage suppression devices: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers

1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
3. Square D; a brand of Schneider Electric.
4. Or approved equal.

2.2 BASIS OF DESIGN

A. The system specified is based upon products by Eaton Electrical Inc.; and represents the performance standard upon which any equivalent solution shall be based.

2.3 GENERAL REQUIREMENTS FOR PANELBOARDS

A. Fabricate and test panelboards according to IEEE 344 to withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."

B. Enclosures: Flush- and surface-mounted cabinets.

1. Rated for environmental conditions at installed location.

a. Indoor Dry and Clean Locations: NEMA 250, Type 1

b. Outdoor Locations: NEMA 250, Type 3R.

c. Kitchen/Wash-Down Areas: NEMA 250, Type 4X, stainless steel.

d. Other Wet or Damp Indoor Locations: NEMA 250, Type 4.

2. Front: Secured to box with concealed trim clamps. For surface-mounted fronts, match box dimensions; for flush-mounted fronts, overlap box.

3. Hinged Front Cover: Entire front trim hinged to box and with standard door within hinged trim cover.

4. Directory Card: Inside panelboard door, mounted in transparent card holder.

C. Incoming Mains Location: Top and bottom.

D. Phase, Neutral, and Ground Buses: Hard-drawn copper, 98 percent conductivity.

E. Conductor Connectors: Suitable for use with conductor material and sizes.

1. Material: Hard-drawn copper, 98 percent conductivity.

2. Main and Neutral Lugs: Mechanical type.

3. Ground Lugs and Bus Configured Terminators: Mechanical type.

4. Feed-Through Lugs: Mechanical type, suitable for use with conductor material. Locate at opposite end of bus from incoming lugs or main device.

5. Sub feed (Double) Lugs: Mechanical type suitable for use with conductor material. Locate at same end of bus as incoming lugs or main device.

F. Service Equipment Label: NRTL labeled for use as service equipment for panelboards with one or more main service disconnecting and overcurrent protective devices.

G. Future Devices: Mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices.

H. Panelboard Short-Circuit Current Rating: Rated for series-connected system with integral or remote upstream overcurrent protective devices and labeled by an NRTL. Include size and type of allowable upstream and branch devices, and listed and labeled for series-connected short-circuit rating by an NRTL.

I. Panelboard Short-Circuit Current Rating: Fully rated to interrupt symmetrical short-circuit current available at terminals.

2.4 DISTRIBUTION PANELBOARDS

A. Panelboards: NEMA PB 1, power and feeder distribution type.

B. Doors: Secured with vault-type latch with tumbler lock; keyed alike.

C. Mains: Circuit breaker.

D. Branch Overcurrent Protective Devices: For Circuit-Breaker Frame Sizes 125 A and Smaller: Bolt-on circuit breakers.

E. Branch Overcurrent Protective Devices: For Circuit-Breaker Frame Sizes Larger Than 125 A: Bolt-on circuit breakers; plug-in circuit breakers where individual positive-locking device requires mechanical release for removal.

F. Branch Overcurrent Protective Devices: Fused switches.

2.5 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

A. Panelboards: NEMA PB 1, lighting and appliance branch-circuit type.

B. Mains: Circuit breaker.

C. Branch Overcurrent Protective Devices: Bolt-on circuit breakers, replaceable without disturbing adjacent units.

D. Provide UL listed non-linear rated panels with 200% neutral bus bars and lugs for all 120/208 volt panelboards where fed from K rated transformers. Bus bar taps for panels with single pole branches shall be arranged for sequence phasing of the branch circuit devices. Bussing shall be braced throughout to conform to industry standard practice governing short circuit stresses in panelboards. Phase bussing shall be full height without reduction.

E. When called for, supply Surge Protective Device (SPD) units in accordance with SPD specification section here within.

F. Contactors in Main Bus: NEMA ICS 2, Class A, electrically held, general-purpose controller, with same short-circuit interrupting rating as panelboard.

G. Doors: Concealed hinges; secured with flush latch with tumbler lock; keyed alike.

H. Column-Type Panelboards: Narrow gutter extension, with cover, to overhead junction box equipped with ground and neutral terminal buses.

2.6 ELECTRONIC-GRADE PANELBOARDS

A. Panelboards: NEMA PB 1; with factory-installed, integral SPD; labeled by an NRTL for compliance with UL 67 after installing SPD.

B. Doors: Secured with vault-type latch with tumbler lock; keyed alike.

C. Main Overcurrent Protective Devices: Bolt-on thermal-magnetic circuit breakers.

D. Branch Overcurrent Protective Devices: Bolt-on thermal-magnetic circuit breakers.

E. Buses:

1. Copper phase and neutral buses; 200 percent capacity neutral bus and lugs.

2. Copper equipment and isolated ground buses.

F. Surge Protection Device: IEEE C62.41.1 – 2002, IEEE C62.41.2 – 2002, UL 1449 Third Edition, or most recent edition & NEC Article 285 -compliant and test devices according to IEEE C62.45 - 2002, integrally mounted, bolt-on, solid-state, parallel-connected, modular (with field-replaceable modules) type, with sine-wave tracking suppression and filtering modules, UL labeled with 200 kA short-circuit current rating (SCCR), and matching or exceeding the panelboard short-circuit rating, redundant suppression circuits, with thermally protected metal-oxide visitors.

1. Accessories:

a. Fabrication using bolted compression lugs for internal wiring.

b. Integral disconnect switch, if no breaker is available.

c. Redundant suppression circuits.

d. Redundant replaceable modules.

e. Arrangement with wire connections to phase buses, neutral bus, and ground bus.

f. LED indicator lights for power and protection status.

g. Audible alarm, with silencing switch, to indicate when protection has failed.

h. Form-C contacts rated at 5 A and 250-V ac, one normally open and one normally closed, for remote monitoring of system operation. Contacts shall reverse position on failure of any surge diversion module or on opening of any current-limiting device. Coordinate with building power monitoring and control system.

i. Six-digit, transient-event counter set to totalize transient surges.

2. Peak Single-Impulse Surge Current Rating: 100 kA per mode/200 kA per phase.

3. Withstand Capabilities: 12,000 IEEE C62.41, Category C3 (10 kA), 8-by-20-mic.sec. surges with less than 5 percent change in clamping voltage.

4. Protection modes and UL 1449 Third Edition, or most recent edition, VPR for grounded wye circuits with 480Y/277 and 208Y/120-V, three-phase, four-wire circuits shall be as follows:

a. Line to Neutral: 1200 V for 480Y/277 and 700 V for 208Y/120.

b. Line to Ground: 1200 V for 480Y/277 and 700 V for 208Y/120.

c. Neutral to Ground: 1200 V for 480Y/277 and 700 V for 208Y/120.

5. Protection modes and UL 1449 Third Edition, or most recent edition, VPRs for 240/120-V, single-phase, three-wire circuits shall be as follows:

a. Line to Neutral: 700 V.

b. Line to Ground: 700 V.

c. Neutral to Ground: 700 V.

6. Protection modes and UL 1449 Third Edition, or most recent edition, VPRs for 240/120-V, three-phase, four-wire circuits with high leg shall be as follows:

a. Line to Neutral: 700 V, 1200 V from high leg.

b. Line to Ground: 700 V.

c. Neutral to Ground: 700 V.

7. Protection modes and UL 1449 Third Edition, or most recent edition, VPRs for 240-, 480-, or 600-V, three-phase, three-wire, delta circuits shall be as follows:

a. Line to Line: 2500 V for 600 V, 3000 V for 480 V and 1500 V for 240 V.

b. Line to Ground: 2500 V for 600 V, 3000 V for 480 V and 1200 V for 240 V.

2.7 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

A. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, with interrupting capacity to meet available fault currents.

1. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads, and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.

2. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.

3. Electronic trip circuit breakers with rms sensing; field-replaceable rating plug or field-replicable electronic trip; and the following field-adjustable settings:

   a. Instantaneous trip.

   b. Long- and short-time pickup levels.

   c. Long- and short-time time adjustments.

   d. Ground-fault pickup level, time delay, and I^2t response.

4. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller; let-through ratings less than NEMA FU 1, RK-5.

5. GFCI Circuit Breakers: Single- and two-pole configurations with Class A ground-fault protection (6-mA trip).

6. Ground-Fault Equipment Protection (GFEP) Circuit Breakers: Class B ground-fault protection (30-mA trip).

7. Arc-Fault Circuit Interrupter (AFCI) Circuit Breakers: Comply with UL 1699; 120/240-V, single-pole configuration.

8. Molded-Case Circuit-Breaker (MCCB) Features and Accessories:

   a. Standard frame sizes, trip ratings, and number of poles.

   b. Lugs: Mechanical style, suitable for number, size, trip ratings, and conductor materials.

   c. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge (HID) lighting circuits.

   d. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.

   e. Communication Capability: Universal-mounted communication module with functions and features compatible with power monitoring and control system specified in Division 26 Section "Electrical Power Monitoring and Control."

   f. Handle Padlocking Device: Fixed attachment, for locking circuit-breaker handle in on or off position.

   g. Handle Clamp: Loose attachment, for holding circuit-breaker handle in on position.

2.8 ACCESSORY COMPONENTS AND FEATURES

A. Portable Test Set: For testing functions of solid-state trip devices without removing from panelboard. Include relay and meter test plugs suitable for testing panelboard meters and switchboard class relays.

2.9 FUSIBLE BRANCH CIRCUIT PANELBOARDS (FBCP)

A. Summary

1. Furnish and install fusible branch circuit panelboards for the life safety branch of the emergency electrical system.

B. System Description

1. The panelboards shall be UL and cULus Listed.
2. Selective Coordination: Panelboards overcurrent protective devices shall be selectively coordinated with all supply side (fed from both the normal and emergency source) Eaton's Bussmann series Low-Peak™ LPJ_SP, TCF_, LPN-RK_SP/LPS-RK_SP or KRP-C_SP fuses sized at a minimum amp ratio of 2:1.

C. Basis of Design

1. Fusible Panelboards shall be Eaton's Bussmann series Quik-Spec™ Coordination Panelboards type QSCP.

D. Panelboard Ratings

1. Panelboards shall be UL Listed with a labeled short-circuit current rating equal to or greater than that indicated on the associated schedules or drawings.
2. Panelboards shall be rated 600Vac/125Vdc but marked for actual system voltage.
3. Provide Main lug only, main fused switch or main non-fused switch as indicated in the associated schedules or drawings.
4. Provide branch circuits as indicated in the associated schedules or drawings.
5. Branch circuits must be interchangeable with fusible switches from 15A to 100A without additional required space.
6. Panelboard branch circuits shall incorporate overcurrent protection and branch-circuit rated disconnecting means into a single integrated component (1 pole, 2 pole or 3 pole) that prevents removal of the fuse while energized, provides open fuse indication, and fuse ampere rating rejection feature at 15A, 20A, 30A, 40A, 50A, 60A, 70A, 90A, and 100A. Provide open fuse indication on the branch circuit fuses where indicated in the associated schedules or drawings.
7. Provide Time-Delay Indicating Fast-Acting Class CF fuses for branch circuits.
8. Bus bars shall be tin-plated copper.
9. Neutral and equipment ground bar (isolated or non-isolated) shall be provided where indicated in the associated schedules or drawings.
10. Panelboard trim shall be door-in-door type.
11. Panelboard enclosure shall be of type indicated in the associated schedules or drawings.
12. Boxes shall be a nominal 20 inches wide and 5-¾ inches deep
13. Panelboard shall be equipped with a spare branch circuit fuse holder and spare fuses (10% of fuse for each ampacity installed in branch circuits).
14. Panelboard shall be equipped with an integral Surge Protective Device, compliant with UL 1449 4th Edition. SPD shall include remote signaling contact.

E. Construction

1. Panelboard circuits 100A and less shall incorporate overcurrent protection and branch-circuit rated disconnecting means into a single integrated component.
2. Interiors shall be factory assembled.

3. Panelboard shall be equipped with a six-space spare fuse compartment for storing replacement branch circuit fuses. Spare fuse compartment shall be located behind locking panel door.
4. Bus bars shall be tin-plated copper with sufficient cross-sectional area to meet UL 67 temperature rise requirements.
5. 200A/400A rated neutrals shall be standard, 400A or 800A rated neutral shall be provided where indicated in the associated schedules or drawings.
6. Bonded neutral shall be provided where specified in associated drawings.
7. Isolated or non-isolated equipment ground bar shall be provided as indicated in the associated schedules or drawings.
8. Where a service-entrance rated panelboard is indicated in associated schedules or drawings, a bonded neutral and non-isolated equipment ground bar shall be provided by the manufacturer.
9. Main lug conductor terminations:
    a. MLO terminations shall be rated for 60/75°C, Cu-Al
    b. Main disconnect terminations shall be rated for 75°C, Cu Only
10. NEMA 1 panelboards shall be field convertible for top or bottom incoming feed. NEMA 3R panelboards are bottom feed only.

F. Main Disconnect

1. Permanently installed lockout means shall be provided on the main disconnect for lockout tagout procedures.
2. Main disconnect shall be quick-make, quick-break type.

G. Branch Fused Disconnects

1. Device shall have visible circuit ON/OFF indication with colored and international symbol markings.
2. Device shall provide open fuse indication via permanently installed indicating light.
3. Device shall be UL and cUL Listed 600Vac/200kA or 125Vdc/100kA voltage/short-circuit current rating, load-break disconnect with amp ratings and number of poles as indicated on the panelboard schedule.
4. Fuse and disconnect assembly shall be a finger-safe component with trim installed.
5. Fuse and disconnect shall be mechanically interlocked so as not to allow fuse removal while fuse terminals are energized.
6. No special tools shall be required for fuse removal.
7. Devices shall have bolt-on style bus connectors.
8. Device housing shall be clearly marked with device amperage.
9. Permanently installed lockout means shall be provided on the device for lockout tagout procedures. Permanently installed means for locking device in the ON position shall also be available.
10. Device shall provide fuse amp rating rejection at the following ampacities to ensure continued circuit protection at the specified circuit rating: 15A, 20A, 30A, 40A, 50A, 60A, 70A, 90A & 100A.

H. Main & Branch Overcurrent Protection

1. All overcurrent protective devices shall have a minimum UL Listed interrupting rating of 300kA and CSA Certified interrupting rating of 200kA.

2. Branch circuit overcurrent protection shall be 600Vac UL Listed minimum 300kA IR and CSA Certified minimum 200kA IR finger-safe fuse with Class CF (equivalent to Class J) performance characteristics.

3. Main overcurrent protective devices shall be 600Vac UL Listed minimum 300kA IR and CSA Certified minimum 200kA IR Class J fuses or Class CF (equivalent to Class J) performance fuses.

4. Where panelboard main fuses are installed, fuses in panelboard branch circuits shall selectively coordinate with main fuses for all overcurrents up to 200kA.

I. Enclosure

1. NEMA 1 enclosures shall be surface or flush mount as indicated in associated schedules or drawings. NEMA 3R enclosures shall be surface mount only.

2. Boxes shall be a nominal 20 inches wide and 5-¾ inches deep (NEMA 1) or 6.3” (NEMA 3R) with wire bending space per the National Electrical Code®.

3. Panelboard trim shall be supplied with lockable door covering all disconnect handles.

4. Panelboard trim shall be dead-front construction covering all energized parts.

5. Enclosures shall be NEMA Type 1 or Type 3R as indicated in associated schedules or drawings.

6. Door-in-door type trim shall be provided for NEMA 1 enclosures where it is specified in the associated schedules or drawings.

7. Front trim shall be lockable. All lock assemblies shall be keyed alike with like NEMA rated enclosures.

J. Integral Surge Protection

1. Panelboard should include an integral UL 1449 4th Edition Recognized Type 2 Component Assembly. Device should be certified by UL to a 20kA nominal rating. Device should also be CSA Accepted.

2. SPD status monitoring shall be provided by local visual indication and, if needed, by remote contact signaling using an optional Form C contact relay.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Receive, inspect, handle, store and install panelboards and accessories according to NEMA PB 1.1.

B. Comply with mounting and anchoring requirements specified in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."

C. Mount top of trim 90 inches (2286 mm) above finished floor unless otherwise indicated.

D. Mount panelboard cabinet plumb and rigid without distortion of box. Mount recessed panelboards with fronts uniformly flush with wall finish and mating with back box.

E. Install overcurrent protective devices and controllers not already factory installed.

1. Set field-adjustable, circuit-breaker trip ranges.

F. Install filler plates in unused spaces.

G. Stub four 1-inch (27-GRC) empty conduits from panelboard into accessible ceiling space or space designated to be ceiling space in the future. Stub four 1-inch (27-GRC) empty conduits into raised floor space or below slab not on grade.

H. Arrange conductors in gutters into groups and bundle and wrap with wire ties.

I. Comply with NECA 1.

3.2 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with Division 26 Section "Identification for Electrical Systems."

B. Create a directory to indicate installed circuit loads and incorporating Owner's final room designations. Obtain approval before installing. Use a computer or typewriter to create directory; handwritten directories are not acceptable.

C. Panelboard Nameplates: Label each panelboard with a nameplate complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

D. Device Nameplates: Label each branch circuit device in distribution panelboards with a nameplate complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

3.3 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Acceptance Testing Preparation:

1. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.

2. Test continuity of each circuit.

C. Tests and Inspections:

1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.

2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

D. Panelboards will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports, including a certified report that identifies panelboards included and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.4 COMMISSIONING

A. Comply with requirements specified in Division 1.

B. Engage a factory-authorized service representative to supervise and assist with startup service. Complete installation and startup checks according to the approved manufacturer's written instructions.

3.5 TRAINING AND SERVICE

A. Comply with Section 26 00 01.

B. Conduct four 4-hour training sessions. Train the Owner’s maintenance personnel on procedures and schedules related to start up and shutdown, troubleshooting, servicing, and preventive maintenance.

End of Section

DO NOT REMOVE
THIS PAGE INTENTIONALLY LEFT BLANK

Section 26 24 19

MOTOR CONTROLS

(TRADE CONTRACT REQUIRED AS PART OF SECTION 26 00 01)

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. PUBLICLY BID TRADE CONTRACT REQUIREMENTS: As provided under Section 26 00 01 - ELECTRICAL and supplemented under the Bidding Requirements, Contract Forms, and Conditions of the Contract, and applicable parts of Division 1 - GENERAL REQUIREMENTS.

1. Work of this Trade Contract includes all individual specification sections listed in Section 26 00 01.

1.2 RELATED DOCUMENTS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications

1.3 SUMMARY

A. This Section specifies furnishing and installing individually mounted motor starters and motor starters provided as components of equipment specified under other sections of these specifications. This section includes ac motor-control devices rated 600 V and less that are supplied as enclosed units.

1.4 SUBMITTALS

A. Product Data: For products specified in this Section. Include dimensions, ratings, and data on features and components.

1. Spare Parts: Include name, address, and telephone number of in-state supplier of spare parts. No out-of-state suppliers shall be permitted.

B. Shop Drawings: For motor controllers in accordance with NEMA Standards ICS for Class II, Type “B” construction, including interconnection wiring diagrams.

1.5 QUALITY ASSURANCE

A. Source Limitations: Obtain similar motor-control devices through one source from a single manufacturer in accordance with Form 816 Article 1.20-1.06.01.

B. Comply with NFPA 70, NEMA ICS, AB1.

C. Listing and Labeling: Provide motor controllers specified in this Section that are listed and labeled.

1. The Terms "Listed" and "Labeled": As defined in the NEC, Article 100. Items to be UL listed and labeled: motor starters, combination motor starters, and motor circuit protectors.

1.6 COORDINATION

A. Coordinate features of controllers and accessory devices with pilot devices and control circuits to which they connect.

B. Coordinate features, accessories, and functions of each motor controller with the ratings and characteristics of the supply circuit, the motor, the required control sequence, and the duty cycle of the motor and load.

C. Coordinate motor starters and combination motor starters with the provider or mechanical equipment. Some mechanical equipment is already supplied with starters and combination motor starters by the manufacturer.

1.7 WARRANTY

A. Comply with Section 260001.

B. The Electrical Trade Contractor shall warranty that all materials furnished shall be free from defects of material for a period of one year from the date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers

1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
3. Square D; a brand of Schneider Electric.
4. Or approved equal.

2.2 BASIS OF DESIGN

A. The system specified is based upon products by Eaton Electrical Inc.; and represents the performance standard upon which any equivalent solution shall be based.

2.3 GENERAL

A. The Electrical Trade Contractor shall furnish and install motor starters for all motors, unless clearly indicated otherwise on the contract documents. Three phase motors shall be provided with a combination magnetic motors starter with ambient compensated overload heaters in each ground leg.

B. Construct all products of the same type, size, rating and functional characteristics to be interchangeable and identically wired (sequence wiring).

C. Nameplates:

1. Provide a nameplate on each motor starter in accordance with NEMA ICS showing manufacturer’s name and brand designation, reference standard, type class and rating as applicable.
2. In addition, provide nameplate indication the starter’s designation as shown on the contract drawings. Nameplates shall be 1 inch wide with ½ inch letters, constructed of three ply laminated phenolic material, engraved through black face to white core

and attached with stainless steel rivets or screws. Legend shall be furnished for approval prior to engraving.

2.4 MANUAL MOTOR CONTROLLERS

A. Provide quick-make, quick-break, toggle switch type, with thermal alloy type overload protection. Use manual motor starters for single-phase motors rated less than 1/2 horsepower.

B. Toggle Switch Operator: Provide operator guarded and equipped with a red indicating light to show when the switch is in the closed position.

C. Designated units shall include "Hand-Off-Auto" selector switch and pilot light in a single enclosure (all starter selector switches shall be key operated except for in the Electrical room and Mechanical room).

D. All "Hand-Off-Auto" controls in the bays shall be key-operated.

2.5 MAGNETIC MOTOR CONTROLLERS

A. Combination Magnetic Controller: Full voltage, across-the-line, magnetic starter with motor circuit protector, sized to conform with standard NEMA ratings for the associated motor, for use on nominal 208 volt, three-phase, 60 Hertz service with control transformer for 120 volt control, three thermal type ambient compensated manual reset overload relays selected on basis of actual motor nameplate current, one convertible auxiliary interlock contacts in addition to units required for indicated control functions, cover mounted control devices (red and green pilot lights, start-stop pushbutton, and "Hand-Off-Auto" selector switch).

2.6 ENCLOSURES

A. Description: Select flush or surface-mounted enclosures suitable for the environment in which they are to be used.

B. Enclosures: Select motor controller and switch enclosures suitable for the environment in which they are to be used as follows:

1. Enclosures for use indoors and in dry, dust free areas: NEMA Type1.

2. Enclosures for outdoor locations or where moisture is present: Stainless steel NEMA Type 4X, weatherproof enclosure, as indicated.

3. Enclosures for areas where dust and dirt likely to be present: NEMA 12 industrial type.

4. Enclosures for hazardous areas: Approved for specific hazardous location.

5. Factory Finish: Degrease and provide phosphate coating, after fabrication, to surfaces which are to be painted. Apply undercoat of rust-resistant paint such as zinc chromate over the phosphate coating (except for stainless steel). Apply finish painting of baked on, ANSI 61 baked enamel.

2.7 ACCESSORIES

A. Accessories: Provide special tools or other devices normally furnished or required for installation, care and maintenance of equipment.

2.8 VARIABLE FREQUENCY DRIVE (VFD)

A. The VFDs (also known as variable frequency control (VFC)) shall be furnished under Division 23; and shall be installed and wired by the Electrical Trade Contractor.

B. All VFD shall include a disconnect switch that is pad-lockable in the open position.

C. For VFD that are in sight from the motor, no separate disconnect is required between it and the motor if equipped with a disconnect switch that is pad-lockable in the open position.

D. For VFD that are not in sight from the motor, provide a separate disconnect ahead of the VFD and the motor. “In sight from the motor” is defined by the National Electrical Code as being visible from and not more than 50 feet from.

E. When a separate motor disconnect switch is provided the disconnect switch shall include automatic “early break” auxiliary contacts that deactivate the VFD whenever the motor disconnect switch is opened. The wiring associated with the early break contacts may be run in the same conduit as the power wiring to the disconnect switch. Assure the electrical drawings indicate the required early break contact wiring. When a common VFD serves multiple direct-drive fan array motors, early break auxiliary contacts are not required.

F. Control wiring shall be as provided by the manufacturer except as modified by the approval and submittal process. Interface all local and remote devices into the control wiring and operational systems for each load as specified on the drawings.

G. Manufacturer's Representative

1. Provide the services of a qualified factory-trained manufacturer's representative to assist the Contractor in installation and start-up of the equipment specified. The manufacturer's representative shall provide technical direction and assistance to the Electrical Trade Contractor in verification of general assembly of the equipment, connections and adjustments, and testing of the assembly and components contained therein.

2. The following minimum work shall be performed under the technical direction of the manufacturer's service representative.

   a. Check all removable cells and starter units for easy removal and insertion.

   b. Perform insulation tests on each phase and verify low resistance ground connection on ground bus.

   c. Verify basic operation of each starter from control power source.

   d. Verification of proper torque on all field and factory bolted bus connections. Utilize calibrated torque wrench and submit calibration records with the startup report.

   e. Calibrate any solid-state metering or control relays for their intended purpose and make written notations of adjustments on record drawings.

   f. Follow the manufacturer's instruction and the contract documents concerning any short circuit device settings, HMCP settings or timing relays. All adjustable settings shall be documented and included in the final O & M manual.

3. Submit the manufacturer's field startup report before final payment is made.

H. Training

1. Provide a training session for up to three representatives for 1/2 normal workdays at the job site or other office location chosen by the Owner's Representative.
2. A manufacturer's qualified representative shall conduct the training session.
3. The training program shall consist of the following:
    a. Review of the one-line drawings and schedules.
    b. Review of the factory record shop drawings and placement of the various cells.
    c. Review of each type of starter cell, components within control and power wiring.
    d. Review contactor coil replacement, and contact replacement procedures.
    e. Discuss the maintenance timetable and procedures to be followed in an ongoing maintenance program.
    f. Provide three ring binders to participants complete with copies of drawings and other course material covered.
    g. Full operation, under any and all operating conditions.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install motor controllers according to manufacturer's written instructions.

B. Install conduit in accordance with CSI Division 26 Section 260533, “Raceway and Boxes for Electrical Systems.”

C. Connect power cable and control wire as recommended by manufacturers. Make power cable and control cable connections to manual starters, and across-the-line magnetic starters by means of integral mechanical connectors. If such items are not furnished with integral mechanical connectors, make connections using compression connectors in accordance with CSI Division 26 Section 260519, “Low-Voltage Electrical Power Conductors and Cables.”

D. Ground motor starter in accordance with CSI Division 26 Section 260526, “Grounding and Bonding for Electrical Systems.”

E. Apply touch up paint as necessary.

3.2 IDENTIFICATION

A. Identify motor-control components and control wiring according to CSI Division 26 Section 260553, "Identification for Electrical Systems."

3.3 CONTROL WIRING INSTALLATION

A. Install wiring between motor-control devices according to CSI Division 26 Section 260519, "Low-Voltage Electrical Power Conductors and Cables."

B. Bundle, train, and support wiring in enclosures.

C. Connect hand-off-automatic switch and other automatic control devices where available.

1. Connect selector switches to bypass only the manual and automatic control devices that have no safety functions when switch is in the hand position.

2. Connect selector switches with motor-control circuit in both hand and automatic positions for safety-type control devices such as low- and high-pressure cutouts, high-temperature cutouts, and motor overload protectors.

3.4 CONNECTIONS

A. Tighten connectors, terminals, bus joints, and mountings. Tighten field-connected connectors and terminals, including screws and bolts, according to manufacturer's published torque-tightening values. Where manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.5 FIELD QUALITY CONTROL

A. Inspection and Tests: In addition to any inspection and test requirements noted elsewhere, the following tests are required.

1. The equipment shall be fully assembled, wired and tested at the factory.

2. The motor controllers shall be given visual inspection, wiring checks and operation, continuity, and electric tests for each circuit in accordance with the latest standards of IEEE, NEMA and ANSI, in order to assure completeness, adequacy, and proper functioning equipment. Perform each visual and mechanical inspection and electrical test stated in NETA ATS, Sections 7.5, 7.6, and 7.16 or per manufacturer’s recommendations. Certify compliance with test parameters.

3. Where more than one test is indicated in test code, state by which method the test will be performed.

4. All tests shall be performed in the presence of the DESIGNER. The DESIGNER shall be permitted to inspect any equipment, material or work to be furnished under these specifications and shall have the right to reject any parts considered defective or unsuitable for the use and purpose intended or not in accordance with these specifications.

5. After installing motor controllers and after electrical circuitry has been energized, demonstrate product capability and compliance with requirements. Remove and replace malfunctioning units with new units, and retest.

3.6 CLEANING

A. Remove paint splatters and other spots, dirt, and debris. Touch up scratches and mars of finish to match original finish. Clean devices internally, using methods and materials recommended by manufacturer.

3.7 COMMISSIONING

A. Comply with requirements specified in Division 1.

B. Engage a factory-authorized service representative to supervise and assist with startup service. Complete installation and startup checks according to the approved manufacturer's written instructions.

3.8 TRAINING AND SERVICE

A. Comply with Section 26 00 01.

B. Conduct two 4-hour training sessions. Train the Owner's maintenance personnel on procedures and schedules related to start up and shutdown, troubleshooting, servicing, and preventive maintenance.

3.9 EXTRA MATERIALS

A. Furnish to the Engineer spare parts described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. One spare contactor (motor starter) for each ten or less contactors (motor starters) of given size.
2. One set of spare overload heater elements for each ten sets of specific size.
3. Ten percent spare fuses for both primary and secondary of control power transformers.
4. 100 percent replacement of indicating lamps.
5. 50 percent replacement of indicating lamp lenses.

End of Section

DO NOT REMOVE
THIS PAGE INTENTIONALLY LEFT BLANK

Section 26 25 00

LOW VOLTAGE PLUG-IN AND FEEDER BUSWAY

(TRADE CONTRACT REQUIRED AS PART OF SECTION 26 00 01)

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. PUBLICLY BID TRADE CONTRACT REQUIREMENTS: As provided under Section 26 00 01 - ELECTRICAL and supplemented under the Bidding Requirements, Contract Forms, and Conditions of the Contract, and applicable parts of Division 1 - GENERAL REQUIREMENTS.

1. Work of this Trade Contract includes all individual specification sections listed in Section 26 00 01.

1.2 RELATED DOCUMENTS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications

1.3 SUMMARY

A. Low-Voltage Plug-in Busway - 225 to 5000 ampere, 600 VAC

1.4 REFERENCES

A. ANSI/IEEE C37.23, Metal-Enclosed Bus and Calculating Losses in Isolated-Bus, Guide for

B. ANSI/NEMA BU 1, Busways

C. ANSI/NEMA KS 1, Enclosed and Miscellaneous Distribution Equipment Switches (600 Volts)

D. ANSI/NFPA 70, National Electrical Code

E. CSA C22.2 No. 27, Busways

F. NEMA AB 1, Molded Case Circuit Breakers and Molded Case Switches

G. NEMA BU1.1, General Instructions for Proper Handling , Installation, Operation, and Maintenance of Busway Rated 600 Volts or Less

H. NEMA ICS 2, Industrial Control and Systems: Controllers, Contactors and Overload Relays, Rated Not More Than 2000 Volts AC or 750 Volts DC

1.5 SYSTEM DESCRIPTION

A. Busway shall be a totally enclosed, indoor low-impedance system.

B. Material and installation shall comply with all applicable codes, recommended practices, and standards of ANSI, IEEE, NEMA, UL, CSA, and ASTA. All busway components shall be UL listed. Arrangements, details, and location shall be as indicated in drawings. Busway shall be tested and conform to IBC-2006 seismic requirements.

C. Short circuit rating of fittings with protective devices shall be equal to the lower short circuit rating of the protective device or the busway. Short circuit rating of busway plugs equals the rating of the fuses or circuit breaker used in the plug.

1.6 SUBMITTALS

A. Product Data on specified product;

B. Shop Drawings on specified product;

C. Design Data, detailed component data on specified product, such as CT ratios, ratings;

D. Certified trip curves for each specified product;

1.7 PROJECT RECORD DOCUMENTS

A. Maintain an up-to-date set of Contract documents. Note any and all revisions and deviations that are made during the course of the project.

1.8 OPERATION AND MAINTENANCE DATA

A. Submit operation and maintenance data based on factory and field testing, operation and maintenance of specified product.

1.9 QUALITY ASSURANCE

A. Manufacturer shall have specialized in the manufacture and assembly of low-voltage plug-in busway for [50] years.

B. Low-voltage plug-in busway shall be listed and/or classified by Underwriters Laboratories.

C. Busway shall be qualified for use in seismic areas as follows:

1. High seismic loading as defined in IEEE Std 693-2005, with 1.3 amplification factor .

2. IBC-2009, Ss = 2.27g, Sds = 1.51g, Ip = 1.5, for z/h equal to 1 and Ss = 3.68g, Sds = 2.45g, Ip = 1.5, for z/h equal to 0 in accordance with ICC-ES-AC156.

3. Seismic compliance shall be qualified only through shake table testing. Compliance by calculation is not acceptable.

D. Installer has specialized in installing low voltage plug-in busways with minimum 10-years documented experience.

1.10 DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, protect, and handle products in accordance with recommended practices listed in manufacturer's Installation and Maintenance Manuals.

B. Deliver each low-voltage plug-in busway in individual shipping cartons for ease of handling. Each busway shall be wrapped for protection.

C. Inspect and report concealed damage to carrier within specified time.

D. Store in a clean, dry space. Maintain factory protection or cover with heavy canvas or plastic to keep out dirt, water, construction debris, and traffic. (Heat enclosures to prevent condensation.)

E. Handle in accordance with NEMA and manufacturer's written instructions to avoid damaging equipment, installed devices, and finish. Lift only by installed lifting eyes.

1.11 PROJECT CONDITIONS

A. Follow (standards) service conditions before, during and after busway installation.

B. Low-voltage plug-in busways shall be located in well-ventilated areas, free from excess humidity, dust and dirt and away from hazardous materials. Ambient temperature of area will be between minus 30 and plus 40 degrees C. Indoor locations shall be protected to prevent moisture from entering enclosure.

1.12 FIELD MEASUREMENTS

A. Make all necessary field measurements to verify that equipment shall fit in allocated space in full compliance with minimum required clearances specified in National Electrical Code.

1.13 WARRANTY

A. Comply with Section 260001.

B. The Electrical Trade Contractor shall warranty that all materials furnished shall be free from defects of material for a period of one year from the date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Eaton

B. General Electric

C. Square D

D. Or approved equal

2.2 COMPONENTS

A. Refer to Drawings for: actual layout and location of equipment and components; current ratings of devices, bus bars, and components; voltage ratings of devices, components, and assemblies; and other required details.

B. Busway housing shall be extruded aluminum for maximum protection against corrosion from water and other contaminants normally encountered during construction. Housing shall be totally enclosed for protection against mechanical damage and dust accumulation. All hardware shall be plated to prevent corrosion. All indoor busway shall be NEMA 1, complying with IEC IP-40.

C. All bus bar insulation material shall be epoxy NEMA Class B (130-degree C). Insulation shall be UL rated as self-extinguishing and shall be impervious to acids, alkalis, acetones, machine oils and lubricants commonly found in industrial environments. Manufacturer shall provide test data documenting insulation's impact resistance, chemical resistance, and expected life (50 years).

D. Busway shall be rated as indicated in drawings.

E. Bus bars shall be copper.

F. Temperature rise at any point in busway shall not exceed 55 degrees C above ambient when operating at rated load current.

G. The busway housing may be used in place of an internal copper ground bar if the manufacturer's documentation shows that the housing provides a lower resistance ground path than the internal copper ground bar. Otherwise an internal copper ground bar shall be provided that is at least 50% the size and conductivity of main phase bars. If housing ground path is used, ground path connections shall be tin plated.

H. Horizontal busway runs shall be UL listed to hang on 10-foot centers in any position. Vertical busway riser runs shall be supported with spring hangers as shown on plans with maximum of 16-foot centers.

I. Where busway passes through walls or floors, manufacturer shall at user's request provide UL-Listed firestop system No. 539.

J. Joints shall have plus or minus 1/2-inch adjustability and be the one-bolt removable type. Joints shall be able to be made from one side when busway is installed against a wall or ceiling. Plug-in and feeder shall use identical parts. All multi-stacks shall be phase collected.

K. Plug-in busway shall be identical to feeder construction and performance except for the following items:

1. Plug in bus shall have 5 outlets per side for 10 total per 10-foot length. All outlets shall be usable simultaneously.

2. Riser bus shall have outlets on only one side and shall have 5 outlets per 10-foot section. All outlets shall be usable simultaneously.

L. Plug-In Unit Safety Device

1. Busway plugs shall be of the type(s) and rating listed in Contract. Breaker busway plugs shall be commercial grade with the breaker operating handle exposed through plug-in housing.

2. Shields shall protect stabs and ground plug body before stabs make contact. A grounding terminal shall be inside plug body and shielding to prevent access to live parts when cover is open. A ground stab shall engage ground tab on busway and internal ground bus shall be provided when required.

3. Cover and operating handle shall have provision to padlock in OFF position. Operating handle shall be easily moved from end to side or vice versa.

4. A releasable cover interlock shall prevent opening cover except when switch is OFF.

5. Circuit breaker plugs shall have true RMS electronic sensing and an interrupting rating of at least 65KAIC RMS, with interchangeable rating plugs.

M. The short circuit rating of the busway, including its integral fittings and protective devices, shall be the lowest of the short circuit ratings of the busway, its fittings, or protective devices. For example, a fusible power takeoff rated 200,000 amperes with Class J fuses is installed on a 65,000-ampere rated busway. The rating of this system is 65,000 amperes.

N. Digital Electronic Trip Unit for Molded Case Circuit Breakers

1. Each plug-in circuit breaker shall have digital electronic trip units.

2. The protective trip unit shall consist of a solid state, microprocessor-based programmer; tripping means; current sensors; power supply and other devices as required for proper operation.

3. Long time and short time protective functions shall have true RMS sensing technology for harmonic rich currents including up to the 19th harmonic.

4. UL Listed interchangeable rating plug. It shall not be necessary to remove the trip unit to change the rating plug. Rating plugs shall be available in sizes from 40% to 100% of the breaker sensor rating.

5. An integral test jack for testing via a portable test set and connection to a battery source.

6. Noise immunity shall meet the requirements of IEEE C37.90.

7. Display trip targets for long time, short time, and ground fault, if included.

8. Visual illuminated indication of the trip unit (normal, pickup, trip, error).

9. As a minimum, the trip unit shall have the following protective functions:

   a. Current setting or long time pickup, adjustable from 50% to 100% of the rating plug value.

   b. Adjustable long-time delay with typical inverse time characteristics (minimum of 10 bands). In addition, a set of straight-line fuse shaped long time delay bands shall be provided to facilitate selectivity with downstream fuses (minimum 7 bands).

   c. Instantaneous pickup, adjustable from 2.0 to 10 times the rating plug in 0.5 increments

   d. Short time pickup and delay. Short time pickup shall be adjustable from 1.5 to 9 times the long-time pickup setting in 0.5 increments with an OFF option. Provide minimum of 12 short time delay bands with three selectable I2t bands.

   e. Adjustable ground fault pickup and delay. Ground fault pickup shall be adjustable from 0.4 to 1.0 times the breaker sensor rating in 0.05 increments. Provide a minimum of 15 ground fault delay bands with three selectable I2t bands.

2.3 ACCESSORIES

A. Furnish nameplates for each device as indicated in drawings. Color schemes shall be as indicated on drawings.

   1. Thermal expansion fittings for:

   2. Runs longer than 150 feet when busway is not free to move at ends of run;

B. When busway run, crosses building expansion joint.

C. Reducer cubicles and special adapter cubicles, as required in drawings.

D. Furnish spring hangers as required for vertical risers at each floor penetration and supplementary support location.

E. Provide floor and wall flanges at each rated wall or floor penetration as shown on the drawings.

F. Furnish cable end or center tap boxes where indicated on the drawings.

2.4 TESTING

A. Each busway item shall pass a dielectric withstand test of 5000 VDC for 5 seconds.

B. Tests prior to energizing: Busway system joint tightness, phasing, and insulation resistance shall be verified by test prior to energizing the system for the first time. Joint resistance shall be evaluated by a qualified person using equipment identified for the function. A written record of these tests shall be made available to the authority having jurisdiction.

2.5 FINISH

A. ANSI-61 gray enamel.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that busways are ready to install.

B. Verify field measurements are as instructed by manufacturer.

C. Verify that required utilities are available, in proper location and ready for use.

D. Beginning of installation means installer accepts conditions.

E. Verify that each spring hanger is properly adjusted to support the required weight as described in the busway installation instructions.

3.2 INSTALLATION

A. Additional provisions and editing may be required for this part.

B. Install per manufacturer's instructions.

C. Install required safety labels.

D. Busway shall be protected from liquids, moisture, and other contaminants or corrosion which may result in electrical failure. Busway shall be protected from moisture during or after installation. Special consideration shall be given to riser busways to protect them from moisture from uncompleted roofs, walls, etc. Busways shall have exposed ends of uncompleted runs protected to prevent accidental contamination during the construction period. Slant shields, drip pans or other approved protective shields shall be installed to protect indoor busway in locations where there is a possibility of water spillage or dripping condensate from roof drains, water pipes, and the like.

3.3 FIELD QUALITY CONTROL

A. Inspect installed busways for anchoring, alignment, grounding, and physical damage.

B. Check tightness of all accessible mechanical and electrical connections with calibrated torque wrench. Minimum acceptable values are specified in manufacturer's instructions.

C. Megger busways using 1000 VDC Megger. Check phase to phase, phase to ground. Individual lengths should be at least 3 megohm(s). Entire run should be at least 1 megohm(s). Divide runs over 100 feet long.

D. Maintain a dry storage area for the busway before installation.

3.4 ADJUSTING

A. Adjust all circuit breakers as described in manufacturer's instructions.

B. Adjust circuit breaker trip and time delay settings to values determined by Power System Studies.

C. Adjust all spring hanger supports to values calculated per the installation instructions.

3.5 CLEANING

A. Clean interiors of switchboards and panelboards to remove construction debris, dirt, shipping materials.

B. Repaint scratched or marred exterior surfaces to match original finish.

3.6 EXTRA MATERIALS

A. Furnish the following component at the end of the project to the Owner:

1. Bus plug one of each type.

End of Section

DO NOT REMOVE
THIS PAGE INTENTIONALLY LEFT BLANK

Section 26 27 26

WIRING DEVICES

(TRADE CONTRACT REQUIRED AS PART OF SECTION 26 00 01)

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. PUBLICLY BID TRADE CONTRACT REQUIREMENTS: As provided under Section 26 00 01 - ELECTRICAL and supplemented under the Bidding Requirements, Contract Forms, and Conditions of the Contract, and applicable parts of Division 1 - GENERAL REQUIREMENTS.

1. Work of this Trade Contract includes all individual specification sections listed in Section 26 00 01.

1.2 RELATED DOCUMENTS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications

1.3 SUMMARY

A. This Section includes the following:

1. Receptacles.
2. Snap switches.
3. Time switches.
4. Outdoor photoelectric switches.
5. Occupancy and daylighting sensor control.
6. Emergency lighting control relay.
7. Lighting contactors.
8. Emergency shunt relay.

1.4 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Shop Drawings: List of legends and description of materials and process used for pre-marking wall plates.

C. Samples: One for each type of device and wall plate specified, in each color specified.

D. Operation and Maintenance Data: For wiring devices to include in all manufacturers' packing label warnings and instruction manuals that include labeling conditions.

1.5 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. Comply with NFPA 70.

1.6 WARRANTY

A. Comply with Section 260001.

B. The Electrical Trade Contractor shall warranty that all materials furnished shall be free from defects of material for a period of one year from the date of Substantial Completion.

PART 2 - PRODUCTS

2.1 WIRING DEVICES

A. Manufacturers

1. Legrand; Wiring Devices & Accessories (Legrand).
2. Hubbell Incorporated; Wiring Device-Kellems (Hubbell).
3. Leviton Mfg. Company Inc. (Leviton).
4. Or approved equal.

B. Basis Of Design

1. Basis of design based upon products by Legrand.

2.2 RECEPTACLE OUTLETS:

A. General: All receptacle outlets shall be tamper-resistant.

B. Tamper-Resistant Convenience Receptacles, 125V, 20A: Comply with NEMA WD1, NEMA WD6 configuration 5-20R, UL498 and Federal Specification W-C-596. Prewired pigtail connectors that accommodate Fed Spec receptacles are approved. Must be crimped and welded terminal right-angle application connector.

1. Pass & Seymour: TR5351 (single), TR5362 (duplex), PTTR5362 (use with PTRA6STRNA prewired pigtail connector).

C. Combination Tamper-Resistant Single Convenience Receptacle with (2) USB ports (Type A and Type C), 125 V, 20 A and USB power supply of 5Vdc @ 3.1A output. cULus Listed, UL Fed Spec Listed. Complies with test requirements UL 498, UL 1310, Fed Spec WC596, CSA C22.2 No. 42, CSA C22.2 No. 223.

1. Pass & Seymour: PTTR20ACUSB*

D. Controlled Tamper-Resistant Convenience Receptacles, 125V, 20A: Comply with NEMA WD1, NEMA WD6 configuration 5-20R, UL498 and Federal Specification W-C-596.

1. Pass & Seymour: 5362CDGN - 20A both outlets controlled with green color.

E. Weather-Resistant Convenience Receptacles, 125V, 20A: Comply with NEMA WD1, NEMA WD6 configuration 5-20R, UL498 and Federal Specification W-C-596. Prewired pigtail connectors that accommodate Fed Spec receptacles are approved. Must be crimped and welded terminal right-angle application connector.

1. Pass & Seymour: WR5362.
2. Wet-Location, Weatherproof Cover Plates: NEMA 250, complying with type 3R weather-resistant thermoplastic with lockable while-in-use cover.
    a. Hubbell: MX3200 single gang
    b. Hubbell: MX6200 dual gang

F. Tamper-Resistant GFCI Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD1, NEMA WD6 configuration 5-20R, UL 498, Federal Specification W-C-596 and UL943, Class A, and include indicator light that is lighted when device is tripped.
1. Pass & Seymour: 2095TR.

G. Range Outlet: Straight Blade Devices, Single, 50A 125/250V, 3-Pole 4-Wire Grounding, 14-50R, Flush Mount, Black.
1. Hubbell: RR450F.

H. Dryer Outlet: Straight Blade Devices, Single, 30A 125/250V, 3-Pole 4-Wire Grounding, 14-30R, Flush Mount, Black.
1. Hubbell RR430F.

I. Cord reel sets, description: Match voltage and current ratings and number of conductors to requirements of equipment being connected.
1. Cord: Rubber-insulated, stranded-copper conductors, with Type SOW-A jacket; with green-insulated grounding conductor and equipment-rating ampacity plus a minimum of 30 percent.
2. Plug: Nylon body and integral cable-clamping jaws. Match cord and receptacle type for connection.
3. Cord reel
    a. Automotive: Legrand: CRSD123GFCI50R20
    b. Classrooms: Legrand: CRCD123GFCI25R20

J. Large Format Display Outlets (Displays furnished under Section 281000)
1. Furnish and install in the TV backbox behind the display:
    a. HDMI Outlet: Auto-switching AV HDBaseT transmitters with (3) HDMI Ports
        1) Hubbell: ISFHDT431BK
    b. USB Charger Tamper Resistant Receptacle, (1) USB Port 3A, 5V DC output, 15A, 125V AC Decorator Duplex
        1) Hubbell: AVPS15xx
        2) The 5V DC output shall power the HDMI outlet.
2. Furnish and install at the security workstation:
    a. HDMI Outlet: Auto-switching AV HDBaseT transmitters with (3) HDMI Ports
        1) Hubbell: ISFHDT431BK
    b. USB Charger Tamper Resistant Receptacle, (1) USB Port 3A, 5V DC output, 15A, 125V AC Decorator Duplex
        1) Hubbell: AVPS15xx

2) The 5V DC output shall power the HDMI outlet.

c. Two Gang AV Wallboxes

1) Hubbell: HBL985

d. Low Voltage Divider

1) Hubbell: HBL989

3. Furnish and install Category 6A cable between the HDMI outlets at the large format display and the workstation.

K. Finishes

1. Wiring Devices Connected to Normal Power System: Color by Architect.
2. Wiring Devices Connected to Emergency (Life Safety) Power System: Red.
3. Wiring Devices Connected to Standby Power System: Brown.
4. Controlled outlets: Green

2.3 SNAP SWITCHES

A. Comply with NEMA WD 1 and UL 20.

B. Switches, 120/277 V, 20 A:

1. Pass & Seymour; CSB20AC1 (single pole), PT20AC1 (single pole – use with PTS6STR3 prewired pigtail connector), CSB20AC2 (two pole), CSB20AC3 (three way), PT20AC3 (three way – use with PTS6STR4 prewired pigtail connector), CSB20AC4 (four way).

C. Pilot Light Switches, 120/277 V, 20 A:

1. Pass & Seymour; PS20AC1RPL for 120V, PS20AC1RPL7 for 277V.

D. Key-Operated Switches, 120/277 V, 20 A:

1. Pass & Seymour; PS20AC1-L.

E. Single-Pole, Double-Throw, Momentary Contact, Center-Off Switches, 120/277 V, 20 A; for use with mechanically held lighting contactors.

1. Pass & Seymour; 1251.

F. Finishes

1. Color by Architect.

2.4 CLOCK BACKBOXES

A. 2-gand back box with cover plate.

1. Legrand: TV2MW

a. Provide 1” EMT conduit stub with pull string from outlet to accessible celling.

B. Furnish and install at each clock location shown on the drawings.

2.5 FLAT PANEL TV BACKBOXES

A. Designed to mount along the bottom edge behind a Plasma or LCD display.

1. FSR: PWB100
    a. Provide 1” EMT conduit stub with pull string to accessible ceiling for data.
    b. Provide 1-1/4” EMT conduit stub with pull string to accessible ceiling for AV.

B. Furnish and install at each TV location shown on the drawings.

2.6 WALL PLATES

A. Single and combination types:
1. Plate-Securing Screws: Metal with head color to match plate finish.
2. Material for Finished Spaces: Stainless Steel.
3. Material for Unfinished Spaces: Galvanized steel.
4. Material for Damp Locations: Cast aluminum with spring-loaded lift cover, and listed and labeled for use in "wet locations."

2.7 FLOOR SERVICE FITTINGS

A. Power/Communications/AV – Floor Box Floor Service (concrete, raised and wood floors):
1. The floor box shall be utilized for floor power and communications to accommodate duplex receptacles, voice/data outlets and AV outlets.
2. Provide where shown on the drawings with face plates and cover assembly. Cover color and type shall be as directed by the Architect.
3. Modular, flush-type, dual-service units suitable for wiring method used.
4. Compartments: Barrier separates power from communications cabling.
5. Furnish and install one 3/4" conduit for power and two 1-1/2” conduits for communications. Run conduits to the nearest wall and stub up above accessible ceiling. Provide bushings and pull string in all conduits.
6. Coordinate with the structural engineer for the maximum size of the conduit allowed to run in the slab. In the event that conduits larger than 3/4" or 1-1/2” are not allowed to run in the slab, run conduits in the ceiling of the floor below or under the slab.
7. Basis of Design: Legrand EFB6S Series, Legrand EFB6S-OG (Ground), and Legrand EFB6S-FC (fire classified).

B. Power/Communications – Floor Box Furniture Feed (concrete, raised and wood floors):
1. The floor box shall be utilized for floor power and communications to accommodate duplex receptacles and voice/data outlets.
2. Provide where shown on the drawings with face plates and cover assembly. Cover color and type shall be as directed by the Architect.
3. Modular, flush-type, dual-service units suitable for wiring method used.
4. Compartments: Barrier separates power from communications cabling.
5. Furnish and install one 1" conduit for power and one 2” conduit for communications. Run conduits to the nearest wall and stub up above accessible ceiling. Provide bushings and pull string in all conduits.
6. Furnish and install power and telecommunications whips to the powered furniture.

7. Coordinate electrical work associated with the powered furniture delivery so that the work is scheduled to be performed when the powered furniture is delivered and assembled on site.
8. Run telecommunications wiring in the modular furniture, furnish and install outlet jacks and faceplates, terminate and test all devices.
9. The work shall be scheduled and performed at no additional cost to the Owner.
10. Basis of Design: Legrand EFBFF- FPFFTC Series.

C. Power/Communications/AV - Poke-Thru Floor Service:

1. The poke-thru service device shall be utilized for floor power, communications and AV to accommodate up to two duplex receptacles, six voice/data outlets and AV outlets.
2. Provide where shown on the drawings with 5-20R receptacles, voice/data outlets and AV outlets together with face plates and die-cast aluminum cover assembly. Color shall be as directed by the Architect.
3. Modular, flush-type, dual-service units suitable for wiring method used.
4. Compartments: Barrier separates power from communications cabling.
5. Furnish and install 3/4" bottom housing assembly for power and two 1-1/2” bottom housing assembly for communications. Provide bushings and pull string in all conduits.
6. Run conduits in the ceiling of the floor below.
7. Basis of Design: Legrand 8AT Series.

D. Power/Communications - Poke-Thru Furniture Feed:

1. The poke-thru service device shall be utilized for floor power and communications to accommodate up to two duplex receptacles and six voice/data outlets.
2. Provide where shown on the drawings.
3. Modular, flush-type, dual-service units suitable for wiring method used.
4. Compartments: Barrier separates power from communications cabling.
5. Furnish and install 3/4" bottom housing assembly for power and 2” conduit bottom housing assembly for communications. Provide bushings and pull string in all conduits.
6. Run conduits in the ceiling of the floor below.
7. Furnish and install power and telecommunications whips to the powered furniture.
8. Coordinate electrical work associated with the powered furniture delivery so that the work is scheduled to be performed when the powered furniture is delivered and assembled on site.
9. Run telecommunications wiring in the modular furniture, furnish and install outlet jacks and faceplates, terminate and test all devices.
10. The work shall be scheduled and performed at no additional cost to the Owner.
11. Basis of Design: Legrand 6AT Series.

E. Power/Communications – Poke-Thru Transient Locations

1. This assembly shall be made up of an insert and an activation cover. Overall poke-thru assembly length shall be 16" 3/8” [416mm].

2. Insert:

   a. The insert body shall have the necessary channels to provide complete separation of power and communication services. There shall be one 3/4" trade size channel for power and two 1/2" trade size channels for communication cabling. The channels shall be arranged such that communication cables can be conduit protected and connected to the insert body using a die-cast zinc conduit connector with two 1/2" trade size threaded openings to accept both rigid and flexible conduit connections.

   b. The insert shall also consist of two 20-amp duplex receptacles. The four receptacles shall be prewired with six #12 AWG THHN solid conductors. Each duplex receptacle shall be wired with individual neutral and individual ground wires. The power receptacles shall be capable of being wired as standard receptacles or for isolated ground. Circuit identifiers shall be clearly marked on each duplex receptacle and a wiring diagram shall be stamped inside the junction box.

   c. The insert body shall also contain a nonmetallic bracket that will accommodate Ortronics workstation connectivity modular inserts, or the Pass & Seymour Network Wiring Systems. The bracket shall allow the inserts to mount flush and recessed.

   d. The body will consist of an intumescent fire stop material to maintain the fire rating of the floor slab. The intumescent material will be held securely in place in the insert body and shall not have to be adjusted to maintain the fire rating of the unit and the floor slab. The insert shall have a spring steel-retaining ring that will hold the poke-thru device in the floor slab without additional fasteners. The poke-thru insert shall also consist of a 3/4" trade size conduit stub that is connected to the insert body and a 24.5 cubic inch [402ml] stamped steel junction box for wire splices and connections. The stamped steel junction box shall also contain the necessary means to electrically ground the poke-thru device to the system ground.

3. Activation Cover:

   a. The trim flange shall be manufactured of die-cast aluminum alloy and be capable of being powder-coated or plated. The coated finish is to be textured, two-stage epoxy paint in gray, black, or ivory. A gasket is attached to the underside of the trim flange to maintain scrub water tightness. The trim flange shall also be available in a solid brass forging and a die cast brushed aluminum finish. Brass and aluminum finish shall be a brushed finish with a lacquer sealant. The trim flange shall be 8 1/4" [210mm] in diameter. The activation slide cover shall be 6 1/4" [159mm] in diameter.

   b. The activation cover shall be manufactured from textured Polycarbonate or PVC and be available in gray, black, ivory, and brass colors. The slide holder assembly shall be flush with the floor and provide “Dead-front” protection that allows the receptacle covers to snap back into place when receptacle is not in use. A gasket is attached to the underside of the cover assembly to maintain scrub water tightness by preventing water, dirt, and debris from entering the power and communication compartments. The device shall also have accommodation for up to four communication connectors. The cover shall have individual slides that allow access to the communication connectors and will close over the connectors when not in use. Each activation cover shall

also provide locations to adhere labels to identify both power and communication circuits.

4. Communication Modules Mounting Accessories:

   a. The poke-thru device manufacturer shall provide a complete line of bezels to facilitate mounting of UTP, STP (150 ohm), fiber optic, coaxial, and communication devices. Communication connectors shall be capable of being installed either flush or recessed. For communications, the unit will contain accommodations for up to four connectors for UTP, fiber optic, coaxial, audio, and video solutions. The poke-thru device shall accommodate Ortronics workstation connectivity outlets and modular inserts or the Pass & Seymour Network Wiring System. To accommodate the communication solutions, the device shall accept discrete keystone type connectivity devices from various manufacturers. All communication inserts shall be nonmetallic. The system shall provide for connection of other modular inserts for additional communication options. The unit will also be supplied with four Category 6 keystone connectors with the standard version. The unit shall also accommodate a mechanism to permit protection of communication cabling. This mechanism shall be zinc die-cast with two openings to accept both flexible and rigid conduit. Openings shall accept 1/2" trade size conduit

5. Basis of Design: Legrand RC4 Series.

F. Installation

1. Preparation

   a. Prepare substrates using the methods recommended by the manufacturer for achieving the best result for the substrate under the project conditions.

   b. If preparation is the responsibility of another installer, notify Architect in writing of deviations from manufacturer’s recommended installation tolerances and conditions.

2. General

   a. Install in accordance with manufacturer's instructions for system components and approved shop drawings. Coordinate installation with adjacent work to ensure proper clearances and to prevent electrical hazards.

   b. Install in accordance with complete system instruction sheets.

   c. Install enclosures to be mechanically continuous and connected to all electrical outlets, boxes, device mounting brackets, and cabinets, in accordance with manufacturer's installation sheets.

   d. Install enclosures to be electrically continuous and bonded in accordance with the National Electric Code for proper grounding.

   e. Mechanical Security: Raceway systems shall be mechanically continuous and connected to all electrical outlets, boxes, device mounting brackets, and cabinets, in accordance with manufacturer’s installation sheets.

   f. Electrical Security: Metal raceway shall be electrically continuous and bonded in accordance with the National Electric Code for proper grounding.

   g. Raceway Support: Raceway shall be supported at intervals not exceeding 5 feet (1524 mm) or in accordance with manufacturer’s installation sheets.

   h. Accessories: Provide accessories as required for a complete installation, including insulated bushings and inserts where required by manufacturer.

i. Unused Openings: Close unused raceway openings using manufacturer's recommended accessories.

j. Install floor boxes to permit all wiring to be completed at floor level.

3. Protection

a. Clean exposed surfaces using non-abrasive materials and methods recommended by manufacturer.

b. Protect installed products until completion of project.

c. Touch-up, repair or replace damaged products before Substantial Completion.

2.8 OUTDOOR GROUND BOX

A. Provide underground power/communications box as shown on the drawings.

B. Classification and Use: Outdoor ground boxes shall have been examined and tested by Underwriters Laboratories Inc. to meet NEMA 6P and IP68 requirements to be safe to use even during inclement weather and bear the cULus Listing Mark.

C. Outdoor Ground Boxes, General:

1. Outdoor ground boxes shall be designed to trap and maintain an air pocket to protect the devices, plugs and connections from water, snow, and ice. Boxes shall be constructed from UV rated chemical resistant materials. Boxes designed to ANSI/SCTE 77 with a Tier 5 rating to hold up to 5000 lbs of load. Boxes install flush to finished ground reducing tripping hazards. Box shall have a diving bell concept to maintain an air pocket and keep water away from connections. Box shall have an egress door that will auto-adjust to cable diameter and auto-lock in the closed position when no cables are exiting the box.

2. Basis of Design Product: Legrand Model XB814 box (5-20R receptacles) and XB814C520-BK Exterior Box Cover Assembly: Assembly prewired with two (2) 20A L5-20R weather-resistant duplex receptacles. Box assemblies shall be 16-1/8” L x 8-1/16” W x 10-3/4” H [410mm x 205mm x 273mm]. Cover assembly includes flange, cover, junction box, (2) 20A 5-20R receptacles, SOOW cord, wet location wire connectors, key, and mounting hardware.

3. Basis of Design Product: Legrand Model XB814 box (Low Voltage) and XB814CLV-BK Exterior Box Cover Assembly: Assembly designed to accept up to 12 communication ports. Cover assemblies shall be 16-1/8” L x 8-1/16” W x 10-3/4” H [410mm x 205mm x 273mm]. Cover assembly includes flange, cover, junction box, corrugated conduit assembly, (1) 12 port communication mounting plate, (1) 8 port Legrand AVIP audio/video mounting plate, key, and mounting hardware.

D. Installation

1. Strictly comply with manufacturer's installation instructions and recommendations. Coordinate installation with adjacent work to ensure proper clearances and to prevent electrical hazards.

E. Cleaning and Protection

1. Clean exposed surfaces using non-abrasive materials and methods recommended by manufacturer.

2. Protect boxes until acceptance.

2.9 TIME SWITCHES

A. Manufacturers:

1. Leviton Mfg. Company Inc.
2. Square D; Schneider Electric.
3. TORK.
4. Or approved equal.

B. Electronic Time Switches: Electronic, solid-state programmable units with alphanumeric display; complying with UL 917.

1. Contact Rating: 20-A ballast load, 120/240-V ac.
2. Program: 8 on-off set points on a 24-hour schedule and an annual holiday schedule that overrides the weekly operation on holidays.
3. Program: 2 on-off set points on a 24-hour schedule, allowing different set points for each day of the week and an annual holiday schedule that overrides the weekly operation on holidays.
4. Programs: 2 channels; each channel shall be individually programmable with 8 on-off set points on a 24-hour schedule.
5. Circuitry: Allow connection of a photoelectric relay as substitute for on-off function of a program on selected channels.
6. Astronomic Time: Selected channels.
7. Battery Backup: For schedules and time clock.

C. Electromechanical-Dial Time Switches: Type complying with UL 917.

1. Contact Rating: 20-A ballast load, 120/240-V ac.
2. Circuitry: Allow connection of a photoelectric relay as substitute for on-off function of a program.
3. Astronomic time dial.
4. Eight-Day Program: Uniquely programmable for each weekday and holidays.
5. Skip-a-day mode.
6. Wound-spring reserve carryover mechanism to keep time during power failures, minimum of 16 hours.

2.10 OUTDOOR PHOTOELECTRIC SWITCHES

A. Manufacturers

1. Square D; Schneider Electric.
2. TORK.
3. Touch-Plate, Inc.
4. Or approved equal.

B. Description: Solid state, with dry contacts rated for 1800-VA tungsten or 1000-VA inductive, to operate connected relay, contactor coils, or microprocessor input; complying with UL 773A.

1. Light-Level Monitoring Range: 1.5 to 10 fc (16.14 to 108 lx), with an adjustment for turn-on and turn-off levels within that range, and a directional lens in front of photocell to prevent fixed light sources from causing turn-off.
2. Time Delay: 15-second minimum, to prevent false operation.
3. Surge Protection: Metal-oxide varistor, complying with IEEE C62.41.1, IEEE C62.41.2, and IEEE 62.45 for Category A1 locations.
4. Mounting: Twist lock complying with IEEE C136.10, with base-and-stem mounting or stem-and-swivel mounting accessories as required to direct sensor to the north sky exposure.

C. Description: Solid state, with dry contacts rated for 1800 VA to operate connected load, relay, or contactor coils; complying with UL 773.

1. Light-Level Monitoring Range: 1.5 to 10 fc (16.14 to 108 lx), with an adjustment for turn-on and turn-off levels within that range.
2. Time Delay: 30-second minimum, to prevent false operation.
3. Lightning Arrester: Air-gap type.
4. Mounting: Twist lock complying with IEEE C136.10, with base.
5. Photo Sensor: Cadmium sulfide.
6. Provide external sliding shield for field adjustment of light level activation.
7. Voltage: As required to control the load indicated on the drawings.
8. Failure Mode: Fails to the on position.
9. Load Rating: As required to control the load indicated on the drawings.
10. Provide accessory wall-mounting bracket where indicated or as required to complete installation

2.11 EMERGENCY LIGHTING

A. Emergency Lighting Control Unit – A UL 924 listed device that monitors a switched circuit providing normal lighting to an area. The unit provides normal ON/OFF control of emergency lighting along with the normal lighting. Upon normal power failure the emergency lighting circuit will close, forcing the emergency lighting ON until normal power is resotred. Features include:

1. 120 - 277 volts, 50/60 Hz., 20 amp ballast rating
2. Push to test button
3. Auxiliary contract for test / Fire Alarm system

2.12 LIGHTING CONTACTORS

A. Manufacturers

1. Allen-Bradley/Rockwell Automation.
2. ASCO Power Technologies, LP; a division of Emerson Electric Co.
3. Eaton Electrical Inc.; Cutler-Hammer Products.
4. Or approved equal.

B. Basis of Design

1. Basis of design based upon products by Elliott Industries, Inc.

C. Description: Electrically operated and electrically held, combination type with fusible switch, complying with NEMA ICS 2 and UL 508.

1. Current Rating for Switching: Listing or rating consistent with type of load served, including tungsten filament, inductive, and high-inrush ballast (ballast with 15 percent or less total harmonic distortion of normal load current).

2. Fault Current Withstand Rating: Equal to or exceeding the available fault current at the point of installation.

3. Enclosure: Comply with NEMA 250.

4. Provide with control and pilot devices as indicated on Drawings, matching the NEMA type specified for the enclosure.

2.13 EMERGENCY SHUNT RELAY

A. Manufacturers

1. Lighting Control and Design, Inc.

2. Wattstopper.

3. Lutron.

4. Or approved equal.

B. Description: Normally closed, electrically held relay, arranged for wiring in parallel with manual or automatic switching contacts; complying with UL 924.

1. Coil Rating: 120/277 V.

2.14 CONDUCTORS AND CABLES

A. Power Wiring to Supply Side of Remote-Control Power Sources: Not smaller than No. 12 AWG. Comply with requirements in Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

B. Classes 2 and 3 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 18 AWG. Comply with requirements in Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

C. Class 1 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 14 AWG. Comply with requirements in Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

2.15 SECONDARY BUS ENCLOSURE

A. Manufacturers

1. Elliott Industries, Inc.

2. Park Detroit

3. Hubbell

4. Or approved equal

B.

C. General

1. The secondary bus enclosure shall be 600 volt class, suitable for use on systems that do not exceed 600 volts to ground (nor 1000 volts phase to phase). The bus shall be constructed for connection to the electrical system with two-hole and/or four-hole NEMA Standard bolt-on cable-terminal lugs (terminal lugs shall be supplied by the user).

2. Tamper resistance shall meet the Enclosure Security requirements of IEEE Standard C57.12.28 (Pad-Mounted Equipment—Enclosure Integrity) to resist unauthorized entry, protect authorized and unauthorized persons, and provide positive safety features when installed in areas accessible to the general public.

3. The enclosure shall be constructed for outdoor installation in areas subject to heavy precipitation and in areas of windblown contamination. The equipment shall be completely assembled prior to shipment.

D. Enclosure Construction

1. The enclosure shall be tamper-resistant, all-welded construction utilizing 11-gauge minimum sheet steel. Corner plates and braces shall be used as necessary to assure rigidity.

2. The enclosure top shall be cross-kinked to provide watershed and rigidity. The enclosure shall be open bottom with a 1-inch flange inside, all around.

3. The door(s) shall be furnished with a stainless-steel door holder that will latch the door open 100 degrees and 140 degrees and resist accidental closing. Door(s) shall be provided with provisions for padlocking and a recessed hex-head (or penta-head) security bolt to prevent unauthorized entry (coordinated to prevent installation of the padlock until the security bolt is tightened when closing the door(s) and to prevent a wrench from operating the security bolt until the padlock is removed when opening the door(s)). The security bolt shall be made captive with a stainless-steel washer compressed to an oval shape to severely discourage removal. Hinges shall be stainless steel (with stainless steel pins not less than 0.3125-inch diameter) and shall be welded to both the enclosure and the door(s) to maintain door alignment for the life of the equipment.

4. The enclosure shall be nonventilated to minimize the entrance of airborne contamination, insects, rodents or reptiles. The protective finish shall include necessary grinding, cleaning and phosphatizing, two-component rust-inhibiting epoxy primer and a Pad-Mount Green two-component polyurethane top coat finish (Munsell color 7GY 3.29/1.5). The primer and top coat shall be electronically monitored during application to insure proper ratio and mixing of each component. Total average thickness of paint (after curing) shall be not less than 5 mils. The protective coating shall meet the Enclosure Coating System requirements of IEEE Standard C57.12.28 (Pad-Mounted Equipment—Enclosure Integrity).

5. Removable lift provisions, adequate to withstand handling with normal utility equipment, shall be provided on the outside of the enclosure. Threaded openings for lift provision bolts shall be blind holes to prevent the entrance of wire or other foreign objects into the enclosure when lift provisions are removed.

E. Bus and Bus Mountings

1. The bus shall be tin-plated copper with all burrs and sharp corners removed prior to installation. It shall be punched with multiple sets of two 0.5625-inch diameter holes on 1.75-inch centers to accommodate both two-hole and four-hole NEMA standard cable-terminal lugs. When the bus for each phase is constructed with more than one conductor, two 0.25-inch x 0.5625-inch ID x 1-inch OD spacers shall be

supplied for each set of two 0.5625-inch diameter holes. The spacers shall be the same metal alloy as the bus conductor.

2. A minimum of two insulators shall be provided for each bus. The insulators shall be cycloaliphatic epoxy and shall be mounted in a manner that will allow field replacement with standard tools without removal of cables that may be bolted to the bus. Insulators and bus bars shall be installed with stainless steel mounting hardware to provide long life and reduced maintenance. All components shall be arranged to allow visual inspection without de-energizing or removing the equipment from service.

F. Grounding Provisions

1. Four high-conductivity bronze eyebolt-type ground lugs, which accept #6 through #2/0 copper conductor, shall be installed on the inside walls of the enclosure (located on each side of each door opening in an accessible position).

G. Accessory Equipment

1. Provide a corrosion proof nameplate with permanent thermal transfer printing to be installed inside one door on the cable compartment. It shall be located at the top corner farthest from the cables when the door is open. The nameplate will provide Type of Equipment, Model Number, Amps Continuous, kV Maximum, BIL, Serial Number, Job Number, Date Manufactured and Weight of Equipment.

2. Provide one “Warning - Keep Out! - Hazardous Voltage” sign, Elliott #7201-W2003-316, on the outside of each door.

3. Provide four anchor-bolt brackets, Elliott #6102-A81-7 or approved equal, to be supplied with each secondary bus enclosure to provide a means of clamping the equipment to the concrete pad.

2.16 NEMA 3R DOUBLE DOOR ENCLOSURES

A. Manufacturers

1. APC Enclosures, Inc.

2. Omega Engineering, Inc.

3. Hoffman

4. Or approved equal

B. Enclosure

1. The complete enclosure shall be made from 14-gauge type 304 stainless steel.

2. The enclosures are equipped with two (2) adjustable "C" mounting channels on both side walls and back wall to provide versatile positioning of shelves or rack mounting angles.

3. Enclosures wider than 60" are equipped with four (4) adjustable "C" mounting channels.

4. The door frame opening shall be double flanged on all four (4) sides. These flanges increase the strength of the door opening and help prevent dust and liquids from dropping into the enclosure when the door is opened.

5. A removable center post shall be an integral part of the three-point latching system and shall provide increased security and environmental protection.

6. All exterior seams shall be ground smooth or sealed weathertight with silicone sealant.

7. Enclosures shall have provisions for mounting a forced air fan system that can be thermostatically controlled, and air is exhausted through a slotted vent system in the roof overhang.

C. Door

1. The door shall utilize an overlapping design and equipped with a three-point latching mechanism with nylon rollers at the top and bottom.

2. The door handle shall be 0.75" stainless steel round bar and shall have provisions for a padlock.

3. The standard main door lock is Corbin #15484-1 or equal.

4. A louvered air vent with filter retaining brackets and a disposable paper filter element shall be provided.

5. The main doors shall be sealed with closed-cell neoprene gasket.

6. The continuous door hinge shall be 0.075" thick stainless steel with a 0.25" stainless steel hinge pin.

D. Finish

1. Color by Architect.

2. Painted enclosures shall be treated with an iron phosphate coating and dried by radiant heat.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that field measurements are as shown on the drawings.

B. Verify that outlet boxes are installed in proper locations and at the proper heights and are properly sized to accommodate devices and conductors in accordance with NFPA 70.

C. Verify that openings for outlet boxes are neatly cut and will be completely covered by devices or wall plates.

D. Verify that final surface finishes are complete, including painting.

E. Verify that branch circuit wiring installation is completed, tested, and ready for connection to lighting control devices.

F. Verify that the service voltage and ratings of lighting control devices are appropriate for the service voltage and load requirements at the location to be installed.

G. Verify that conditions are satisfactory for installation prior to starting work.

3.2 PREPARATION

A. Provide extension rings to bring outlet boxes flush with finished surface.

B. Clean dirt, debris, plaster, and other foreign material from outlet boxes.

3.3 INSTALLATION

A. Perform work in a neat and workmanship manner in accordance with NECA 1 and where applicable, NECA 130, including mounting heights specified in those standards unless otherwise indicated.

A. Comply with NECA 1, including the mounting heights listed in that standard, unless otherwise noted.

B. Coordination with Other Trades:

1. Take steps to ensure that devices and their boxes are protected. Do not place wall finish materials over device boxes and do not cut holes for boxes with routers that are guided by riding against outside of the boxes.

2. Keep outlet boxes free of plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other material that may contaminate the raceway system, conductors, and cables.

3. Install device boxes in brick or block walls so that the cover plate does not cross a joint unless the joint is troweled flush with the face of the wall.

4. Install wiring devices after all wall preparation, including painting, is complete.

C. Conductors:

1. Do not strip insulation from conductors until just before they are spliced or terminated on devices.

2. Strip insulation evenly around the conductor using tools designed for the purpose. Avoid scoring or nicking of solid wire or cutting strands from stranded wire.

3. The length of free conductors at outlets for devices shall meet provisions of NFPA 70, Article 300, without pigtails.

4. Existing Conductors:

a. Cut back and pigtail, or replace all damaged conductors.

b. Straighten conductors that remain and remove corrosion and foreign matter.

c. Pigtailing existing conductors is permitted provided the outlet box is large enough.

D. Device Installation:

1. Replace all devices that have been in temporary use during construction or that show signs that they were installed before building finishing operations were complete.

2. Keep each wiring device in its package or otherwise protected until it is time to connect conductors.

3. Do not remove surface protection, such as plastic film and smudge covers, until the last possible moment.

4. Connect devices to branch circuits using pigtails that are not less than 6 inches (152 mm) in length.

5. When there is a choice, use side wiring with binding-head screw terminals. Wrap solid conductor tightly clockwise, 2/3 to 3/4 of the way around terminal screw.

6. Use a torque screwdriver when a torque is recommended or required by the manufacturer.

7. When conductors larger than No. 12 AWG are installed on 15- or 20-A circuits, splice No. 12 AWG pigtails for device connections.
8. Tighten unused terminal screws on the device.
9. When mounting into metal boxes, remove the fiber or plastic washers used to hold device mounting screws in yokes, allowing metal-to-metal contact.

E. Receptacle Orientation:

1. Install ground pin of vertically mounted receptacles up, and on horizontally mounted receptacles to the left.

F. Device Plates: Do not use oversized or extra-deep plates. Repair wall finishes and remount outlet boxes when standard device plates do not fit flush or do not cover rough wall opening.

G. Dimmers:

1. Install dimmers within terms of their listing.
2. Verify that dimmers used for fan speed control are listed for that application.
3. Install unshared neutral conductors on line and load side of dimmers according to manufacturers' device listing conditions in the written instructions.

H. Arrangement of Devices: Unless otherwise indicated, mount flush, with long dimension vertical and with grounding terminal of receptacles on top. Group adjacent switches under single, multi-gang wall plates.

I. Install lighting control devices in accordance with manufacturer’s instructions.

J. Unless otherwise indicated, connect lighting control device grounding terminal or conductor to branch circuit equipment grounding conductor and to outlet box with bonding jumper.

K. Install lighting control devices plumb and level, and held securely in place.

L. Where applicable, install lighting control devices and associated wall plates to fit completely flush to mounting surface with no gaps and rough opening completely covered without strain on wall plate. Repair or reinstall improperly installed outlet boxes or improperly sized rough opening. Do not use oversized wall plates in lieu of meeting this requirement.

M. Occupancy Sensor Locations:

1. Location Adjustments: Within the design intent, reasonably minor adjustments to locations may be made in order to optimize coverage nd avoid conflicts or problems affecting coverage.
2. Locate ultrasonic and dual technology passive infrared/ultrasonic occupancy sensors a minimum 4 feet from air supply ducts or other sources of heavy air flow and as per manufacturers recommendations, in order to minimum false triggers.

N. Outdoor Photo Control Locations:

1. Where possible, locate outdoor photo controls with photo sensor facing north. If north facing photo sensor is not possible, install photo sensor facing east, west or down.
2. Locate outdoor photo controls so that photo sensor do not face artificial light sources, including light sources controlled by the photo control itself.

O. Install outdoor photo controls so that connections are weatherproof. Do not install photo controls with conduit stem facing up in order to prevent infiltration of water into the photo control.

P. Lamp Burn-in: Operate lamps at full output for minimum of 100 hours or prescribed period per manufacturer's recommendation prior to use with any dimming controls. Replace lamps that fail prematurely due to improper lamp burn-in.

Q. Unless otherwise indicated, install power packs for lighting control devices above accessible ceiling or above access panel inaccessible ceiling near the sensor location.

R. Where indicated, install separate compatible wall switches for manual control interface with lighting control devices or associated power packs.

S. Unless otherwise indicated, install switches on load side of power packs so that switch does not turn off power pack.

T. Where indicated or required, provide cabinet or enclosure for mounting of lighting control device system components.

3.4 IDENTIFICATION

A. Comply with Division 26 Section "Identification for Electrical Systems."

1. Receptacles: Identify panelboard and circuit number from which served. Use hot, stamped or engraved machine printing with black-filled lettering on face of plate, and durable wire markers or tags inside outlet boxes.

3.5 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.

1. Test Instruments: Use instruments that comply with UL 1436.

2. Test Instrument for Convenience Receptacles: Digital wiring analyzer with digital readout or illuminated LED indicators of measurement.

B. Tests for Convenience Receptacles:

1. Line Voltage: Acceptable range is 105 to 132 V.

2. Percent Voltage Drop under 15-A Load: A value of 6 percent or higher is not acceptable.

3. Ground Impedance: Values of up to 2 ohms are acceptable.

4. GFCI Trip: Test for tripping values specified in UL 1436 and UL 943.

5. Using the test plug, verify that the device and its outlet box are securely mounted.

6. The tests shall be diagnostic, indicating damaged conductors, high resistance at the circuit breaker, poor connections, inadequate fault current path, defective devices, or similar problems. Correct circuit conditions, remove malfunctioning units and replace with new, and retest as specified above.

C. Lighting Control:

1. Inspect each lighting control device for damage and defects.

2. Test occupancy sensors to verify operation, including time delays and ambient light thresholds where applicable. Verify optimal coverage for entire room or area. Record test results in written report to be included with submittals.

3. Test outdoor photo controls to verify proper operation, including time delays where applicable.

4. Correct wiring deficiencies and replace damaged or defective lighting control devices.

3.6 ADJUSTING

A. Adjust devices and wall plates to be flush and level.

B. Adjust occupancy sensors settings to minimize undesired activations while optimizing energy savings, and to achieve optimal coverage as required.

C. Where indicated or as directed by Architect/Engineer, install factory masking material or adjust integral blinders on passive infrared (PIR) and dual technology occupancy sensor lenses to block undesired motion detection.

D. Adjust external sliding shields on outdoor photo controls under optimum lighting conditions to achieve desired turn-on and turn-off activation as indicated or as directed by Architect/Engineer.

3.7 CLEANING

A. Clean exposed surfaces to remove dirt, paint, or other foreign material and restore to match original factory finish.

3.8 COMMISSIONING

A. Comply with requirements specified in Division 1.

B. Engage a factory-authorized service representative to supervise and assist with startup service. Complete installation and startup checks according to the approved manufacturer's written instructions.

3.9 TRAINING AND SERVICE

A. Comply with Section 26 00 01.

B. Conduct two 4-hour training sessions. Train the Owner’s maintenance personnel on procedures and schedules related to start up and shutdown, troubleshooting, servicing, and preventive maintenance.

3.10 EXTRA MATERIALS

A. Furnish the following component at the end of the project to the Owner:

1. Each type of receptacle (single, duplex, normal, controlled, GFCI, USB: 10

2. Each type of switch: 10

3. Each type of wall plate: 10

End of Section

DO NOT REMOVE
THIS PAGE INTENTIONALLY LEFT BLANK

Section 26 27 29

ELECTRIC VEHICLE CHARGING STATION

(TRADE CONTRACT REQUIRED AS PART OF SECTION 26 00 01)

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. PUBLICLY BID TRADE CONTRACT REQUIREMENTS: As provided under Section 26 00 01 - ELECTRICAL and supplemented under the Bidding Requirements, Contract Forms, and Conditions of the Contract, and applicable parts of Division 1 - GENERAL REQUIREMENTS.

1. Work of this Trade Contract includes all individual specification sections listed in Section 26 00 01.

1.2 RELATED DOCUMENTS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications

1.3 SUMMARY

A. Provide design and engineering, labor, material, equipment, related services, and supervision required, including, but not limited to, manufacturing, fabrication, erection, and installation for electric vehicle (EV) charging stations as required for the complete performance of the work, and as shown on the Drawings and as herein specified.

B. The work specified in this Section includes, but shall not be limited to, complete, electric vehicle charging stations as indicated on the Drawings and as specified herein.

1. The extent of the electric vehicle charging infrastructure work shall be as indicated by the Drawings and by the requirements of this Section, including, but not limited to, the following:

a. Power distribution equipment, underground conduit, concrete bases, wiring and commissioning.

b. Work stations, software, and communications hardware.

2. System installation shall include, but shall not be limited to, the following:

a. Wiring of branch circuit conductors.

b. Installation of charging stations.

c. Installation of communications conductors and associated hardware.

d. Configuration of software for payment service.

C. REFERENCES

1. American Society of Civil Engineers (ASCE):

a. ASCE 7, "Minimum Design Loads for Buildings and Other Structures" (copyrighted by ASCE, ANSI approved).

2. ASTM (ASTM):

a. ASTM E 329, "Standard Specification for Agencies Engaged in the Testing and/or Inspection of Materials Used in Construction."

3. California Code of Regulations (CCR):

a. CCR Title 24, “California Building Standards Code.”

4. International Code Council (ICC):

a. ICC ES AC156, “Acceptance Criteria for Seismic Qualification by Shake Table Testing of Nonstructural Components and Systems.”

b. ICC IBC, "International Building Code."

5. National Fire Protection Association (NFPA):

a. NFPA 70, "National Electrical Code" (copyrighted by NFPA, ANSI approved) hereinafter referred to as NEC.

b. NFPA 5000, “Building Construction and Safety Code.”

6. SAE International (SAE):

a. SAE J1772, "Standard for Electric Vehicle Conductive Charge Coupler."

7. Underwriters Laboratories, Inc. (UL):

a. UL 991, "Standard for Tests for Safety Related Controls Employing Solid State Devices."

b. UL 1998, "Standard for Software in Programmable Components."

c. UL 2231 1, "Standard for Personnel Protection Systems for Electric Vehicle (EV) Supply Circuits: General Requirements."

d. UL 2231 2, "Standard for Personnel Protection Systems for Electric Vehicle (EV) Supply Circuits: Particular Requirements for Protection Devices for Use in Charging Systems."

e. UL 2251, "Standard for Plugs, Receptacles and Couplers for Electric Vehicles."

f. UL 2594, "Standard for Electric Vehicle Supply Equipment.”

1.4 SUBMITTALS

A. Product Data: Submit product data showing material proposed. Submit sufficient information to determine compliance with the Drawings and Specifications, including, but not limited to, manufacturer's product data and installation instructions for each component and system.

B. Shop Drawings: Submit shop drawings for each product and accessory required. Include information not fully detailed in manufacturer’s standard product data, including, but not limited to, list of components and equipment to be supplied, including, but not limited to, proposed locations, clearances, and power requirements.

1. Drawings: Submit manufacturer’s dimensional drawings.

2. One Line Diagrams: Submit one line diagrams of the system configuration proposed if it differs from that illustrated in the riser diagram included in these Construction Documents. Submit one line drawings indicating location and addresses of all hardware, including, but not limited to, panelboard or load center, circuit breaker, and charging stations.

C. Wiring Diagrams: Submit wiring diagrams detailing power, signal, and control systems, clearly differentiating between manufacturer installed wiring and field installed wiring, and between components provided by the manufacturer and those provided by others.

1. Submit typical connection diagrams for all components including, but not limited to, panelboards, communications devices, and personal computers.

D. Qualification Data: Submit qualification data for firms and persons specified in Quality Assurance Article to demonstrate their capabilities and experience. Include lists of completed projects with project names and addresses, names of architects and owners, and other information specified.

E. Contract Closeout Submittals:

1. Operation and Maintenance Data: Submit operation and maintenance data for electric vehicle charging stations.

2. Warranty Data: Submit manufacturer's standard warranty documents.

1.5 QUALITY ASSURANCE

A. Qualifications

1. Manufacturer Qualifications: Manufacturer shall be a firm engaged in the manufacture of electric vehicle charging stations of types and sizes required, and whose products have been in satisfactory use in similar service for a minimum of 10 years.

a. The manufacturer shall be ISO 9001 certified and shall be designed to internationally accepted standards.

b. Factory fax/telephone/email system support shall be available free of charge from the manufacturer during normal business hours.

2. Installer Qualifications: Installer shall be a firm that shall have a minimum of five years of successful installation experience with projects utilizing electric vehicle charging stations similar in type and scope to that required for this Project and shall be approved by the manufacturer.

3. Inspecting and Testing Agency Qualifications: To qualify for acceptance, an independent inspecting and testing agency hired by the Contractor or manufacturer to test products shall demonstrate to the Architect/Engineer’s satisfaction that they are qualified according to ASTM E 329 to conduct testing indicated.

B. Regulatory Requirements: Comply with applicable requirements of the laws, codes, ordinances, and regulations of Federal, State, and local authorities having jurisdiction. Obtain necessary approvals from such authorities.

C. Standards: Comply with applicable requirements of the following standards:

1. NEMA Compliance: Applicable portions of NEMA standards pertaining to types of electrical equipment and enclosures.

2. NEC Compliance: Applicable portions of the NEC.

3. UL Compliance: Applicable UL standards for electric vehicle supply equipment, panelboards, circuit breakers, and energy management equipment.

4. FCC Emissions: Comply with FCC emissions standards.

5. Seismic Compliance: NFPA 5000, ASCE 7, ICC ES AC156, and/or ICC IBC, as applicable to the Project location and as required by authorities having jurisdiction.

D. Electrical Components, Devices, and Accessories: Electrical components, devices, and accessories shall be listed and labeled as defined in NEC, Article 100, by an inspecting and testing agency acceptable to authorities having jurisdiction, and marked for intended use.

E. Pre Installation Conference: Prior to commencing the installation, meet at the Project site to review the material selections, installation procedures, and coordination with other trades. Pre-installation conference shall include, but shall not be limited to, the Contractor, the Installer, and any trade that requires coordination with the work. Date and time of the pre-installation conference shall be acceptable to the Owner and the Architect/Engineer.

F. Coordination: Coordinate the work in this Section with all of the trades covered in other sections of the Specification to provide a complete and operable system. Furnish inserts and anchors that must be built into other work. Work closely with installers of finish materials so that units are properly aligned with adjacent materials.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver materials to the Project site in supplier's or manufacturer's original wrappings and containers, labeled with supplier's or manufacturer's name, material or product brand name, and lot number, if any.

B. Store materials in their original, undamaged packages and containers, inside a well ventilated area protected from weather, moisture, soiling, extreme temperatures, and humidity.

1.7 PROJECT CONDITIONS

A. Environmental Requirements: Do not install electric vehicle charging stations until space is enclosed and weatherproof, wet work in space is completed and nominally dry, work above ceilings is complete, and ambient temperature and humidity conditions are and will be continuously maintained at values near those indicated for final occupancy.

1.8 WARRANTY

A. Comply with Section 260001.

B. The Electrical Trade Contractor shall warranty that all materials furnished shall be free from defects of material for a period of one year from the date of Substantial Completion.

C. Provide a 3-year preventive maintenance plan. The plan shall include one site visit per year after the warranty period to verify that the system is working per the specifications and to proactively perform maintenance, repairs, and replacements to prevent failures before they occur.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers

1. ChargePoint
2. General Electric
3. Schneider

4. Or approved equal

2.2 BASIS OF DESIGN

A. Product specified is “Electric Vehicle (EV) Charging Station” Charge Point CT4000 Family

1. Model CT4021-GW1 Dual Port Bollard USA Gateway Station with Concrete Mounting Kit CY4001-CCM.
2. Connectivity:
   a. Local Area Network: 2.4 GHz Wi-Fi (802.11 b/g/n)
   b. Wide Area Network: 3G GSM, 3G CDMA
3. Power management kit: CT4000-PMGMT
4. ChargePoint Commercial Service Plan, 3 Year Subscription CTSW-SAS-COMM-3.
5. ChargePoint Station Installation and Validation CT4000-INSTALLVALID.
6. ChargePoint Station Activation and Configuration CPSUPPORT-ACTIVE.
7. ChargePoint Assure CT4000-ASSURE3.

2.3 ELECTRIC VEHICLE SUPPLY EQUIPMENT (EVSE)

A. Electrical Input

1. Input Current: 30A x 2.
2. Input Power Connection: Two independent 40A branch circuits.
3. Required Service Panel Breaker: 40A dual pole (non-GFCI type) x 2.
4. Service Panel GFCI: Do not provide external GFCI as it may conflict with internal GFCI (CCID).
5. Wiring – Standard: 5-wire (L1, L1, L2, L2, Earth).
6. Station Power: 8W typical (standby), 15W maximum (operation).

B. Electrical Output

1. Output: 7.2kW (240V AC@30A) x 2.

C. Functional Interfaces

1. Connector(s) Type: SAE J1772™ x 2.
2. Cable Length - 2440 mm (8') Cable Management: 7 m (23').
3. Overhead Cable Management System: Yes.
4. LCD Display: 145 mm (5.7") full color, 640x480, 30fps full motion video, active matrix, UV protected.
5. Card Reader: ISO 15693, ISO 14443, NFC.
6. Locking Holster: Yes x 2.

D. Safety and Connectivity Features

1. Ground Fault Detection: 20mA CCID with auto retry.
2. Open Safety Ground Detection: Continuously monitors presence of safety (green wire) ground connection.

3. Plug-Out Detection: Power terminated per SAE J1772™ specifications.
4. Power Measurement Accuracy: +/- 2% from 2% to full scale (30A).
5. Power Report/Store Interval: 15 minute, aligned to hour.
6. Local Area Network: 2.4 GHz Wi-Fi (802.11 b/g/n).
7. Wide Area Network: 3G GSM, 3G CDMA.

E. Safety and Operational Ratings

1. Enclosure Rating: Type 3R per UL 50E.
2. Safety Compliance: UL listed for USA and cUL certified for Canada; complies with UL 2594, UL 2231-1, UL 2231-2, and NEC Article 625.
3. Surge Protection: 6kV @ 3000A. In geographic areas subject to frequent thunder storms, supplemental surge protection at the service panel is recommended.
4. EMC Compliance: FCC Part 15 Class A.
5. Operating Temperature: -30°C to +50°C (-22°F to 122°F).
6. Storage Temperature: -30°C to +60°C (-22°F to 140°F).
7. Non-Operating Temperature: -40°C to +60°C (-40°F to 140°F).
8. Operating Humidity: Up to 85% @ +50°C (122°F) non-condensing.
9. Non-Operating Humidity: Up to 95% @ +50°C (122°F) non-condensing.
10. Terminal Block Temperature Rating: 105°C (221°F).
11. Charging Stations per 802.11 Radio Group: Maximum of 10. Each station must be located within 45m (150') “line of sight” of a gateway station.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verification of Conditions: Examine areas and conditions under which the work is to be installed, and notify the Contractor in writing, with a copy to the Owner and the Architect/Engineer, of any conditions detrimental to the proper and timely completion of the work. Do not proceed with the work until unsatisfactory conditions have been corrected.

1. Beginning of the work shall indicate acceptance of the areas and conditions as satisfactory by the Installer.

3.2 INSTALLATION

A. Preparation and installation shall be in accordance with reviewed product data, final shop drawings, manufacturer’s written instructions and recommendations, and as indicated on the Drawings. System installation shall be coordinated with related and adjacent work.

3.3 PROTECTION

A. Provide final protection and maintain conditions in a manner acceptable to the Installer, that shall ensure that the electric vehicle charging stations shall be without damage at time of Substantial Completion.

3.4 COMMISSIONING

A. Comply with requirements specified in Division 1.

B. Engage a factory-authorized service representative to supervise and assist with startup service. Complete installation and startup checks according to the approved manufacturer's written instructions.

3.5 TRAINING AND SERVICE

A. Comply with Section 26 00 01.

B. Conduct two 4-hour training sessions. Train the Owner’s maintenance personnel on procedures and schedules related to start up and shutdown, troubleshooting, servicing, and preventive maintenance.

End of Section

DO NOT REMOVE
THIS PAGE INTENTIONALLY LEFT BLANK

Section 26 28 13

FUSES

(TRADE CONTRACT REQUIRED AS PART OF SECTION 26 00 01)

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. PUBLICLY BID TRADE CONTRACT REQUIREMENTS: As provided under Section 26 00 01 - ELECTRICAL and supplemented under the Bidding Requirements, Contract Forms, and Conditions of the Contract, and applicable parts of Division 1 - GENERAL REQUIREMENTS.

1. Work of this Trade Contract includes all individual specification sections listed in Section 26 00 01.

1.2 RELATED DOCUMENTS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications

1.3 SUMMARY

A. This Section includes the following:

1. Cartridge fuses rated 600 V and less for use in controllers and motor-control centers.

1.4 SUBMITTALS

A. Product Data: For each fuse type indicated.

B. Operation and maintenance data.

1.5 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. Comply with NEMA FU 1.

C. Comply with NFPA 70.

1.6 WARRANTY

A. Comply with Section 260001.

B. The Electrical Trade Contractor shall warranty that all materials furnished shall be free from defects of material for a period of one year from the date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Bussman, Inc.

B. Eagle Electric Mfg. Co., Inc.; Cooper Industries, Inc.

C. Ferraz Shawmut, Inc.

D. Or approved equal.

2.2 CARTRIDGE FUSES

A. Characteristics: NEMA FU 1, nonrenewable cartridge fuse; class and current rating indicated; voltage rating consistent with circuit voltage.

PART 3 - EXECUTION

3.1 FUSE APPLICATIONS

A. Motor Branch Circuits: Class RK1/RK5, time delay.

3.2 INSTALLATION

A. Install fuses in fusible devices. Arrange fuses so rating information is readable without removing fuse.

3.3 IDENTIFICATION

A. Install labels indicating fuse replacement information on inside door of each fused switch.

3.4 EXTRA MATERIALS

A. Ten percent spare fuses. Provide a minimum of three of each type.

End of Section

Section 26 28 16

(TRADE CONTRACT REQUIRED AS PART OF SECTION 26 00 01)

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. PUBLICLY BID TRADE CONTRACT REQUIREMENTS: As provided under Section 26 00 01 - ELECTRICAL and supplemented under the Bidding Requirements, Contract Forms, and Conditions of the Contract, and applicable parts of Division 1 - GENERAL REQUIREMENTS.

1. Work of this Trade Contract includes all individual specification sections listed in Section 26 00 01.

1.2 RELATED DOCUMENTS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications

1.3 SUMMARY

A. This Section includes the following individually mounted, enclosed switches and circuit breakers:

1. Fusible switches.
2. Non-fusible switches.
3. Molded-case circuit breakers.
4. Enclosures.

1.4 SUBMITTALS

A. Product Data: For each type of enclosed switch, circuit breaker, accessory, and component indicated.

B. Shop Drawings: Diagram power, signal, and control wiring.

C. Field quality-control test reports.

D. Operation and maintenance data.

1.5 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. Comply with NFPA 70.

1.6 WARRANTY

A. Comply with Section 260001.

B. The Electrical Trade Contractor shall warranty that all materials furnished shall be free from defects of material for a period of one year from the date of Substantial Completion.

PART 2 - PRODUCTS

2.1 FUSIBLE AND NONFUSIBLE SWITCHES

A. Available Manufacturers

1. Eaton Corporation; Cutler-Hammer Products.
2. General Electric Co.; Electrical Distribution & Control Division.
3. Square D/Group Schneider.
4. Or approved equal.

B. Fusible Switch, 1200A and Smaller: NEMA KS 1, Type HD, with clips or bolt pads to accommodate specified fuses, lockable handle with capability to accept two padlocks, and interlocked with cover in closed position.

C. Non-fusible Switch1200 A and Smaller: NEMA KS 1, Type HD, lockable handle with capability to accept two padlocks, and interlocked with cover in closed position.

D. Accessories:

1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
2. Neutral Kit: Internally mounted; insulated, capable of being grounded, and bonded; and labeled for copper and aluminum neutral conductors.
3. Auxiliary Contact Kit: Auxiliary set of contacts arranged to open before switch blades open.

2.2 MOLDED-CASE CIRCUIT BREAKERS AND SWITCHES

A. Manufacturers:

1. Eaton Corporation; Cutler-Hammer Products.
2. General Electric Co.; Electrical Distribution & Control Division.
3. Square D/Group Schneider.
4. Or approved equal.

B. Molded-Case Circuit Breaker: NEMA AB 1, with interrupting capacity to meet available fault currents.

1. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
2. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
3. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller and let-through ratings less than NEMA FU 1, RK-5.
4. GFCI Circuit Breakers: Single- and two-pole configurations with [5] [30]-mA trip sensitivity.

C. Molded-Case Circuit-Breaker Features and Accessories:

1. Standard frame sizes, trip ratings, and number of poles.

2. Lugs: Mechanical style suitable for number, size, trip ratings, and conductor material.

3. Application Listing: Type SWD for switching fluorescent lighting loads; Type HACR for heating, air-conditioning, and refrigerating equipment.

4. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.

2.3 ENCLOSURES

A. NEMA AB 1 and NEMA KS 1 to meet environmental conditions of installed location.

1. Outdoor Locations: NEMA 250, Type 3R; Type 4X where noted.

2. Kitchen Areas: NEMA 250, Type 4X, stainless steel.

3. Other Wet or Damp Indoor Locations: NEMA 250, Type 4.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Coordinate size and location of concrete bases. Verify structural requirements with structural engineer.

B. Concrete base is specified in Division 26 and concrete materials are specified in Division 03.

C. Comply with applicable portions of NECA 1, NEMA PB 1.1, and NEMA PB 2.1 for installation of enclosed switches and circuit breakers.

D. Mount individual wall-mounting switches and circuit breakers with tops at uniform height, unless otherwise indicated. Anchor floor-mounting switches to concrete base.

E. Comply with mounting and anchoring requirements specified in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."

F. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

G. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs as specified in Division 26.

3.2 FIELD QUALITY CONTROL

A. Prepare for acceptance testing as follows:

1. Inspect mechanical and electrical connections.

2. Verify switch and relay type and labeling verification.

3. Verify rating of installed fuses.

B. Perform the following field tests and inspections and prepare test reports:

1. Perform each electrical test and visual and mechanical inspection stated in NETA ATS, Section 7.5 for switches and Section 7.6 for molded-case circuit breakers. Certify compliance with test parameters.
2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

End of Section

Section 26 31 00

PHOTOVOLTAIC SYSTEM

(TRADE CONTRACT REQUIRED AS PART OF SECTION 26 00 01)

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. PUBLICLY BID TRADE CONTRACT REQUIREMENTS: As provided under Section 26 00 01 - ELECTRICAL and supplemented under the Bidding Requirements, Contract Forms, and Conditions of the Contract, and applicable parts of Division 1 - GENERAL REQUIREMENTS.

1. Work of this Trade Contract includes all individual specification sections listed in Section 26 00 01.

1.2 RELATED DOCUMENTS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications

1.3 SCOPE OF WORK

A. It is the intent of these specifications that the Contractor, Manufacturer and/or its Authorized System Integrator expeditiously furnishes and installs a system complete in every respect and ready to operate. All miscellaneous items and accessories required for such installation, whether or not each such item or accessory as shown on the plans or mentioned in these specifications, shall be furnished and installed.

B. The Photovoltaic (PV) Trade Contractor is responsible for furnishing and installing the cabling and conduit from the main electrical distribution to the exterior building mounted AC disconnects, as well as the conduit, with pull strings, from the exterior building mounted AC disconnects to the inverters. The PV Trade Contractor is responsible for furnishing and installing the cabling from the exterior building mounted AC disconnects to the inverters, as well as the remaining portion of the complete photovoltaic system. The complete photovoltaic system also includes DC disconnect switches, inverters, PV sub-combiners, roof-mounted racking structure, photovoltaic panels, power optimizers and sting combiners.

C. The PV Trade Contractor shall provide complete installation, commissioning, and testing for a grid-tied roof-mounted system and a grid-tied parking canopy-mounted system, as described herein. It is the intent of the design to provide module level monitoring and rapid shutdown by utilizing power optimizers.

1. The roof-mounted system shall comprise 1,570 405W PV modules (635.85kW DC STC/606.1kW AC STC).

2. The parking canopy-mounted system shall comprise 408 405WPV modules (165.24kW DC STC/166.5kW AC STC).

D. The system shall comply with these specifications, all codes, and local authorities. The design shall include, but not be limited to, design drawings showing all AC and DC wiring associated with the system, conduit layout, details of equipment location, equipment selection, and specifications. The equipment includes, but is not limited to, PV modules, inverters, disconnects, wire, conduit, junction boxes, mounting structure and hardware, monitoring equipment, and any other needed equipment.

E. All DC conductors shall be sized such that there is a maximum of 1% voltage drop measured at the short circuit current rating of that circuit over the entire length of each circuit from PV module to inverter and back to PV module. All AC conductors shall be sized for a maximum of 1% voltage drop measured at the continuous AC current rating of the inverter between the inverter and the point of interconnection with the grid.

F. Each series string of PV modules shall be independently protected by an isolation fuse or breaker before it is connected in parallel with the other string on that PV output circuit. The current rating of this isolation fuse or breaker shall be less than the de-rated ampacity of the wiring that it is protecting and greater than 1.56 times the short circuit current rating of the PV modules in that PV source circuit. All other conductors and overcurrent devices shall be sized per the requirements of National Electric Code (NEC).

G. An isolation transformer shall be part of the offered system for interfacing to the building's electrical system.

H. Photovoltaic modules shall be tested in the factory for design performance and results shall be included in the Operation and Maintenance manuals.

I. Inverters shall be factory tested for performance and results shall be included in the 0 & M manuals. The work includes furnishing and/or paying for all materials, fees, permits not covered in the general building permit, labor, tools, equipment, transportation and services required for a complete installation.

J. The PV Trade Contractor shall provide access to equipment for maintenance and service as required by the manufacturer’s instructions and/or applicable codes.

K. The contract drawings show general equipment locations and sizes for some of the major PV system equipment. The PV Trade Contractor shall comply with these criteria and include them in the PV Trade Contractor design. The PV Trade Contractor must obtain approval before altering any of the criteria set forth in these performance specifications or the architectural drawings.

L. The PV Trade Contractor shall coordinate with the Architect on the locations and appearance of all exposed equipment, including but not limited to, PV modules, mounting structure, conduit, inverters, wireways, and control and monitoring equipment. All locations must be approved by the Architect before the PV Trade Contractor’s design drawings are completed and installation begins.

M. The PV Trade Contractor shall visit the site to ascertain the nature and location of the work and the general and local conditions that could affect the work or the cost thereof.

N. The PV Trade Contractor shall provide coordination with all trades needed for a complete installation including all required controls, electrical services, and clearances.

1.4 SYSTEM OPERATION

A. During the day the PV modules convert sunlight into electricity. When the grid is present, solar power output is used run AC loads on site, and sell excess power to the grid (in this order of priority).

B. Any electrical loads on during the day will be powered directly by the solar with any excess spinning the meter backwards and crediting the account (per the requirements of the Net Metering Law).

C. If the electrical load on site exceeds the solar output (as it will every night and during periods of rainy weather), then the utility company supplies the balance seamlessly. (It works this way because the PV output is in parallel with the grid and operating at a slightly higher voltage).

D. If the utility grid fails, the solar output also ceases. No power is available until grid power returns.

E. When utility power returns, the system automatically switches back to normal grid-intertie mode, and solar power resumes.

1.5 REFERENCES

A. Definitions:

1. CEC: California Energy Commission.
2. ETFE: Ethylene tetrafluoroethylene.
3. FEP: Fluorinated ethylene propylene.
4. IP Code: Required ingress protection to comply with IEC 60529.
5. Imp: Optimum Operating Current
6. Isc: Short Circuit Current
7. MPPT: Maximum power point tracking.
8. Pmax: Maximum Power Output
9. PTC: USA standard conditions for PV.
10. PV: Photovoltaic.
11. STC: Standard Test Conditions defined in IEC 61215.
12. NOCT: Normal operation cell temperature.
13. Vmp: Optimum Operating Voltage
14. Voc: Open Circuit Voltage

B. Reference Standards:

1. American National Standards Institute (ANSI):
   a. ANSI/UL 1703 Standard for Flat-Plate Photovoltaic Modules and Panels.
2. International Electrical Commission (IEC):
   a. IEC 61215 International Standard (Extended Version) - Crystalline silicon terrestrial photovoltaic (PV) modules - Design qualification and type approval.
   b. IEC 61730-1 International Standard - Photovoltaic (PV) module safety qualification - Part 1 - Requirements for construction
   c. IEC 61730-2 International Standard - Photovoltaic (PV) module safety qualification - Part 2 - Requirements for testing.
3. International Organization for Standardization (ISO):
   a. ISO 9001 Quality Management Systems.
   b. ISO 14001 Environmental Management Systems.
4. Underwriters Laboratories, Inc. (UL):
   a. UL 790 Standard Test Methods for Fire Tests of Roof Coverings.
   b. UL 1703 Standard for Flat-Plate Photovoltaic Modules and Panels.
5. Underwriters Laboratories of Canada (ULC):
   a. ULD/ORD-C1703 Requirements for Flat-Plate Photovoltaic Modules and Panels.

1.6 QUALITY ASSURANCE:

A. Manufacturer:

1. Having 10 years' experience manufacturing components similar to or exceeding requirements of project.

2. Having sufficient capacity to produce and deliver required materials without causing delay in work.

3. Capable of providing field service representation during construction.

4. Manufacturing facility certified to ISO 9001 and to ISO 14001.

B. PV Trade Contractor

1. The PV system described herein shall be installed by a PV Trade Contractor / Installer certified by NABCEP (North American Board of Certified Energy Practitioners).

2. Acceptable to the manufacturer, experienced in performing work of this section and has specialized in installation of work similar to that required for this project.

1.7 PERMITS, FEES, TRANSPORTATION, AND INSPECTIONS

A. The PV Trade Contractor shall give all necessary notices, obtain all permits and pay all government sales taxes, fees and other costs, including utility connections or extensions, in connection with his work; file all necessary plans, prepare all documents and obtain all necessary approvals of all governmental departments having jurisdiction; obtain all required certificates of inspection for his work and deliver same to the Owner before request for acceptance and final payment for the work. Construction cannot begin until the proper permits have been obtained and are posted.

B. The PV Trade Contractor shall include in the work, without extra cost to the Owner, any labor, materials, services, transportation, disposal, apparatus, and drawings needed, and in order to comply with all applicable laws, ordinances, rules and regulations, whether or not shown on drawings or specified.

1.8 UTILITY APPROVAL

A. Once the PV system design and drawings are completed and approved by the Architect and the PV Trade Contractor has all required building and electrical permits, PV Trade Contractor shall file all required paperwork and forms with utility company to apply for interconnection with the utility grid.

B. Upon receipt of final building inspection approval, PV Trade Contractor shall immediately send a copy of the signed-off building permit to utility company and schedule the final utility company inspection for the system. This inspection shall be scheduled for a date no later than two weeks after the date of final building inspection.

C. The PV Trade Contractor shall coordinate and carry the cost of the installation of a cellular bi-directional meter at the padmount transformer with the utility company in his bid.

1.9 PV SYSTEM REGISTRATION

A. The PV Trade Contractor shall coordinate the registration of the PV system to receive net-metering and renewable energy credits.

B. The PV Trade Contractor shall facilitate the PV system registration with:

1. MassACA – Massachusetts System of Assurance of Net Metering Eligibility (for issuance of net metering credits).

2. MassCEC-PTS (the DAS system will automatically feed production information there on a monthly basis)

3. NEPOOL-GIS (which verifies production received from MassCEC-PTS and then issues and allows for trading of Solar Renewable Energy Credits)

1.10 SUBMITTALS

A. Refer to Division 01 for general requirements.

B. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for PV panels.

2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

C. Shop Drawings:

1. Electrical Calculations: Include plans, elevations, sections, mounting details and design calculations to comply with performance requirements and design criteria signed and sealed by the qualified professional engineer responsible for their preparation.

2. Wind-load and Ballast Calculations: Include plans, elevations, sections, and mounting details to comply with wind-load calculations signed and sealed by the qualified professional engineer responsible for their preparation. Refer to Structural Drawings for information on the building roof.

3. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

4. Detail fabrication and assembly.

5. Include diagrams for power, signal, and control wiring.

1.11 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For PV modules to include in operation and maintenance manuals.

1.12 DELIVERY, STORAGE & HANDLING

A. Delivery and Acceptance Requirements:

1. Deliver material in accordance with manufacturer's written instructions.

2. Deliver materials in manufacturer's original packaging with identification labels intact and in sizes to suit project.

B. Storage and Handling Requirements:

1. Store materials protected from exposure to harmful weather conditions and at temperature conditions recommended by manufacturer.

C. Packaging Waste Management:

1. Separate waste materials for recycling.

2. Remove packaging materials from site and dispose of at appropriate recycling facilities.

3. Collect and separate for disposal packaging material in appropriate onsite bins for recycling.

4. Fold metal and plastic banding. Flatten and place in designated area for recycling.

1.13 WARRANTY

A. Comply with Section 260001.

B. The Electrical Trade Contractor shall warranty that all materials furnished shall be free from defects of material for a period of one year from the date of Substantial Completion.

C. Provide a 3-year preventive maintenance plan. The plan shall include one site visit per year after the warranty period to verify that the system is working per the specifications and to proactively perform maintenance, repairs, and replacements to prevent failures before they occur.

D. Manufacturer's Warranty

1. PV Modules: 15 Years. Limited PV Module Warranty of Materials and Workmanship

2. Limited Power Output Warranty of 25 years (90% / 80%)

a. The manufacturer shall warranty that they will deliver additional PV Module(s) to replace the missing power output, or repair the PV Module(s), or replace the PV Module(s) with equivalent PV Module(s), at the manufacturer's sole option if:

b. Within the first ten (10) years from the date of sale to the Customer, the PV Module(s) exhibits a power output of less than ninety percent (90%) of the original minimum rated power specified at the time of sale, or

c. Within twenty-five (25) years from the date of sale to the Customer, the PV Module(s) exhibits a power output of less than eighty percent (80%) of the original minimum rated power specified at the time of sale,

d. The period of the output warranty for these additional or replacement module(s) will be equal to the remainder of the warranty period of the originally supplied modules(s).

3. Inverter: 25 years.

4. Power Optimizers: 25 years.

PART 2 - PRODUCTS

2.1 PHOTOVOLTAIC PANELS

A. Available Manufacturers

1. LG

2. Hanwha

3. Sunpreme

4. Or approved equal

B. Basis of Design product shall be 405W LG NEON 2-72 cell.

1. Mechanical Properties

a. Cells: 6x12

b. Cell Vendor: LG

c. Cell Type: Monocrystalline /N-type
d. Cell Dimensions: 1617x1617mm
e. # of Busbar: 12 (Multi Wire Busbar)
f. Dimensions (LxWkH): 2024 x1024 x40 mm
g. Front Load: 5400 Pa
h. Rear Load: 4300 Pa
i. Weight: 21.7 kg
j. Connector Type: Genuine MC4.IP68 (Male: PV-KST4) (Female: PV-KBT4)
k. Junction Box: IP68 with 3 bypass diodes
l. Length of Cables: 2 x 1200 mm
m. Front cover: High transmission tempered glass
n. Frame: Anodised aluminum

2. Electrical Properties (STC)
   a. Module Type: 405 W
   b. Maximum Power Pmax (W): 405
   c. MPP Voltage Vmpp(V): 41.0
   d. MPP Current Impp (A): 9.89
   e. Open Circuit Voltage Voc (V): 49.4
   f. Short Circuit Current Isc (A): 10.51
   g. Module Efficiency (%): 19.4
   h. Operating Temperature (°C): -40 ~ +90
   i. Maximum System Voltage (V): 1000(IEC) / 1500 (UL)
   j. Maximum Series Fuse Rating (A): 20
   k. Power Tolerance (%): 0 ~ +3
3. Electrical Properties (NOCT)
   a. Module Type: 405 W
   b. Maximum Power Pmax (W): 300
   c. MPP Voltage Vmpp(V): 38.0
   d. MPP Current Impp (A): 7.91
   e. Open Circuit Voltage Voc (V): 46.2
   f. Short Circuit Current Isc (A): 8.44
4. Temperature Characteristics
   a. NOCT: 45 ± 3*0
   b. Pmax: -0.36 %/°C
   c. Voc: -0.26 %/°C
   d. Isc: 0.02 %/°C
5. Certifications and Warranty
   a. Certifications

1) ISO 9001
2) IEC61215, IEC 61730-1/-2
3) IEC62716 (Ammonia Test)
4) IEC 61701 (Salt Mist Corrosion Test)

b. Module Fire Rating: Class C
c. Product Warranty: 15-Years
d. Output Warranty of Pmax (Measurement Tolerance - 3%): Linear Warranty.

2.2 DC/AC INVERTER

A. Available Manufacturers
1. Solar Edge
2. SMA
3. Solectria Renewables
4. Or approved equal.

B. Basis of design product shall be by Solar Edge.

C. 10kW Inverter
1. Output
a. Rated AC Power Output: 10000 VA
b. Maximum AC Power Output: 10000VA
c. AC Output Line Connections: 4-wire WYE (L1-L2-L3-N) plus PE
d. AC Output Voltage Minimum-Nominal-Maximum (L-N): 244 - 277 – 305 Vac
e. AC Output Voltage Minimum-Nominal-Maximum (L-L): 422.5 - 480 – 529 Vac
f. AC Frequency Min-Nom-Max: 59.3 - 60 - 60.5 Hz
g. Maximum Continuous Output Current (per Phase) @277V: 12 A
h. GFDI Threshold: 1 A
i. Utility Monitoring, Islanding Protection, Configurable Power Factor, Country Configurable Thresholds: Yes
2. Input
a. Maximum DC Power (Module STC) / Unit: 13500 W
b. Transformer-less, Ungrounded: Yes
c. Maximum Input Voltage DC to Gnd: 490 Vdc
d. Maximum Input Voltage DC+ to DC-: 980 Vdc
e. Nominal Input Voltage DC to Gnd: 420 Vdc
f. Nominal Input Voltage DC+ to DC-: 840 Vdc
g. Maximum Input Current: 13.5 Adc
h. Maximum Input Short Circuit Current: 45 Adc
i. Reverse-Polarity Protection: Yes
j. Ground-Fault Isolation Detection: 1MΩ Sensitivity per Unit

k. CEC Weighted Efficiency: 98%

l. Nighttime Power Consumption: <3 W

3. Additional Features

a. Supported Communication Interfaces: RS485, Ethernet, Cellular GSM (optional)

b. Rapid Shutdown: NEC2014 and NEC2017 compliant/certified, upon AC Grid Disconnect

c. RS48S Surge Protection: Built-in

4. Standard Compliance

a. Safety: UL1741, UL1741 SA, UL1699B, UL1998, CSA 2.22

b. Grid Connection Standards: IEEE 1547, Rule 21, Rule 14 (HI)

c. Emissions: FCC part15 class B

5. Installation Specifications

a. AC Output Conduit Size / Max AWG / Max PE AWG: (3/4")(12-6AWG)

b. DC Output Conduit Size/ Terminal Block AWG Range / Number of Strings: (3/4")(12-6AWG)

c. Number of DC Inputs: 2 pairs

d. Dimensions (H x W x D): 21" x 12.5" x 10.5"

e. Dimension with Safety Switch (H x W x D): 30.5" x 12.5" x 10.5"

f. Weight: 73.2 lb.

g. Weight with Safety Switch: 79.7 lb.

h. Cooling: Fan

i. Noise: <50 dBA

j. Operating Temperature Range: -40 to +140 F

k. Protection Rating: NEMA 3R

D. 20kW Inverter

1. Output

a. Rated AC Power Output: 20000 VA

b. Maximum AC Power Output: 20000VA

c. AC Output Line Connections: 4-wire WYE (L1-L2-L3-N) plus PE

d. AC Output Voltage Minimum-Nominal-Maximum (L-N): 244 - 277 – 305 Vac

e. AC Output Voltage Minimum-Nominal-Maximum (L-L): 422.5 - 480 – 529 Vac

f. AC Frequency Min-Nom-Max: 59.3 - 60 - 60.5 Hz

g. Maximum Continuous Output Current (per Phase) @277V: 24 A

h. GFDI Threshold: 1 A

i. Utility Monitoring, Islanding Protection, Configurable Power Factor, Country Configurable Thresholds: Yes

2. Input

a. Maximum DC Power (Module STC) / Unit: 27000 W

b. Transformer-less, Ungrounded: Yes

c. Maximum Input Voltage DC to Gnd: 490 Vdc

d. Maximum Input Voltage DC+ to DC-: 980 Vdc

e. Nominal Input Voltage DC to Gnd: 420 Vdc

f. Nominal Input Voltage DC+ to DC-: 840 Vdc

g. Maximum Input Current: 26.5 Adc

h. Maximum Input Short Circuit Current: 45 Adc

i. Reverse-Polarity Protection: Yes

j. Ground-Fault Isolation Detection: 1MΩ Sensitivity per Unit

k. CEC Weighted Efficiency: 98%

l. Nighttime Power Consumption: <3 W

3. Additional Features

a. Supported Communication Interfaces: RS485, Ethernet, Cellular GSM (optional)

b. Rapid Shutdown: NEC2014 and NEC2017 compliant/certified, upon AC Grid Disconnect

c. RS48S Surge Protection: Built-in

4. Standard Compliance

a. Safety: UL1741, UL1741 SA, UL1699B, UL1998, CSA 2.22

b. Grid Connection Standards: IEEE 1547, Rule 21, Rule 14 (HI)

c. Emissions: FCC part15 class B

5. Installation Specifications

a. AC Output Conduit Size / Max AWG / Max PE AWG: (3/4”)(12-6AWG)

b. DC Output Conduit Size/ Terminal Block AWG Range / Number of Strings: (3/4”)(12-6AWG)

c. Number of DC Inputs: 2 pairs

d. Dimensions (H x W x D): 21” x 12.5” x 10.5”

e. Dimension with Safety Switch (H x W x D): 30.5” x 12.5” x 10.5”

f. Weight: 73.2 lb.

g. Weight with Safety Switch: 79.7 lb.

h. Cooling: Fan

i. Noise: <50 dBA

j. Operating Temperature Range: -40 to +140 F

k. Protection Rating: NEMA 3R

E. 33.3kW Inverter

1. Output

a. Rated AC Power Output: 33300 VA

b. Maximum AC Power Output: 33300VA

c. AC Output Line Connections: 4-wire WYE (L1-L2-L3-N) plus PE

d. AC Output Voltage Minimum-Nominal-Maximum (L-N): 244 - 277 – 305 Vac

e. AC Output Voltage Minimum-Nominal-Maximum (L-L): 422.5 - 480 – 529 Vac

f. AC Frequency Min-Nom-Max: 59.3 - 60 - 60.5 Hz

g. Maximum Continuous Output Current (per Phase) @277V: 40 A

h. GFDI Threshold: 1 A

i. Utility Monitoring, Islanding Protection, Configurable Power Factor, Country Configurable Thresholds: Yes

2. Input

a. Maximum DC Power (Module STC) / Unit: 45000 W

b. Transformer-less, Ungrounded: Yes

c. Maximum Input Voltage DC to Gnd: 490 Vdc

d. Maximum Input Voltage DC+ to DC-: 980 Vdc

e. Nominal Input Voltage DC to Gnd: 420 Vdc

f. Nominal Input Voltage DC+ to DC-: 840 Vdc

g. Maximum Input Current: 40 Adc

h. Maximum Input Short Circuit Current: 45 Adc

i. Reverse-Polarity Protection: Yes

j. Ground-Fault Isolation Detection: 350kΩ Sensitivity per Unit

k. CEC Weighted Efficiency: 98.5%

l. Nighttime Power Consumption: <4 W

3. Additional Features

a. Supported Communication Interfaces: RS485, Ethernet, Cellular GSM (optional)

b. Rapid Shutdown: NEC2014 and NEC2017 compliant/certified, upon AC Grid Disconnect

c. RS48S Surge Protection: Built-in

4. Standard Compliance

a. Safety: UL1741, UL1741 SA, UL1699B, UL1998, CSA 2.22

b. Grid Connection Standards: IEEE 1547, Rule 21, Rule 14 (HI)

c. Emissions: FCC part15 class B

5. Installation Specifications

a. AC Output Conduit Size / Max AWG / Max PE AWG: (3/4”)(8-4AWG)

b. DC Output Conduit Size/ Terminal Block AWG Range / Number of Strings: (3/4”)(12-6AWG)

c. Number of DC Inputs: 3 pairs

d. Dimensions (H x W x D): 21” x 12.5” x 10.5”

e. Dimension with Safety Switch (H x W x D): 30.5” x 12.5” x 10.5”

f. Weight: 99.5 lb.

g. Weight with Safety Switch: 106 lb.

h. Cooling: Fan

i. Noise: <55 dBA

j. Operating Temperature Range: -40 to +140 F

k. Protection Rating: NEMA 3R

F. 66.6kW Inverter

1. Output

a. Rated AC Power Output: 66600 VA

b. Maximum AC Power Output: 66600 VA

c. AC Output Line Connections: 4-wire WYE (L1-L2-L3-N) plus PE

d. AC Output Voltage Minimum-Nominal-Maximum (L-N): 244 - 277 – 305 Vac

e. AC Output Voltage Minimum-Nominal-Maximum (L-L): 422.5 - 480 – 529 Vac

f. AC Frequency Min-Nom-Max: 59.3 - 60 - 60.5 Hz

g. Maximum Continuous Output Current (per Phase) @277V: 80 A

h. GFDI Threshold: 1 A

i. Utility Monitoring, Islanding Protection, Configurable Power Factor, Country Configurable Thresholds: Yes

2. Input

a. Maximum DC Power (Module STC) / Unit: 90000 / 45000 W

b. Transformer-less, Ungrounded: Yes

c. Maximum Input Voltage DC to Gnd: 500 Vdc

d. Maximum Input Voltage DC+ to DC-: 1000 Vdc

e. Nominal Input Voltage DC to Gnd: 425 Vdc

f. Nominal Input Voltage DC+ to DC-: 850 Vdc

g. Maximum Input Current: 80 Adc

h. Maximum Input Short Circuit Current: 120 Adc

i. Reverse-Polarity Protection: Yes

j. Ground-Fault Isolation Detection: 350kΩ Sensitivity per Unit

k. CEC Weighted Efficiency: 98.5%

l. Nighttime Power Consumption: <12 W

3. Additional Features

a. Supported Communication Interfaces: RS485, Ethernet, Cellular GSM (optional)

b. Rapid Shutdown: NEC2014 and NEC2017 compliant/certified, upon AC Grid Disconnect

c. RS48S Surge Protection: Built-in

4. DC Safety Switch

a. DC Disconnect: 1000V/ 2 x 40A

b. DC Surge Protection: Type II, field replaceable

5. Standard Compliance

a. Safety: UL1741, UL1741 SA, UL1699B, UL1998, CSA 2.22

b. Grid Connection Standards: IEEE 1547, Rule 21, Rule 14 (HI)

c. Emissions: FCC part15 class A

6. Installation Specifications

a. Number of units: 2

b. AC Output Conduit Size / Max AWG / Max PE AWG: (1.5”)(2/0)(6)

c. DC Output Conduit Size/ Terminal Block AWG Range / Number of Strings: (2x1.25")(6-14)(6 strings)

d. Dimensions (H x W x D): Primary Unit: 37” x 12.5” x 10.5”; Secondary Unit: 21” x 12.5” x 10.5”

e. Weight: Primary Unit: 105.8 lb.; Secondary Unit 99.2 lb.

f. Operating Temperature Range: -40 to +140 F

g. Cooling: Fan

h. Noise: <60 dBA

i. Protection Rating: NEMA 3R

j. Bracket Mounted (Brackets Provided)

G. 100kW Inverter

1. Output

a. Rated AC Power Output: 100000 VA

b. Maximum AC Power Output: 100000 VA

c. AC Output Line Connections: 4-wire WYE (L1-L2-L3-N) plus PE

d. AC Output Voltage Minimum-Nominal-Maximum (L-N): 244 - 277 – 305 Vac

e. AC Output Voltage Minimum-Nominal-Maximum (L-L): 422.5 - 480 – 529 Vac

f. AC Frequency Min-Nom-Max: 59.3 - 60 - 60.5 Hz

g. Maximum Continuous Output Current (per Phase) @277V: 120 A

h. GFDI Threshold: 1 A

i. Utility Monitoring, Islanding Protection, Configurable Power Factor, Country Configurable Thresholds: Yes

2. Input

a. Maximum DC Power (Module STC) / Unit: 135000 / 45000 W

b. Transformer-less, Ungrounded: Yes

c. Maximum Input Voltage DC to Gnd: 500 Vdc

d. Maximum Input Voltage DC+ to DC-: 1000 Vdc

e. Nominal Input Voltage DC to Gnd: 425 Vdc

f. Nominal Input Voltage DC+ to DC-: 850 Vdc

g. Maximum Input Current: 120 Adc

h. Maximum Input Short Circuit Current: 120 Adc

i. Reverse-Polarity Protection: Yes

j. Ground-Fault Isolation Detection: 350kΩ Sensitivity per Unit

k. CEC Weighted Efficiency: 98.5%

l. Nighttime Power Consumption: <12 W

3. Additional Features

a. Supported Communication Interfaces: RS485, Ethernet, Cellular GSM (optional)

b. Rapid Shutdown: NEC2014 and NEC2017 compliant/certified, upon AC Grid Disconnect

c. RS48S Surge Protection: Built-in

4. DC Safety Switch

a. DC Disconnect: 1000V/ 3 x 40A

b. DC Surge Protection: Type II, field replaceable

5. Standard Compliance

a. Safety: UL1741, UL1741 SA, UL1699B, UL1998, CSA 2.22

b. Grid Connection Standards: IEEE 1547, Rule 21, Rule 14 (HI)

c. Emissions: FCC part15 class A

6. Installation Specifications

a. Number of units: 3

b. AC Output Conduit Size / Max AWG / Max PE AWG: (2”)(4/0)(4)

c. DC Output Conduit Size/ Terminal Block AWG Range / Number of Strings: (2x1.25")(6-14)(9 strings)

d. Dimensions (H x W x D): Primary Unit: 37” x 12.5” x 10.5”; Secondary Unit: 21” x 12.5” x 10.5”

e. Weight: Primary Unit: 105.8 lb.; Secondary Unit 99.2 lb.

f. Operating Temperature Range: -40 to +140 F

g. Cooling: Fan

h. Noise: <60 dBA

i. Protection Rating: NEMA 3R

j. Bracket Mounted (Brackets Provided)

2.3 POWER OPTIMIZERS

A. 850W Power Optimizer: Provide one for every two PV modules.

1. Input

a. Rated Input DC Power: 850 W

b. Absolute Maximum Input Voltage (Voc at lowest temperature): 120 Vdc

c. MPPT Operating Range: 12.5-105 Vdc

d. Maximum Short Circuit Current (Isc): 12.5 Adc

e. Maximum DC Input Current: 15.63 Adc

f. Maximum Efficiency: 99.5%

g. Weighted Efficiency: 98.6%

h. Overvoltage Category: II

2. Output During Operation
    a. Maximum Output Current: 18 Adc
    b. Maximum Output Voltage: 85 Vdc
3. Output During Standby
    a. Safety Output Voltage per Power Optimizer: 1 +/- 0.1 Vdc
4. Standard Compliance
    a. EMC: FCC Partl5 Class B, IEC61000-6-2, IEC61000-6-3
    b. Safety: IEC62109-1 (class II safety), UL1741
    c. Material: UL-94(5-VA),UV Resistant
    d. RoHS: Yes
5. Installation Specifications
    a. Compatible SolarEdge Inverters: Three Phase Inverters
    b. Maximum Allowed System Voltage: 1000 Vdc
    c. Dimensions (WxLxH): 5” x 5.97” x 2.32”
    d. Weight (including cables): 2.34 lb.
    e. Input Connector: MC4 Compatible
    f. Output Wire Type / Connector: Double Insulated; MC4 Compatible
    g. Output Wire Length: 6.9 ft.
    h. Operating Temperature Range: -40F to +185F
    i. Protection Rating: P68/NEMA6P
    j. Relative Humidity: 0-100%

2.4 MONITORING

A. Data Acquisition and Monitoring System
1. Manufacturer: PowerDash.
2. The Data Acquisition and Monitoring System for South High School will integrate into the City of Worcester existing PowerDash data acquisition and monitoring infrastructure.
3. The Vendor will provide all necessary hardware as well as software to facilitate the integration per the City’s requirements.
4. The Data Acquisition and Monitoring System (DAS) shall allow the owner to monitor and utilize the collected data for educational purposes over the school network. The system shall allow measurement, calculation, and display of:
    a. Ambient temperature.
    b. Wind speed.
    c. Solar irradiation.
    d. System electrical functions (instantaneous and accumulated power output (KW and KWH), AC and DC system voltage and amperage, and peak value tracking with associated time stamps).
    e. Pounds of CO2 emissions avoided from the generation of PV energy at the site.

5. The DAS shall include a data logger, modem for data retrieval, and all parts and sensors to accurately measure the above specified data points.

B. Module Level Monitoring

1. Register the PV system with the inverter/optimizer manufacturer. Provide free web-based monitoring portal through the manufacturer.
2. The web-based monitoring portal shall provide enhanced PV performance monitoring and yield assurance through immediate fault detection and alerts at module level, string level and system level.
3. The monitoring sensors and transmitters shall be built into the power optimizer and solar inverter, and measurement data shall be transmitted over the regular power lines.
4. Features:
   a. Tracks technical and financial performance of the PV system.
   b. A display of all installations on a map.
   c. Enables logical and physical PV site visualization with real-time performance data for each individual module and for the whole system.
   d. Presents historical and aggregated data, comparative analysis diagnostics and a guided root-cause fault analysis. All data is logged and can be securely reviewed and analyzed at any time from any location.
   e. Enables the creation of the physical layout.
   f. Enables generation of comprehensive reports on site's energy production, revenues and technical status.
   g. Enables immediate fault detection and troubleshooting, efficient maintenance management, and site profitability analysis.
   h. Configurable rule engine automatically detects problems, issues status reports and sends alerts via e-mail.
   i. Remote service capabilities.
   j. Interactive charts and site layout make it easy for installers to ensure a system is functioning properly after installation.
   k. The Playback feature visualizes the harvested power of a site during a selected time fragment.

2.5 RACKING

A. Available Manufacturers

1. Genmounts Solar Racking Systems.
2. AET Solar Mounting Solutions.
3. Unirack.
4. Or approved equal.

B. Features

1. No compression clips.
2. Designed to withstand wind loads up to 150 mph.
3. Non-penetrating, flexible, ballasted PV mounting system.
4. Integrated bonding—arrays ground at one point (no clips or copper wires).

5. Ballast widely distributed (no large point load).
6. Array remains bonded even when multiple modules are removed.
7. UL 467 approved, wind tunnel tested.

2.6 SOLAR CANOPY

A. The steel and caissons for the solar canopy will be furnished and installed by the Construction Manager.

B. The Electrical Trade Contractor shall provide dimensional requirements for the construction of the steel associate supports, purlins, etc. for the mounting of the solar PV modules,

C. The Electrical Trade Contractor shall furnish PV modules, inverters, wiring, supports, etc. for a complete functional solar canopy PV system.

2.7 INSTALLATION

A. All PV modules to be installed such that they are 100% free from shade between 8am and 5pm daily.

B. The Contractor shall be responsible for the installation of foundations and placement of anchor bolts. Contractor shall also be responsible for the removal and/or stockpiling of any spoils due to foundation drilling from the site daily.

C. Installation of the entire system and all components shall be in strict accordance with Manufacturer’s recommendations.

D. System Installation shall conform to Manufacturer’s Installation Manual, approved project drawings and specifications.

E. All Local and NEC codes shall be observed.

F. Array mounting hardware supplied by the Canopy Manufacturer shall be compatible with the site considerations and environment. Special attention shall be paid to minimizing the risk from exposed fasteners, sharp edges, and potential damage to the modules or support structures. Corrosion resistance and durability of the mechanical hardware shall be emphasized — the use of galvanized steel fasteners and aluminum support structures are required. The use of ferrous metals, wood and plastic components are not acceptable.

G. Contractor shall ensure installing subcontractors (if used) are familiar with Manufacturer's installation guidelines. Deliver canopy, PV modules and system components to their final locations in protective wrappings, containers, and other protection that will exclude dirt and moisture and prevent damage from construction operations. Contractor shall remove protection only after equipment is safe from such hazards.

H. Cranes or rigging equipment shall operate in compliance with all local codes and requirements at the Contractor’s expense.

I. After the system has been fully erected, the Contractor shall provide the materials and labor to grout the base of the column to produce a finished joint.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrate areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Do not begin installation until mounting surfaces have been properly prepared.

C. If preparation of mounting surfaces is the responsibility of another installer, notify Architect of unsatisfactory preparation before proceeding.

D. Examine modules and array frame before installation. Reject modules and arrays that are wet, moisture damaged, or mold damaged.

E. Examine roofs, supports, and supporting structures for suitable conditions where PV system will be installed.

F. Proceed with installation only after unsatisfactory conditions have been corrected.

G. Provide insulating dielectric fittings specifically designed for the purpose wherever dissimilar metals would otherwise be in contact. DO NOT mount aluminum or stainless steel panels or hardware directly to steel structure or roofing

H. Carefully coordinate with Roofing Subcontractor and/or support framing for proper support of PV panels without compromising integrity of the roof or structure.

3.2 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections..

B. Perform tests and inspections with the assistance of a factory-authorized service representative.

C. PV module will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.3 UTILITY COMPANY PHASE LOSS TEST

A. Perform a Phase Loss Test in the presence of the utility company representative. The test procedure shall be as follows:

1. Establish proper PPE guidelines and wear proper PPE.
2. Open DC DISCONNECT at the INVERTER.
3. Open PV INTERCONNECTION DISCONNECT.
4. Lockout PV INTERCONNECTION DISCONNECT in open position.
5. Open Utility AC DISCONNECT.
6. Unfasten Utility AC DISCONNECT DOOR.
7. Remove phase A conductor from load side of UTILITY AC DISCONNECT.
8. Tape and cap exposed conductors with insulated end caps to ensure that cable is fully insulated.
9. Move cable aside and stabilize inside the disconnect so there is no interference with test.

10. Secure UTILITY AC DISCONNECT door.
11. Close DC DISCONNECT at the INVERTER.
12. Close PV INTERCONNECTION DISCONNECT.
13. Close UTILITY AC DISCONNECT.
14. Confirm that Inverter does not operate (after 5 minutes).
15. Repeat steps 2 – 6.
16. Replace phase A conductor in load side terminal of UTILITY AC DISCONNECT.
17. Remove phase B from load side of UTILITY AC DISCONNECT.
18. Repeat steps 8 – 14.
19. Repeat steps 2 – 6.
20. Replace phase B in load side terminal of UTILITY AC DISCONNECT.
21. Remove phase C from load side of UTILITY AC DISCONNECT.
22. Repeat steps 8 – 14.
23. Repeat steps 2 – 6.
24. Replace phase C in load side terminal of UTILITY AC DISCONNECT.
25. Repeat steps 10 – 13.
26. Confirm that inverter re-engages with utility power.

3.4 TRAINING AND SERVICE

A. Comply with Section 26 00 01.

B. Conduct four 4-hour training sessions. Train the Owner’s maintenance personnel on procedures and schedules related to start up and shutdown, troubleshooting, servicing, and preventive maintenance.

C. Conduct two 4-hour training sessions. Train the Owner’s personnel on procedures and schedules related to monitoring the system through PowerDash and through web portal provided by the manufacturer.

End of Section

DO NOT REMOVE
THIS PAGE INTENTIONALLY LEFT BLANK

Section 26 32 13

ENGINE GENERATORS

(TRADE CONTRACT REQUIRED AS PART OF SECTION 26 00 01)

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. PUBLICLY BID TRADE CONTRACT REQUIREMENTS: As provided under Section 26 00 01 - ELECTRICAL and supplemented under the Bidding Requirements, Contract Forms, and Conditions of the Contract, and applicable parts of Division 1 - GENERAL REQUIREMENTS.

1. Work of this Trade Contract includes all individual specification sections listed in Section 26 00 01.

1.2 RELATED DOCUMENTS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications

1.3 SUBMITTALS

A. Product Data: For each type of packaged engine generator and accessory indicated.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

C. Manufacturer Seismic Qualification Certification: Submit certification that engine-generator set, batteries, battery racks, accessories, and components will withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems." Include the following:

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."

b. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.

3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

D. Source quality-control test reports.

E. Field quality-control test reports.

F. Operation and maintenance data.

1.4 QUALITY ASSURANCE

A. Installer Qualifications: Manufacturer's authorized representative who is trained and approved for installation of units required for this Project.

B. Manufacturer Qualifications: A qualified manufacturer. Maintain, within 200 miles (321 km) of Project site, a service center capable of providing training, parts, and emergency maintenance repairs.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

D. Comply with ASME B15.1.

E. Comply with NFPA 37.

F. Comply with NFPA 70.

G. Comply with NFPA 110.

H. Comply with UL 2200.

I. Engine Exhaust Emissions: Comply with applicable state and local government requirements.

J. Noise Emission: Comply with applicable state and local government requirements for maximum noise level at adjacent property boundaries due to sound emitted by generator set including engine, engine exhaust, engine cooling-air intake and discharge, and other components of installation.

1.5 PROJECT CONDITIONS

A. Environmental Conditions: Engine-generator system shall withstand the following environmental conditions without mechanical or electrical damage or degradation of performance capability:

1. Ambient Temperature: Minus 15 to plus 40 deg C.

2. Relative Humidity: 0 to 95 percent.

3. Altitude: Sea level to 1000 feet (300 m).

1.6 WARRANTY

A. Comply with Section 260001.

B. The Electrical Trade Contractor shall warranty that all materials furnished shall be free from defects of material for a period of one year from the date of Substantial Completion.

C. Provide a 3-year preventive maintenance plan. The plan shall include one site visit per year after the warranty period to verify that the system is working per the specifications and to proactively perform maintenance, repairs, and replacements to prevent failures before they occur.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Generac

B. Caterpillar; Engine Division

C. Kohler Co.; Generator Division

D. Or approved equal.

2.2 ENGINE-GENERATOR SET

A. Factory-assembled and -tested, engine-generator set.

B. Mounting Frame: Maintain alignment of mounted components without depending on concrete foundation; and have lifting attachments.

C. Capacities and Characteristics:

1. Power Output Ratings: Nominal ratings as indicated on the drawings.
2. Output Connections: Three-phase, four wire.
3. Nameplates: For each major system component to identify manufacturer's name and address, and model and serial number of component.

D. Generator-Set Performance:

1. Steady-State Voltage Operational Bandwidth: 3 percent of rated output voltage from no load to full load.
2. Transient Voltage Performance: Not more than 20 percent variation for 50 percent step-load increase or decrease. Voltage shall recover and remain within the steady-state operating band within three seconds.
3. Steady-State Frequency Operational Bandwidth: 0.5 percent of rated frequency from no load to full load.
4. Steady-State Frequency Stability: When system is operating at any constant load within the rated load, there shall be no random speed variations outside the steady-state operational band and no hunting or surging of speed.
5. Transient Frequency Performance: Less than 5 percent variation for 50 percent step-load increase or decrease. Frequency shall recover and remain within the steady-state operating band within five seconds.
6. Output Waveform: At no load, harmonic content measured line to line or line to neutral shall not exceed 5 percent total and 3 percent for single harmonics. Telephone influence factor, determined according to NEMA MG 1, shall not exceed 50 percent.
7. Sustained Short-Circuit Current: For a 3-phase, bolted short circuit at system output terminals, system shall supply a minimum of 250 percent of rated full-load current for not less than 10 seconds and then clear the fault automatically, without damage to generator system components.
8. Below requires 10-second maximum start time under specific conditions and includes startup only, not load assumption.
9. Start Time: Comply with NFPA 110, Type 10, system requirements.

2.3 ENGINE

A. Fuel: Fuel oil, Grade DF-2.

B. Rated Engine Speed: 1800 rpm.

C. Maximum Piston Speed for Four-Cycle Engines: 2250 fpm (11.4 m/s).

D. Lubrication System: The following items are mounted on engine or skid:

1. Filter and Strainer: Rated to remove 90 percent of particles 5 micrometers and smaller while passing full flow.

2. Thermostatic Control Valve: Control flow in system to maintain optimum oil temperature. Unit shall be capable of full flow and is designed to be fail-safe.

3. Crankcase Drain: Arranged for complete gravity drainage to an easily removable container with no disassembly and without use of pumps, siphons, special tools, or appliances.

E. Engine Fuel System:

1. Main Fuel Pump: Mounted on engine. Pump ensures adequate primary fuel flow under starting and load conditions.

2. Relief-Bypass Valve: Automatically regulates pressure in fuel line and returns excess fuel to source.

F. Coolant Jacket Heater: Electric-immersion type, factory installed in coolant jacket system. Comply with NFPA 110 requirements for Level 1 equipment for heater capacity.

G. Governor: Adjustable isochronous, with speed sensing.

H. Cooling System: Closed loop, liquid cooled, with radiator factory mounted on engine-generator-set mounting frame and integral engine-driven coolant pump.

1. Coolant: Solution of 50 percent ethylene-glycol-based antifreeze and 50 percent water, with anticorrosion additives as recommended by engine manufacturer.

2. Temperature Control: Self-contained, thermostatic-control valve modulates coolant flow automatically to maintain optimum constant coolant temperature as recommended by engine manufacturer.

I. Muffler/Silencer: Critical type, sized as recommended by engine manufacturer and selected with exhaust piping system to not exceed engine manufacturer's engine backpressure requirements.

1. Minimum sound attenuation of 25 dB at 500 Hz.

2. Sound level measured at a distance of 10 feet (3 m) from exhaust discharge after installation is complete shall be 85 dBA or less.

J. Air-Intake Filter: Heavy-duty, engine-mounted air cleaner with replaceable dry-filter element and "blocked filter" indicator.

K. Starting System: 24-V electric, with negative ground.

1. Cranking Motor: Heavy-duty unit that automatically engages and releases from engine flywheel without binding.

2. Cranking Cycle: As required by NFPA 110 for system level specified.

3. Battery: Adequate capacity within ambient temperature range specified in Part 1 "Project Conditions" Article to provide specified cranking cycle at least twice without recharging.

4. Battery-Charging Alternator: Factory mounted on engine with solid-state voltage regulation and 35-A minimum continuous rating.

   a. Battery Charger: Current-limiting, automatic-equalizing and float-charging type. Unit shall comply with UL 1236.

2.4 FUEL OIL STORAGE

A. Comply with NFPA 30.

B. Base-Mounted Fuel Oil Tank: Factory installed and piped, complying with UL 142 fuel oil tank. Features include the following:

1. Tank level indicator.

2. Capacity: Minimum 2700 gallons.

3. Vandal-resistant fill cap.

4. Containment Provisions: Fuel Oil Storage Tanks are to be double wall and dual containment type.

2.5 AUTOMATED FUEL FILTRATION SYSTEM

A. Description: Stand-alone, factory complete, automated, programmable, Green Clean Institute Certified, fuel filtration, optimization and maintenance system shall be provided for each diesel fuel storage tank to optimize and maintain the condition of fuel stored in that tank. The system shall be capable of eliminating microbial contamination and removing water, sediment and particulate to comply with ASTM D975 (Standard Specification for diesel Fuel Oils).

1. Enclosure: All system components shall be contained within a powder coated or stainless steel, weatherproof, outdoor NEMA / UL 50 Type 4 listed enclosure with appropriate ventilation. Hinged front door shall be equipped with quarter-turn key lockable handle. Fluid containment area with leak detection shall be an integral component of the enclosure. Literature pocket inside enclosure and external enclosure brackets for wall or rack mounting to be included.

2. Plumbing: Components shall be located within the enclosure. Internal plumbing will be primarily executed in stainless steel.

3. Installation: System shall provide male pipe connections protruding from the enclosure for customer plumbing connection. System shall be located as close as possible to designated fuel tank. The system’s fuel supply and discharge lines shall be independent and separate from other fuel lines, with the supply line originating at the lowest point at the bottom of the tank and the discharge line as far away as possible from the supply line.

4. Filtration / water separation: Three stage filtration / water separation process:

   a. Stage 1: Centrifugal water and coalescing particulate separation – with water detection sensor and “push and turn” safety drain valve.

   b. Stage 2: Fuel Conditioner – to reduce the size and mass of fuel sediments which naturally form in fuel.

c. Stage 3: Secondary Filtration – Uses a spin-on filter element. Elements shall be available with particulate filtration of 1 micron and dissolved and emulsified water absorbing “WB water block” filtration of 3 microns.

d. Filter / Water Separator shall be equipped with a liquid-filled compound vacuum/pressure gauge.

5. Water Sensor: Microcontroller-based water sensor alarm module to eliminate probe corrosion.

6. Controls / Display functions: System control features and indicator lights shall be located on the display panel of the Smart Filtration Controller for easy operator access. A stack light beacon shall be located on the top of the enclosure to provide an external indication of a system alarm condition as listed below. Additional alarm and system status information shall be displayed on the PLC text screen. System shall provide the following control and display functions via a PLC controller:

a. Programmable digital timer – Memory backup to retain program memory during power outages

b. Pump operating hour counter

c. Pump control switch (Auto-Off-Manual) - Key operated, on the display panel of the Smart Filtration Controller

d. Power available indicator - Green LED indicator light, on the display panel of the Smart Filtration Controller

e. Pump running indicator - Amber LED indicator light, on the display panel of the Smart Filtration Controller

f. Alarm indicator - Red LED indicator light for high vacuum, high pressure, high water level in filter bowl, and leak detection alarms - on the display panel of the Smart Filtration Controller

g. Alarm reset push button - on the display panel of the Smart Filtration Controller

7. Electrical enclosure / Controller: All electrical control features shall be contained within a separate UL 508A listed industrial control panel located within the mechanical enclosure. The controller shall monitor the following system alarm conditions:

a. Leak in enclosure (system shutdown)

b. Primary Filter/Water Separator high vacuum (system shutdown)

c. Primary Filter/Water Separator high water level (system shutdown)

d. Secondary filter high pressure (system shutdown)

e. External system shut down input

8. Pump: Positive displacement, internal gear, direct coupled, rotary pump with cast iron housing and built-in pressure relief bypass valve. Pump flow rate of 2.5 gallons per minute.

9. Motor: UL Listed, ODP, Thermal overload protection, continuous duty.

B. Performance / Design Criteria: Manufacturer must have a minimum of 10 years’ experience within industry. System shall be capable of filtering the entire tank volume with a required filtration run-time of ideally 24 hours but no more than 48 hours. Sufficient sediment as well as water-holding capacity should be ensured. System run-time requirements will vary with

climate, tank-layout, fuel delivery, refueling intervals, etc. and shall be adjusted in accordance with the input from pressure and vacuum gauges as well as water sensor.

C. Operation System shall provide dry contacts for summary alarm and leak detection alarm to interface with building monitoring or building alarm system. An external shut down feature shall be provided to interrupt pump operation from the Building Management System (BMS).

2.6 DUCT MOUNTED LOAD BANK WITH AUTOMATIC LOAD LEVELING CONTROL

A. Provide a UL Listed, “In-Line” Duct Mounted Resistive Load Bank. The load bank shall be suitable for installation in the following ambient conditions:

1. Seismic Rating: Zone 4
2. Ambient Temperature: -20ºF to +120ºF
3. Altitude: 5,000 feet above sea level

B. The Load Bank will be sized at 30% maximum of the GenSet KW rating.

C. The load bank will be rated for a continuous duty cycle at 300KW at 480 Volts AC, 3-phase, 60 Hertz. The Load Step Resolution shall be approximately 20 percent of the total load bank capacity.

D. The Engine fan shall deliver the required airflow volume (CFM) for cooling the resistor load elements.

E. The load bank enclosure is an open resistor frame of galvanized steel construction. The steel frame provides a 2 ½” mounting flange for direct mounting/coupling to the engine exhaust duct.

F. All power connections including main-input load bus and customer interface connections are made within the enclosed relay/connection compartment. Bottom access through a removable gland plate provides a “safe and sealed” ease of installation of all conduit entry cable. Load connections are made directly to the main input load bus bars. A standard NEMA 4-hole pattern shall be provided for customer load cables connections. All copper bus bars are plated for superior oxidation resistance. Relay/connection compartment is heated and thermostatically controlled to limit any harmful effects of condensation.

G. The load bank control circuits will be operated at 120 VAC AC, 1-phase. The control power will be derived from a control transformer. The Control Transformer will be primary and secondary fuse protected.

H. Resistor load element provide the necessary KW load rating for each load step. Resistors are fully supported across their entire length within the air stream by stainless steel support rods which are insulated with heavy-duty, high temperature ceramic insulators. The change in resistance is minimized by maintaining conservative resistor designs.

I. Branch circuit fuse protection provides short-circuit protection of all load steps. Fuses are fast-acting, current-limiting type with an interrupting rating of 200K A.I.C.

J. The load bank will include safety circuits which will disable the load bank if an over-temperature condition occurs. Load cannot be reapplied until the fault condition is corrected.

K. Load Bank Control Panel will be installed locally on the load bank. The control panel will include; Main Power On/Off switch, Master Load On/Off switch, and Individual Load Step

switches KW On/Off). Illuminated indicators provide Power On, Blower On, Over-Temperature and Load Dump. An Emergency-Stop (E-STOP) push button is provided to disable control power voltage to all operator control circuits and load application circuits.

L. Automatic Load Leveling Control will add/subtract load bank load in response to dynamic power fluctuations of the connected building load. It utilizes the load bank as a supplemental load for maintaining a minimum load on the power source. A customer supplied “transfer of control” contact closure initiates the load bank and time delay load application circuit. A separately supplied current transformer provides the necessary feedback signal for sensing the building load.

M. Automatic Load Dump circuit provides user interface provisions to the generator controls, automatic transfer switch, to disconnect and disable all load steps from a normally closed (NC) set of auxiliary contacts. In the event of an actual power failure, all load bank load is removed from the source under test.

N. Remote Indication and Alarm contact closure form-c-type, normally open and normally closed, provides user interface to building management system for indication, detection and alarm of Over-Temperature and Load Dump.

2.7 CONTROL AND MONITORING

A. Automatic Starting System Sequence of Operation: When mode-selector switch on the control and monitoring panel is in the automatic position, remote-control contacts in one or more separate automatic transfer switches initiate starting and stopping of generator set. When mode-selector switch is switched to the on position, generator set starts. The off position of same switch initiates generator-set shutdown. When generator set is running, specified system or equipment failures or derangements automatically shut down generator set and initiate alarms.

B. Manual Starting System Sequence of Operation: Switching on-off switch on the generator control panel to the on position starts generator set. The off position of same switch initiates generator-set shutdown. When generator set is running, specified system or equipment failures or derangements automatically shut down generator set and initiate alarms.

C. Configuration: Operating and safety indications, protective devices, basic system controls, and engine gages shall be grouped in a common control and monitoring panel mounted on the generator set. Mounting method shall isolate the control panel from generator-set vibration.

D. Readouts:

1. Engine oil pressure
2. Coolant temperature
3. Engine RPM
4. System DC Voltage
5. Engine running hours
6. Generator AC volts
7. Generator frequency
8. Generator AC amps

E. Solid state engine monitoring system with monitors in accordance with NFPA 70, NFPA 110 and local code requirements with lamps, audible alarm, lamp test switch, individual alarm contacts and a common alarm contact for:

1. Overcrank shutdown
2. Low coolant temperature warning
3. Pre-warning for high engine temperature
4. High engine temperature shutdown
5. Pre-warning for low lube oil pressure
6. Low lube oil pressure shutdown
7. Overspeed shutdown
8. Low fuel in main tank warning
9. Low coolant level warning
10. Generator (EPS) supplying load.
11. Generator control switch not in auto position warning
12. High battery voltage warning
13. Low cranking voltage warning
14. Low battery voltage warning
15. Battery charger failure
16. Generator output breaker(s) open warning
17. Emergency stop depressed
18. [Customer alarm]
19. [Customer alarm]
20. [Customer alarm]
21. Provide two dry auxiliary contacts one for common alarm and one for engine running.

F. Control Functions / Interfaces: Provide the following control functions:

1. Terminals located inside the control panel for REMOTE EMERGENCY STOP
2. ON / OFF / AUTO control switch

G. Supporting Items: Include sensors, transducers, terminals, relays, and other devices and include wiring required to support specified items. Locate sensors and other supporting items on engine or generator, unless otherwise indicated.

H. Common Remote Audible Alarm: Comply with NFPA 110 requirements for Level 1 systems. Include necessary contacts and terminals in control and monitoring panel.

1. Overcrank shutdown.
2. Coolant low-temperature alarm.
3. Control switch not in auto position.
4. Battery-charger malfunction alarm.
5. Battery low-voltage alarm.

I. Remote Alarm Annunciator

1. Flush mounted remote annunciators shall be microprocessor based annunciator with network communication type, located as shown on the Drawings, and shall have audible and LED visual signal devices, powered by the electric set lead acid battery set, to provide a warning of derangement or alarm conditions in the electric set in compliance with the NFPA 70, NFPA 110 level 1, 20 lamp and the requirements of these Specifications. The enclosure shall be constructed of sturdy sheet steel, and shall have removable front panel and adapter ring for flush mounting. The face of the front panel shall contain LED's (visual signals), and audible alarm, an alarm silence push button, and a LED test push button. The internal wiring, terminal block, and battery voltage sensors shall be accessible by removing the front panel of the enclosure.

2. Remote annunciators shall indicate the following conditions:

   a. Overcrank shutdown

   b. Low coolant temperature warning

   c. Pre-warning for high engine temperature

   d. High engine temperature shutdown

   e. Pre-warning for low lube oil pressure

   f. Low lube oil pressure shutdown

   g. Overspeed shutdown

   h. Low coolant level warning

   i. Generator control switch not in auto position warning

   j. Low cranking voltage warning

   k. Low battery voltage warning

   l. Generator output breaker(s) open warning

   m. Generator power available

   n. Low fuel in main tank warning

   o. Fuel in outer tank

   p. Emergency stop depressed

   q. Load Bank Connected

   r. Load Bank Over-Temperature

   s. Load Bank Load Dump

   t. Permanent generator Disconnected/Portable Generator (signal from manual transfer switch)

   u. Spare/Customer alarm

   v. Spare/Customer alarm

3. Visible indicator for:

   a. Battery voltage okay

2.8 GENERATOR OVERCURRENT AND FAULT PROTECTION

A. Generator Circuit Breakers: shall be Standard Micrologic (LSI or where applicable LSIG) with solid-state trip unit and flux transfer shunt trip. Breakers shall have trip rating plugs with ratings as indicated on the drawings Rating plugs shall be interlocked so they are NOT interchangeable between frames and interlocked such that a breaker cannot be latched with the rating plug removed; 100 percent rated; adjust breaker frame to achieve selective coordination per NFPA 70 complying with NEMA AB 1 and UL 489.

1. Tripping Characteristic: Designed specifically for generator protection.
2. Trip Rating: Matched to generator rating.
3. Shunt Trip: Connected to trip breaker when generator set is shut down by other protective devices.
4. Mounting: Adjacent to or integrated with control and monitoring panel.

B. Ground-Fault Indication: Comply with NFPA 70, "Emergency System" signals for ground-fault. Integrate ground-fault alarm indication with other generator-set alarm indications.

C. The generator circuit breakers shall be of the same manufacturer as the ones provided on the supply side for switchboards and panelboards.

D. All emergency system overcurrent devices be selectively coordinated with the overcurrent devices installed on their supply side per Section 700.27 of the National Electrical Code.

E. Each generator circuit breaker shall be installed in a separate enclosure to physically separate the circuit breakers feeding the different emergency branches i.e. Emergency Life Safety, Legally Required Standby, Optional Standby, Fire Pump, etc.

2.9 GENERATOR, EXCITER, AND VOLTAGE REGULATOR

A. Comply with NEMA MG 1.

B. Drive: Generator shaft shall be directly connected to engine shaft. Exciter shall be rotated integrally with generator rotor.

C. Electrical Insulation: Class H or Class F.

D. Stator-Winding Leads: Brought out to terminal box to permit future reconnection for other voltages if required.

E. Construction shall prevent mechanical, electrical, and thermal damage due to vibration, over-speed up to 125 percent of rating, and heat during operation at 110 percent of rated capacity.

F. Enclosure: Drip-proof.

G. Delete first paragraph below if instrument transformers are housed in control and power panel.

H. Instrument Transformers: Mounted within generator enclosure.

I. Voltage Regulator: Solid-state type, separate from exciter, providing performance as specified.

1. Adjusting rheostat on control and monitoring panel shall provide plus or minus 5 percent adjustment of output-voltage operating band.

J. Strip Heater: Thermostatically controlled unit arranged to maintain stator windings above dew point.

K. Windings: Two-thirds pitch stator winding and fully linked amortisseur winding.

L. Sub-transient Reactance: 12 percent, maximum.

2.10 SOUND ATTENUATED WEATHER PROTECTIVE OUTDOOR GENERATOR-SET ENCLOSURE

A. A weatherproof, sound attenuated, enclosure shall be provided to house the engine/generator and accessories. The enclosure is to be in compliance with the National Electrical Code (NEC), and the National Fire Protection Association (NFPA) for clearance around electrical equipment as specified. The enclosure shall conform to the following design criteria:

1. Material: Aluminum min. thickness 16 gauge.
2. Rigidity wind test equal to 115 MPH
3. Roof load equal to 50 lbs. per sq. ft.
4. Floor load equal to 200 lbs. per sq. ft.
5. Rain test equal to 4" per hour
6. Certified to meet the BOCA basic bldg. and mech. Codes
7. The sound attenuation shall be Level I not to exceed 76dB at 23 ft.
8. The generator length and width dimension shall not exceed 290” L x 120” W due to location restrictions.

B. Provide stairs complete with platforms, railings, and handrails to provide full access to each service access door. They shall be aluminum, hot-dipped galvanized after fabrication. They shall comply with the applicable building codes, OSHA standards, State Occupational Safety and Health Plan requirements, and other applicable regulations. Enclosures without platforms, railings, and handrails shall not be acceptable. Note: the generator sits on a concrete pad, coordinate and verify dimensions prior to construction of the platform.

C. Test data on similar construction by manufacturer, reviewed by a P.E. licensed in the Commonwealth of Massachusetts, shall be available upon request.

D. Enclosure will consist of a roof, fuel tank and rupture basin base, two (2) side walls, and two (2) end walls, of stressed skin, semi-monocoque construction.

E. The system shall include a cooling and combustion air inlet silencer section, an equipment enclosure section, and a cooling air discharge silencer section. enclosure shall be designed as follows:

1. Roof and walls shall each be of one-piece semi-monocoque construction. All framing members shall be 6063-T6 aluminum. Skin material shall be min. thickness 16 gauge pre-painted aluminum (roof shall be mill-finish). A minimum of six colors shall be available for enclosure exterior. Skin panels shall be hard-riveted to framing members on 3" centers maximum. Pop rivets and bolts are not acceptable fasteners to attach exterior skin to framing. Roof assembly shall be cambered to aid in rain runoff.
2. Insulation in walls and roof shall be semi-rigid, thermo-acoustic, thickness as required to meet the noise criteria specified. Lining shall be perforated, mill- finish

aluminum. Self-adhesive foam and loose or bat-type insulating materials will not be accepted.

F. An integral fuel tank underframe with floor and rupture basin shall be supplied, consisting of the following: a rupture basin utilizing minimum 7 ga. steel channel perimeter walls and bottom; a U.L. listed (per U.L. 142) above-ground rectangular tank of minimum 12 ga. steel construction; and a floor system consisting of fabricated or structural steel cross members on centers averaging 16 inches. The cross members will be overlaid with OSB board topped with 14 ga. steel diamond plate. This wood/steel combination must be used for acoustic isolation of the generator set from base. The tank shall have venting and emergency venting per U.L. 142, lockable fill, low level and high level alarm contacts, and a D.C. electric analog level gauge. The cross members shall incorporate 3/8" thick steel tapping plates for genset mounting. The rupture basin shall have a float contact to indicate tank rupture, and the entire system shall be leak tested prior to installation.

G. Four-point lifting provisions shall be provided at or near the enclosure base, with capacity suitable for rigging the entire assembly. Quality assurance procedures of the manufacturer shall include regular testing of the lift devices.

H. Two (2) single personnel access doors shall be provided. Door shall consist of an extruded aluminum frame with skin material matching enclosure. Door shall be fully gasketed to form a weather tight perimeter seal. Hinges shall be forged aluminum with stainless steel pins, handle shall be stainless steel and padlockable, and lock mechanism shall be three-point, with panic hardware to allow opening from inside even when padlocked. Include stairs and entry platform at each door.

I. Air handling shall be as follows: Air will enter the enclosure through removable hood(s) or an integral, baffled plenum. Motor operated damper(s) will be provided, wired to open upon engine startup. Radiator discharge will be through a gravity operated damper and into a hood or vertical plenum, as dictated by airflow. The system shall not exceed 0.5" w.g. total external static pressure to ensure adequate airflow for cooling and combustion.

J. A bolt-in-place removable wall panel shall be provided for maintenance and/or equipment installation.

K. Enclosure manufacturer shall provide all necessary hardware to internally mount the specified exhaust silencer(s) and maintain the weatherproof integrity of the system. Silencer and exhaust flex shall be insulated. Include a 10’ stainless steel concentric exhaust extension when required by local code.

L. The enclosure shall include A.C. and D.C. lighting, duplex receptacles, and an A.C. distribution panel. D.C. lights to have timer type switch. All devices in the enclosure, including specified generator set accessories, shall be prewired in E.M.T. by enclosure manufacturer. In addition, the manufacturer shall perform the system integration of all components in the enclosure, mechanical and electrical. The enclosure shall include:

1. Mechanical ventilation and an electric unit heater thermostatically controlled suitable to maintain space temperature of maximum 95°F, minimum 50°F in Massachusetts.

M. Interior Lights with Switch: Factory-wired, vaporproof-type fixtures within housing; arranged to illuminate controls and accessible interior. Arrange for external electrical connection.

1. AC lighting system and connection point for operation when remote source is available.

2. DC lighting system for operation when remote source and generator are both unavailable.

N. Convenience Outlets: Factory wired**,** GFCI. Arrange for external electrical connection.

O. A 100 AMP main breaker 208Y/120V 3-phase 4-wire 12-pole panelboard with all necessary circuit breakers for serving engine jacket water heater, battery charger, electric unit heater, etc.

2.11 STACK HEIGHT AND EMISSION DISPERSION

A. All engines or turbines shall utilize an exhaust stack that discharges so as to not cause a condition of air pollution (310 CMR 7.01(1)). Exhaust stacks shall be configured to discharge the combustion gases vertically and shall not be equipped with any part or device that restricts the vertical exhaust flow of the emitted combustion gases, including but not limited to rain protection devices "shanty caps" and "egg beaters". Any emission impacts of exhaust stacks upon sensitive receptors including, but not limited to, people, windows and door, that open, and building fresh air intakes shall be minimized by employing good air pollution control engineering practices. Such practices include without limitation:

1. Avoiding locations that may be subject to downwash of the exhaust;

2. Installing stack(s) of sufficient height in locations that will prevent and minimize flue gas impacts upon sensitive receptors.

B. Engines or turbines with a rated power output equal to or greater than 300 kW, but less than 1 MW, shall have a minimum stack height of ten feet above the facility rooftop or the emergency engine or turbine enclosure, whichever is lower.

C. Engines with a rated power output equal to or greater than one MW shall be equipped with a stack with a minimum stack height of 1.5 times the height of the building on which the stack is located. If the stack is lower than 1.5 times the building height or lower than the height of a structure that is within 5L of the stack (5L being five times the lesser of the height or maximum projected width of the structure), an EPA Guideline air quality model shall be run to document that the operation of the applicable emergency engine or turbine will not cause an exceedance of any National Ambient Air Quality Standard.

2.12 VIBRATION ISOLATION DEVICES

A. Elastomeric Isolator Pads: Oil- and water-resistant elastomer or natural rubber, arranged in single or multiple layers, molded with a nonslip pattern and galvanized-steel baseplates of sufficient stiffness for uniform loading over pad area, and factory cut to sizes that match requirements of supported equipment.

B. Restrained Spring Isolators: Freestanding, steel, open-spring isolators with seismic restraint.

1. Housing: Steel with resilient vertical-limit stops to prevent spring extension due to wind loads or if weight is removed; factory-drilled baseplate bonded to 1/4-inch- (6-mm-) thick, elastomeric isolator pad attached to baseplate underside; and adjustable equipment mounting and leveling bolt that acts as blocking during installation.

2. Outside Spring Diameter: Not less than 80 percent of compressed height of the spring at rated load.

3. Minimum Additional Travel: 50 percent of required deflection at rated load.

4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.

5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

2.13 FINISHES

A. Indoor and Outdoor Enclosures and Components: Manufacturer's standard finish over corrosion-resistant pretreatment and compatible primer.

2.14 EMERGENCY STOP BUTTON

A. Furnish and install an emergency stop button and wiring on the exterior of the generator enclosure and next to each transfer switch.

B. The emergency stop button shall be:

1. Pilla Electrical Products, Inc., Model ST120SN3RSL-GLS or approved equal. Surface mount, NEMA 3R with 2 replacement glasses and painted steel enclosure.

2.15 INTEGRATION TO BUILDING MANAGEMENT SYSTEM (BMS):

A. Provide Modbus RS-485 communications wiring from the generator to:

1. BMS system.
2. Generator Annunciator.

B. The BMS system shall monitor the following points:

1. Overcrank shutdown
2. Low coolant temperature warning
3. Pre-warning for high engine temperature
4. High engine temperature shutdown
5. Pre-warning for low lube oil pressure
6. Low lube oil pressure shutdown
7. Overspeed shutdown
8. Low fuel in main tank warning
9. Low coolant level warning
10. Generator (EPS) supplying load.
11. Generator control switch not in auto position warning
12. High battery voltage warning
13. Low cranking voltage warning
14. Low battery voltage warning
15. Battery charger failure
16. Generator output breaker(s) open warning
17. Emergency stop depressed
18. Load Bank Connected
19. Load Bank Over-Temperature
20. Load Bank Load Dump

21. Permanent generator Disconnected/Portable Generator (signal from manual transfer switch)

22. Spare/Customer alarm

23. Spare/Customer alarm

C. The electrical contractor shall provide wiring from the BMS system to the generator for the load bank “transfer of control” contact closure to initiate the load bank and time delay load application circuit.

D. The electrical contractor shall provide wiring from the generator to the BMS for indication, detection and alarm of Load Bank Over-Temperature and Load Dump.

E. Coordinate exact requirements with the BMS vendor.

2.16 SOURCE QUALITY CONTROL

A. Prototype Testing: Factory test engine-generator set using same engine model, constructed of identical or equivalent components and equipped with identical or equivalent accessories.

1. Tests: Comply with NFPA 110 and with IEEE 115.

2. Report factory test results within 10 days of completion of test.

2.17 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

B. Tests and Inspections:

1. Perform tests recommended by manufacturer and each electrical test and visual and mechanical inspection for "AC Generators and for Emergency Systems" specified in NETA Acceptance Testing Specification. Certify compliance with test parameters.

2. NFPA 110 Acceptance Tests: Perform tests required by NFPA 110 that are additional to those specified here including, but not limited to, single-step full-load pickup test.

3. Battery Tests: Equalize charging of battery cells according to manufacturer's written instructions. Record individual cell voltages.

a. Measure charging voltage and voltages between available battery terminals for full-charging and float-charging conditions. Check electrolyte level and specific gravity under both conditions.

b. Test for contact integrity of all connectors. Perform an integrity load test and a capacity load test for the battery.

c. Verify acceptance of charge for each element of the battery after discharge.

d. Verify that measurements are within manufacturer's specifications.

4. Battery-Charger Tests: Verify specified rates of charge for both equalizing and float-charging conditions.

5. System Integrity Tests: Methodically verify proper installation, connection, and integrity of each element of engine-generator system before and during system operation. Check for air, exhaust, and fluid leaks.

6. Exhaust-System Back-Pressure Test: Use a manometer with a scale exceeding 40-inch wg (120 kPa). Connect to exhaust line close to engine exhaust manifold. Verify that back pressure at full-rated load is within manufacturer's written allowable limits for the engine.

7. Verify local requirements and delete first subparagraph below for most projects. Few jurisdictions require this test for emergency or standby generator sets.

8. Exhaust Emissions Test: Comply with applicable government test criteria.

9. Voltage and Frequency Transient Stability Tests: Use recording oscilloscope to measure voltage and frequency transients for 50 and 100 percent step-load increases and decreases, and verify that performance is as specified.

10. Harmonic-Content Tests: Measure harmonic content of output voltage under 25 percent and at 100 percent of rated linear load. Verify that harmonic content is within specified limits.

11. Noise Level Tests: Measure A-weighted level of noise emanating from generator-set installation, including engine exhaust and cooling-air intake and discharge, at four locations on the property line, and compare measured levels with required values.

C. Coordinate tests with tests for transfer switches and run them concurrently.

D. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.

E. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.

F. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

G. Remove and replace malfunctioning units and retest as specified above.

H. Retest: Correct deficiencies identified by tests and observations and retest until specified requirements are met.

I. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation resistances, time delays, and other values and observations. Attach a label or tag to each tested component indicating satisfactory completion of tests.

2.18 LOAD BANK TEST

A. Provide all equipment, labor, materials, and supervision necessary to test the stand-by diesel engine driven electric generator set specified. Tests shall be performed as installed on-site.

B. Acceptance testing of the installed generator set shall be conducted by a factory trained representative of the generator set manufacturer. An authorized representative of the Owner will also witness the acceptance tests.

C. The test results shall be submitted to and approved by the Engineer before the generator set is accepted. The Contractor shall furnish all testing equipment, materials, fuel, etc.,

needed to demonstrate the set is in compliance with the specification. Any deficiencies brought to the attention of the Contractor shall be corrected and if warranted or requested by the Owner, the test shall be re-performed prior to acceptance. Final Operations & Maintenance (O&M) manuals shall be submitted before the acceptance tests commence.

D. The acceptance tests shall be performed during a field test during which the manufacturer's representative shall demonstrate that the system performs in complete compliance with the specifications. As a minimum, a load bank test performed in accordance with NFPA 110 shall be conducted. The load test shall use dry type load banks specifically utilized for this purpose. The load bank will be capable of definite and precise incremental loading and shall not be dependent on the generator control instrumentation to read voltage and amperage of each phase. The test instrumentation will serve as a check of the generator set meters. Salt water brine tank load banks are not acceptable for this purpose and are disallowed and will not be utilized for this test.

E. Load bank testing shall be performed for a period of four (4) hours at the full rated load of the generator and witnessed by the Owner's representative.

F. The Electrical Trade Contractor shall provide a full tank of diesel fuel for the completion of all testing.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with packaged engine-generator manufacturers' written installation and alignment instructions and with NFPA 110.

B. Install packaged engine generator to provide access, without removing connections or accessories, for periodic maintenance.

C. Install packaged engine generator with restrained spring isolators having a minimum deflection of 1 inch (25 mm) on 4-inch- (100-mm-) high concrete base. Secure sets to anchor bolts installed in concrete bases. Concrete base construction is specified in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."

D. Install Schedule 40, black steel piping with welded joints and connect to engine muffler. Install thimble at wall. Piping shall be same diameter as muffler outlet. Flexible connectors and steel piping materials and installation requirements are specified in Division 22.

1. Install condensate drain piping to muffler drain outlet full size of drain connection with a shutoff valve, stainless-steel flexible connector, and Schedule 40, black steel pipe with welded joints. Flexible connectors and piping materials and installation requirements are specified in Division 22.

E. Electrical Wiring: Install electrical devices furnished by equipment manufacturers but not specified to be factory mounted.

F. Piping installation requirements are specified in Division 22 Sections. Drawings indicate general arrangement of piping and specialties.

G. Connect fuel, cooling-system, and exhaust-system piping adjacent to packaged engine generator to allow service and maintenance.

H. Connect engine exhaust pipe to engine with flexible connector.

I. Connect fuel piping to engines with a gate valve and union and flexible connector.

J. Ground equipment according to Division 26.

K. Connect wiring according to Division 26.

L. Identify system components according to Division 22 and Division 26.

3.2 COMMISSIONING

A. Comply with requirements specified in Division 1.

B. Engage a factory-authorized service representative to supervise and assist with startup service. Complete installation and startup checks according to the approved manufacturer's written instructions.

3.3 TRAINING AND SERVICE

A. Comply with Section 26 00 01.

B. Conduct four 4-hour training sessions. Train the Owner’s maintenance personnel on procedures and schedules related to start up and shutdown, troubleshooting, servicing, and preventive maintenance.

End of Section

DO NOT REMOVE
THIS PAGE INTENTIONALLY LEFT BLANK

Section 26 36 00

TRANSFER SWITCHES

(TRADE CONTRACT REQUIRED AS PART OF SECTION 26 00 01)

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. PUBLICLY BID TRADE CONTRACT REQUIREMENTS: As provided under Section 26 00 01 - ELECTRICAL and supplemented under the Bidding Requirements, Contract Forms, and Conditions of the Contract, and applicable parts of Division 1 - GENERAL REQUIREMENTS.

1. Work of this Trade Contract includes all individual specification sections listed in Section 26 00 01.

1.2 RELATED DOCUMENTS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications

1.3 SUBMITTALS

A. Product Data: Include rated capacities, weights, operating characteristics, furnished specialties, and accessories.

B. Shop Drawings: Dimensioned plans, elevations, sections, and details showing minimum clearances, conductor entry provisions, gutter space, installed features and devices, and material lists for each switch specified.

C. Manufacturer Seismic Qualification Certification: Submit certification that transfer switches accessories, and components will withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems." Include the following:

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2. Dimensioned Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.

3. Detailed description of equipment anchorage devices on which the certification is based.

D. Field quality-control test reports.

E. Operation and maintenance data.

1.4 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. Comply with NEMA ICS 1.

C. Comply with NFPA 70.

D. Comply with NFPA 99.

E. Comply with NFPA 110.

F. Comply with UL 1008 unless requirements of these Specifications are stricter.

1.5 SCOPE

A. Furnish and install automatic transfer switches (ATS) with number of poles, amperage, voltage, withstand and close-on ratings as shown on the plans. Each automatic transfer shall consist of an inherently double throw power transfer switch mechanism and a microprocessor controller to provide automatic operation. All transfer switches and controllers shall be the products of the same manufacturer.

1.6 CODES AND STANDARDS

A. The automatic transfer switches and controls shall conform to the requirements of:

1. UL 1008 - Standard for Transfer Switch Equipment
2. IEC 60947-6-1 Low-voltage Switchgear and Control gear; Multifunction equipment; Automatic Transfer Switching Equipment
3. NFPA 70 - National Electrical Code
4. NFPA 110 - Emergency and Standby Power Systems
5. IEEE Standard 446 - IEEE Recommended Practice for Emergency and Standby Power Systems for Commercial and Industrial Applications
6. NEMA Standard ICS10-1993 (formerly ICS2-447) - AC Automatic Transfer Switches
7. UL 508 Industrial Control Equipment

1.7 WARRANTY

A. Comply with Section 260001.

B. The Electrical Trade Contractor shall warranty that all materials furnished shall be free from defects of material for a period of one year from the date of Substantial Completion.

C. Provide a 3-year preventive maintenance plan. The plan shall include one site visit per year after the warranty period to verify that the system is working per the specifications and to proactively perform maintenance, repairs, and replacements to prevent failures before they occur.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. ASCO

B. RussElectric

C. Zenith

D. Or approved equal

2.2 BASIS OF DESIGN

A. Automatic Transfer Switch: ASCO 7000 Series with bypass isolation switch.

B. Manual Transfer Switch: ASCO 300 Series.

C. Portable Generator Dock: ASCO Quick Connect Power Panel

2.3 AUTOMATIC TRANFER SWITCH

A. General

1. Furnish and install automatic transfer & bypass-isolation switch (ATS/BPS) system(s) with number of poles, amperage, voltage, withstand and close-on ratings as shown on the plans. Each automatic transfer shall consist of an inherently double throw power transfer switch mechanism and a microprocessor controller to provide automatic operation. All automatic transfer & bypass-isolation switches and controllers shall be the products of the same manufacturer

B. Codes and Standards

1. UL 1008 - Standard for Transfer Switch Equipment
2. CSA certified to CSA 22.2 No 178 - 1978 Automatic Transfer Switches
3. IEC 60947-6-1 Low-voltage Switchgear and Control gear; Multifunction equipment; Automatic Transfer Switching Equipment
4. NFPA 70 - National Electrical Code
5. NFPA 99 - Essential Electrical Systems for Health Care Facilities
6. NFPA 110 - Emergency and Standby Power Systems
7. IEEE Standard 446 - IEEE Recommended Practice for Emergency and Standby Power Systems for Commercial and Industrial Applications
8. NEMA Standard ICS10-1993 {formerly ICS2-447) - AC Automatic Transfer Switches
9. International Standards Organization ISO 9001:2008
10. UL 508 Industrial Control Equipment

C. Mechanically Held Transfer Switch

1. The transfer switch shall be electrically operated and mechanically held. The electrical operator shall be a momentarily energized, single-solenoid mechanism. Main operators which include overcurrent disconnect devices, linear motors or gears shall not be acceptable. The switch shall be mechanically interlocked to ensure only two possible positions, normal or emergency.

2. All transfer switch sizes shall use only one type of main operator for ease of maintenance and commonality of parts.

3. The switch shall be positively locked and unaffected by momentary outages, so that contact pressure is maintained at a constant value and contact temperature rise is minimized for maximum reliability and operating life.

4. All main contacts shall be silver composition. Switches rated 800 amperes and above shall have segmented, blow-on construction for high withstand and close-on capability and be protected by separate arcing contacts.

5. Inspection of all contacts shall be possible from the front of the switch without disassembly of operating linkages and without disconnection of power conductors. Switches rated 800 amps and higher shall have front removable and replaceable contacts. All stationary and moveable contacts shall be replaceable without removing power conductors and/or bus bars.

6. Designs utilizing components of molded-case circuit breakers, contactors, or parts thereof, which are not intended for continuous duty, repetitive switching or transfer between two active power sources are not acceptable.

7. Where neutral conductors must be switched as shown on the plans, the AS shall be provided with fully rated overlapping neutral transfer contacts. The neutrals of the normal and emergency power sources shall be connected together only during the transfer and retransfer operation and remain connected together until power source contacts close on the source to which the transfer is being made. The overlapping neutral contacts shall not overlap for a period greater than 100 milliseconds. Neutral switching contacts which do not overlap are not acceptable.

8. Where neutral conductors are to be solidly connected as shown on the plans, a neutral conductor plate with fully rated AL-CU pressure connectors shall be provided.

D. Bypass-Isolation Switch

1. A two-way bypass-isolation switch shall provide manual bypass of the load to either source and permit isolation of the automatic transfer switch from all source and load power conductors. All main contacts shall be manually driven.

2. Power interconnections shall be silver-plated copper bus bar. The only field installed power connections shall be at the service and load terminals of the bypass-isolation switch. All control inter-wiring shall be provided with disconnect plugs.

3. Separate bypass and isolation handles shall be utilized to provide clear distinction between the functions. Handles shall be permanently affixed and operable without opening the enclosure door. Designs requiring insertion of loose operating handles or opening of the enclosure door to operate are not acceptable.

4. Bypass to the load-carrying source shall be accomplished with no interruption of power to the load (make before break contacts). Designs which disconnect the load when bypassing are not acceptable. The bypass handle shall have three operating modes: "Bypass to Normal," "Automatic," and "Bypass to Emergency." The operating speed of the bypass contacts shall be the same as the associated transfer switch and shall be independent of the speed at which the manual handle is operated. In the "Automatic" mode, the bypass contacts shall be out of the power circuit so that they will not be subjected to fault currents to which the system may be subjected.

5. The isolation handle shall provide three operating modes: "Closed," "Test," and "Open." The 'Test" mode shall permit testing of the entire emergency power system,

including the automatic transfer switches with no interruption of power to the load. The "Open" mode shall completely isolate the automatic transfer switch from all source and load power conductors. When in the "Open" mode, it shall be possible to completely withdraw the automatic transfer switch for inspection or maintenance to conform to code requirements without removal of power conductors or the use of any tools.

6. When the isolation switch is in the "Test" or "Open" mode, the bypass switch shall function as a manual transfer switch.

7. Designs requiring operation of key interlocks for bypass isolation or ATSs which cannot be completely withdrawn when isolated are not acceptable.

E. Microprocessor Controller

1. The controller's sensing and logic shall be provided by a single built-in microprocessor for maximum reliability, minimum maintenance, andthe ability to communicate serially through an optional serial communication module.

2. A single controller shall provide twelve selectable nominal voltages for maximum application flexibility and minimal spare part requirements. Voltage sensing shall be true RMS type and shall be accurate to ± 1% of nominal voltage. Frequency sensing shall be accurate to ± 0.2%. The panel shall be capable of operating over a temperature range of -20 to +60 degrees C and storage from -55 to +85 degrees C.

3. The controller shall be connected to the transfer switch by an interconnecting wiring harness. The harness shall include a keyed disconnect plug to enable the controller to be disconnected from the transfer switch for routine maintenance. Sensing and control logic shall be provided on multi-layer printed circuit boards. Interfacing relays shall be industrial grade plug-in type with dust covers. The panel shall be enclosed with a protective cover and be mounted separately from the transfer switch unit for safety and ease of maintenance. The protective cover shall include a built-in pocket for storage of the operator's manuals.

4. All customer connections shall be wired to a common terminal block to simplify field-wiring connections.

5. The controller shall meet or exceed the requirements for Electromagnetic Compatibility (EMC) as follows:

a.	EN 55011:1991	Emission standard - Group 1, Class A
b.	EN 50082-2:1995	Generic immunity standard
c.	EN 61000-4-2:1995	Electrostatic discharge (ESD) immunity
d.	ENV 50140:1993	Radiated Electro-Magnetic field immunity
e.	EN 61000-4-4:1995	Electrical fast transient (EFT) immunity
f.	EN 61000-4-5:1995	Surge transient immunity
g.	EN 61000-4-6:1996	Conducted Radio-Frequency field immunity

F. Enclosure

1. The ATS/BPS shall be furnished in a Type 1 enclosure unless otherwise shown on the plans.

2. All standard and optional door-mounted switches and pilot lights shall be 16-mm industrial grade type or equivalent for easy viewing & replacement. Door controls shall be provided on a separate removable plate, which can be supplied loose for open type units.

G. Controller Display and Keypad

1. A four-line, 20 character LCD display and keypad shall be an integral part of the controller for viewing all available data and setting desired operational parameters. Operational parameters shall also be available for viewing and limited control through the serial communications input port. The following parameters shall only be adjustable via DIP switches on the controller:

   a. Nominal line voltage and frequency

   b. Single or three phase sensing

   c. Operating parameter protection

   d. Transfer operating mode configuration

2. All instructions and controller settings shall be easily accessible, readable and accomplished without the use of codes, calculations, or instruction manuals.

H. Voltage, Frequency and Phase Rotation Sensing

1. Voltage and frequency on both the normal and emergency sources (as noted below) shall be continuously monitored, with the following pickup, dropout and trip setting capabilities (values shown as % of nominal unless otherwise specified):

Parameter	Sources	Dropout/Trio	Pickup / Reset
Undervoltaqe	N&E,3-phase	70 to 98%	85 to 100%
Overvoltage	N&E,3-phase	102 to 115%	2% below trip
Underfrequency	N&E	85 to 98%	90 to 100%
Overfrequency	N&E	102 to 110%	2% below trip
Voltage unbalance	N&E	5 to 20%	1 % below dropout

2. Repetitive accuracy of all settings shall be within ± 0.5% over an operating temperature range of -20°C to 60°C.

3. Voltage and frequency settings shall be field adjustable in 1% increments either locally with the display and keypad or remotely via serial communications port access.

4. The controller shall be capable (when activated by the keypad or through the serial port) of sensing the phase rotation of both the normal and emergency sources. The source shall be considered unacceptable if the phase rotation is not the preferred rotation selected (ABC or CBA).

5. Source status screens shall be provided for both normal & emergency to provide digital readout of voltage on all 3 phases, frequency, and phase rotation.

6. The controller shall include a user selectable algorithm to prevent repeated transfer cycling to a source on an installation which experiences primary side, single phase failures on a Grounded Wye - Grounded Wye transformer which regenerates voltage when unloaded. The algorithm shall also inhibit retransfer to the normal (utility) source upon detection of a single phasing condition until a dedicated timer expires, the alternate source fails, or the normal source fails completely and is restored during this time delay period. The time delays associated with this feature shall be adjustable by the user through the controller keypad and LCD.

I. Time Delays

1. An adjustable time delay of 0 to 6 seconds shall be provided to override momentary normal source outages and delay all transfer and engine starting signals. Capability shall be provided to extend this time delay to 60 minutes by providing an external 24 VDC power supply.
2. A time delay shall be provided on transfer to emergency, adjustable from 0 to 60 minutes, for controlled timing of transfer of loads to emergency.
3. Two time delay modes (which are independently adjustable) shall be provided on re-transfer to normal. One time delay shall be for actual normal power failures and the other for the test mode function. The time delays shall be adjustable from 0 to 60 minutes. Time delay shall be automatically bypassed if the emergency source fails and the normal source is acceptable.
4. A time delay shall be provided on shut down of engine generator for cool down, adjustable from 0 to 60 minutes.
5. A time delay activated output signal shall also be provided to drive an external relay(s) for selective load disconnect control. The controller shall have the ability to activate an adjustable 0 to 5 minute time delay in any of the following modes:
    a. Prior to transfer only.
    b. Prior to and after transfer.
    c. Normal to emergency only.
    d. Emergency to normal only.
    e. Normal to emergency and emergency to normal.
    f. All transfer conditions or only when both sources are available.
6. The controller shall also include the following built-in time delays for optional Closed Transition and Delayed Transition operation:
    a. 1 to 5 minute time delay on failure to synchronize normal and emergency sources prior to closed transition transfer.
    b. 0.1 to 9.99 second time delay on an extended parallel condition of both power sources during closed transition operation.
    c. 0 to 5 minute time delay for the load disconnect position for delayed transition operation.
7. All time delays shall be adjustable in 1 second increments, except the extended parallel time, which shall be adjustable in .01 second increments.
8. All time delays shall be adjustable by using the LCD display and keypad or with a remote device connected to the serial communications port.

J. Additional Features

1. A three position momentary-type test switch shall be provided for the test / automatic / reset modes. The test position will simulate a normal source failure. The reset position shall bypass the time delays on either transfer to emergency or retransfer to normal.
2. A SPDT contact, rated 5 amps at 30 VDC, shall be provided for a low-voltage engine start signal. The start signal shall prevent dry cranking of the engine by requiring the generator set to reach proper output and run for the duration of the cool down setting, regardless of whether the normal source restores before the load is transferred.

3. Auxiliary contacts, rated 10 amps, 250 VAC shall be provided consisting of one contact, closed when the ATS is connected to the normal source and one contact closed, when the ATS is connected to the emergency source.

4. LED indicating lights (16 mm industrial grade, type 12) shall be provided; one to indicate when the ATS is connected to the normal source (green) and one to indicate when the ATS is connected to the emergency source (red).

5. LED indicating lights (16 mm industrial grade, type 12) shall be provided and energized by controller outputs. The lights shall provide true source availability of the normal and emergency sources, as determined by the voltage sensing trip and reset settings for each source.

6. Provide the ability to select "commit/no commit to transfer" to determine whether the load should be transferred to the emergency generator if the normal source restores before the generator is ready to accept the load.

7. An Inphase monitor shall be provided in the controller. The monitor shall control transfer so that motor load inrush currents do not exceed normal starting currents and shall not require external control of power sources. The inphase monitor shall be specifically designed for and be the product of the ATS manufacturer. The inphase monitor shall be equal to ASCO Feature 27.

8. The controller shall be capable of accepting a normally open contact that will allow the transfer switch to function in a non-automatic mode using an external control device.

9. Engine Exerciser - The controller shall provide an internal engine exerciser. The engine exerciser shall allow the user to program up to seven different exercise routines. For each routine, the user shall be able to:

    a. Enable or disable the routine.

    b. Enable or disable transfer of the load during routine.

    c. Set the start time,

        1) time of day

        2) day of week

        3) week of month (1st, 2nd, 3rd, 4th, alternate or every)

    d. Set the duration of the run.

    e. At the end of the specified duration the switch shall transfer the load back to normal and run the generator for the specified cool down period. A 10-year life battery that supplies power to the real time clock in the event of a power loss will maintain all time and date information.

10. Terminals shall be provided for a remote contact which opens to signal the ATS to transfer to emergency and for remote contacts which open to inhibit transfer to emergency and/or retransfer to normal. Both of these inhibit signals can be activated through the keypad or serial port.

11. System Status - The controller LCD display shall include a "System Status" screen which shall be readily accessible from any point in the menu by depressing the "ESC" key a maximum of two times. This screen shall display a clear description of the active operating sequence and switch position. For example,

    Normal Failed
    Load on Normal
    TD Normal to Emerg

2min15s

12. Controllers that require multiple screens to determine system status or display "coded" system status messages, which must be explained by references in the operator's manual, are not permissible.

13. Self-Diagnostics - The controller shall contain a diagnostic screen for the purpose of detecting system errors. This screen shall provide information on the status input signals to the controller which may be preventing load transfer commands from being completed.

14. Data Logging - The controller shall have the ability to log data and to maintain the last 99 events, even in the event of total power loss. The following events shall be time and date stamped and maintained in a nonvolatile memory:

    a. Event Logging

        1) Data and time and reason for transfer normal to emergency.

        2) Data and time and reason for transfer emergency to normal.

        3) Data and time and reason for engine start.

        4) Data and time engine stopped.

        5) Data and time emergency source available.

        6) Data and time emergency source not available.

    b. Statistical Data

        1) Total number of transfers.

        2) Total number of transfers due to source failure.

        3) Total number of days controller is energized.

        4) Total number of hours both normal and emergency sources are available.

15. Communications Module - Shall provide remote interface module to support monitoring of vendor's transfer switch, controller and optional power meter. Module shall provide status, analog parameters, event logs, equipment settings & configurations over embedded webpage and open protocol. Features shall include:

    a. Email notifications and SNMP traps of selectable events and alarms may be sent to a mobile device or PC.

    b. Modbus TCP/IP, SNMP, HTTP, SMTP open protocols shall be simultaneously supported.

    c. Web app interface requiring user credentials to monitor and control the transfer switch supporting modern smart phones, tablets and PC browsers. User will be able to view the dynamic one-line; ATS controls status, alarms, metering, event logging as well as settings.

    d. Secure access shall be provided by requiring credentials for a minimum of 3 user privilege levels to the web app, monitor (view only), control (view and control) and administrator (view, control and change settings). 128-Bit AES encryption standard shall be supported for all means of connectivity.

    e. Shall allow for the initiating of transfers, retransfers, bypassing of active timers and the activating/deactivating of engine start signal shall be available over the embedded webpage and to the transfer switch vendor's monitoring equipment.

f. An event log displaying a minimum of ninety-nine (300) events shall be viewable and printable from the embedded webpages and accessible from supported open protocols.

g. Four (4) 100 Mbps Ethernet copper RJ-45 ports, five (2) serial ports, Termination dip-switches and LEDs for diagnostics.

h. DIN rail mountable.

16. External DC Power Supply - An optional provision shall be available to connect an external 24 VDC power supply to allow the LCD and the door mounted control indicators to remain functional when both power sources are dead.

K. Withstand and Closing Ratings

1. The ATS/BPS shall be rated to close on and withstand the available RMS symmetrical short circuit current at the ATS/BPS terminals with the type of overcurrent protection shown on the plans.

2. The ATS/BPS shall be UL listed in accordance with UL 1008 and be labeled in accordance with .025 and .050 seconds, time based ratings, or appropriate short time rating(s) as applicable. ATS/BPSs which are not tested and labeled with.025 and.050 seconds time based rating(s) or appropriate short time rating(s) and have series, or specific breaker ratings only, are not acceptable.

L. Tests and Certification

1. The complete ATS/BPS shall be factory tested to ensure proper operation of the individual components and correct overall sequence of operation and to ensure that the operating transfer time, voltage, frequency and time delay settings are in compliance with the specification requirements.

2. The ATS/BPS manufacturer shall be certified to ISO 9001:2008 International Quality Standard and the manufacturer shall have third party certification verifying quality assurance in design/development, production, installation and servicing in accordance with ISO 9001:2008.

M. Service Representation

1. The ATS/BPS manufacturer shall maintain a national service organization of company-employed personnel located throughout the contiguous United States. The service center's personnel must be factory trained and must be on call 24 hours a day, 365 days a year.

2. The manufacturer shall maintain records of each switch, by serial number, for a minimum of 20 years.

2.4 MANUAL TRANSFER SWITCH

A. General

1. Furnish and install manual transfer switches (MTS) with number of poles, amperage, voltage, and withstand current ratings as shown on the plans. Each manual transfer shall consist of a 3-position center off mechanically held power transfer switch unit and a mechanical operating mechanism to provide complete manual operation. All transfer switches and mechanical operating mechanism shall be the product of the same manufacturer.

B. Codes and Standards

1. UL 1008 Listed for Optional Standby Transfer Switches (Manual Transfer Switches)

2. CSA C22.2 No.178 – 1978
3. IEC 60947-6-1 Low – Voltage Switchgear and Controller
4. NFPA 70 - National Electrical Code
5. NFPA 99 – Essential Electrical Systems for Health Care Facilities
6. IEEE Standard 446 - IEEE Recommended Practice for Emergency and Standby Power Systems for Commercial and Industrial Applications
7. UL 508 Industrial Control Equipment
8. NEC Article 700.3 (F)
9. International Standards Organization ISO 90estrication 01: 2008
10. RoHs compliant (Restriction of Hazardous Substances)
11. Seismic qualification – International Building Code & OSHPD to SDS level of 2.5

C. Mechanically Held Transfer Switch

1. The transfer switch unit shall be manually operated and mechanically held. The switch shall be mechanically interlocked to ensure only one of three possible positions, Source 1, Source 2, or Center Off Fused disconnect type switches shall not be acceptable.
2. The switch shall be positively locked and unaffected by momentary outages so that contact pressure is maintained at a constant value and temperature rise at the contacts is minimized for maximum reliability and operating life.
3. All main contacts shall be silver composition. Switches rated 600 amperes and above shall have segmented blow-on construction for high withstand current capability and be protected by separate arcing contacts.
4. Inspection of all contacts shall be possible from the front of the switch without disassembly of operating linkages and without disconnection of power conductors.
5. Designs utilizing components of molded-case circuit breakers, contactors, or parts thereof which are not intended for continuous duty, repetitive switching or transfer between two active power sources are not acceptable.
6. Where neutral conductors must be switched, the MTS shall be provided with fully-rated neutral transfer contacts.
7. Where neutral conductors are to be solidly connected, a neutral terminal plate with fully-rated AL-CU pressure connectors shall be provided.
8. The MTS shall be tested in accordance with UL 1008 for transfer switches. Switch ratings of 260 amperes and less shall have endurance rating of 6000 cycles, 400 ampere shall have endurance rating of 4000 cycles, and 600 - 3000 ampere shall have endurance rating of 3000 cycles.

D. Manual Operations Provisions

1. The transfer switch shall be arranged for manually actuated manual operation.
2. The manual transfer shall be actuated via a mechanical operating mechanism.
3. The manual operating handle shall be capable of external operation without opening the enclosure door.
4. It shall have the same contact to contact speed as automatic operation
5. There shall be three positions for manual operation:

a. Connected to Source 1 (preferred)

b. Connected to Source 2 (alternate)

c. Connected to center off (disconnected position)

6. Switch position when connected to Source 1, or Source 2 shall be pad – lockable

E. Enclosure

1. The 3MTS shall be furnished in a NEMA type 1 enclosure unless otherwise shown on the plans.

2. Enclosures shall be free standing, floor mounted.

3. Enclosures shall be code gauge steel as per UL 50 with ANSI #61 powder coat finish.

4. Outdoor enclosures shall be available in 316 stainless steel

5. Provide strip heater with thermostat for Type 3R enclosure requirements.

F. Additional Features

1. Mechanical position indicators (yellow) visible to the operator shall be included for Source 1 (preferred), Source 2, (alternate), and Center Off (disconnected).

2. LED indicators shall be available for Source 1 (preferred), and Source 2 (alternate).

3. Auxiliary position indicating contacts, rated 10 amps, 250 Vac shall be provided consisting of one closed when the MTS is connected to Source 1 (preferred), and one contact closed when the MTS is connected to Source 2 (alternate)

4. A form A contact shall be provided to indicate switch is in the Center Off (disconnected) position.

5. Surge Suppression – A TVSS with a surge current rating of 65kA shall be provided with individually matched fused metal oxide varistors (MOVs). It shall include LED status indication of normal operation, under voltage, power loss, phase loss or component failure. Shall include form C dry contacts for external alarm or monitoring. The unit shall be enclosed in a Noryl housing rated NEMA 4, 12, and 4X. Shall comply with UL 1449 3rd edition

6. Accessory 170 Base Package Bundle – Two form C contacts shall be connected to customer terminal block that operate when Source 1 and Source 2 voltage is present at transfer switch terminals. The following indicators shall be provided:

a. Load Connected to Source 1 (Green)

b. Load Connected to Source 2 (Red)

c. Source 1 Available (Green)

d. Source 2 Available (Red)

e. Load Disconnect (Yellow)

G. Withstand and Closing Ratings

1. The MTS shall be rated to close on and withstand the available RMS symmetrical short circuit current at the MTS terminals with the type of overcurrent protection shown on the plans. WCR MTS ratings @ 480v shall be as follows when used with specific circuit breakers or current limiting fuses:

MTS Size	Withstand & Closing	W/CLF

	Rating MCCB	
150A – 600A	50,000A	200,000A
800A – 1200A	65,000A	200,000A
1600A – 3000A	100,000A	200,000A

H. Tests and Certification

1. The complete MTS shall be factory tested to ensure proper operation of the individual components and correct overall sequence of operation and to ensure compliance with the specification requirements.

2. Upon request, the manufacturer shall provide a notarized letter certifying compliance with all of the requirements of this specification including compliance with the above codes and standards and withstand and closing ratings. The certification shall identify, by serial number(s), the equipment involved. No exceptions to the specifications, other than those stipulated at the time of the submittal, shall be included in the certification.

3. The MTS manufacturer shall be certified to ISO 9001: 2008 International Quality Standard and the manufacturer shall have third party certification verifying quality assurance in design/development, production, installation and servicing in accordance with ISO 9001: 2008.

I. Service Representation

1. The MTS manufacturer shall maintain a national service organization of company-employed personnel located throughout the contiguous United States. The service center's personnel must be factory trained and must be on call 24 hours a day, 365 days a year.

2. The manufacturer shall maintain records of switch shipments, by serial number, for a minimum of 20 years.

3. For ease of maintenance, the transfer switch nameplate shall include drawing numbers and serviceable part numbers.

2.5 PORTABLE GENERATOR DOCK

A. General

1. Quick Connect Input Power panels shall provide a convenient, reliable and economical way to connect temporary emergency power from portable generators to a facility in conjunction with an ASCO transfer switch. Quick Connect Output Panels shall provide a convenient way to connect load banks to a facility.

2. The Quick Connect Power panels shall be available in rating configurations from 400 Amp to 4000 Amp Service. Input Panels shall be listed to UL 1008 as a transfer switch accessory; Output Panels shall be listed to UL 891 for Switchboards.

3. Quick Connect Power Panels shall be ASCO 300 Series (3QC). Any alternate shall be submitted for approval to the consulting engineer at least 10 days prior to bid. Alternate bids must list any deviations from this specification.

B. Mechanical

1. All quick connect power panels shall be Type 3R compliant and constructed of aluminum, mild steel or Stainless Steel. The Type 3R rating shall be maintained with the temporary cables installed.

2. Cables shall enter and exit the wiring chamber via access holes specifically designed for conductors and shall be provided with a bushing or shall be formed so that there are no sharp edges with which conductor insulation may come in contact.
3. Connections shall be arranged so that cables drape downward when connected.
4. 400-800 Amp Models
    a. The quick connect panel shall have an enclosure manufactured of aluminum and painted ANSI 61 gray or Grade 316 stainless steel.
    b. The quick connect panel enclosure dimensions shall be 24" wide x 32” high x 11” deep.
    c. The quick connect panel shall include four (4) integral mounting tabs for wall mounting.
    d. The quick connect panel shall be divided into an upper termination chamber and a lower wiring chamber.
    e. The upper termination chamber shall have a dead front panel covering all exposed electrical parts.
    f. The lower chamber shall have individual cable holes to restrict access and reducing the possibility of theft.
    g. The cable access holes shall have a hinged cover held closed by springs inherently resistant to corrosion in order to securely cover the cable access holes when the temporary cables are not installed.
    h. The quick connect panel shall have an additional cable lock plate to reduce risk of cable theft. This lock plate will also serve to lock the hinged cable access door(s) when the temporary power cables are not installed.
    i. The quick connect panel shall have an outer single hinged access door restricting access to both wiring chambers for safety and security.
    j. The outer access door shall have a padlock hasp preventing unauthorized entry.
5. 1200- and 1600-Amp Models
    a. The quick connect panel shall have an enclosure manufactured of 12 gauge galvanized steel painted ANSI 61 gray or 316 stainless steel.
    b. The quick connect panel enclosure dimensions shall be 35” wide x 56” high x 28” deep.
    c. The quick connect panel shall include four (4) feet for floor or concrete pad mounting. Holes in the bottom of the feet shall be available for anchoring the enclosure to the floor or pad.
    d. The quick connect panel shall be divided into an upper termination chamber and a lower wiring chamber.
    e. The upper termination chamber shall have a key lock handle door covering all exposed electrical parts.
    f. The lower chamber main door shall have a key lock handle main door covering all exposed camlock connectors.
    g. The lower chamber main door shall have a smaller trap door for cable egress. This trap door shall have a key lock handle to preventing unauthorized entry.
6. 2000A-4000A Amp Models

a. The quick connect power panel shall have an enclosure manufactured of aluminum or 316 stainless steel.

b. The quick connect panel shall not have enclosure dimensions that exceed 39.00" H x 31.00” W x 50.00” D for 2000A and 39.00" H x 48.00” W x 50.00”D for 2400A and above.

c. The quick connect panel shall be able to accommodate rear, side and bottom cable entry.

d. Multiple Chamber style design to isolate permanent connections and camlock connections.

e. Pad-lockable tamper resistant door preventing access to temporary connections while unit is in use.

f. Trap door for cable egress.

g. 45-degree camlocks for hassle free connection eliminating stress on cables during operation.

h. Provisions for Trap Key interlock prevent access to temporary connections while cables are energized.

i. Slotted fingers to restrict cable access reducing theft.

C. Electrical

1. The quick connect panel shall be have input and output connections rated up to 600 VAC, as specified in the contract documents.

   a. Input Panels - Recessed male connectors

   b. Output Panels - Female connectors with flip covers.

2. All electrical connectors shall be cam type single pole connectors compatible with Marinco or Leviton 16 Series CAM Locks™ and available color coded as per industry standard practice:

   a. 240V and below: phase 1 = black, phase 2 = red, phase 3 = blue (if required).

   b. 440 to 480V: phase 1 = brown, phase 2 = orange, phase 3 = yellow.

   c. Ground shall always be green.

   d. Neutral shall always be white.

3. 400-800 Amp Models

   a. The upper termination chamber shall be provided with lug terminals for the permanently installed conductors.

   b. The lower chamber shall have the cam type single pole connectors as specified above:

   c. For 400A models, there shall be one (1) row of up to five (5) series single pole connections.

   d. For 800A models, there shall be two (2) rows of up to five (5) single pole connections.

   e. Withstand Current Rating (WCR) shall be no less than 10kA verified by testing supervised by a Nationally Recognized Testing Laboratory, not by calculation.

4. 1200-1600A Amp Models

a. The upper termination chamber shall have copper buss bars:

1) Designed for a current density not to exceed 725 amps per square inch cross sectional area

2) With holes to accommodate standard ½" hardware drilled on 1.95" centers.

b. The lower chamber shall have the cam type single pole connectors as specified above:

1) For 1200A, there shall be three (3) rows of up to 5 single pole connections.

2) For 1600A, there shall be four (4) rows of up to 5 single pole connections.

c. Withstand Current Rating (WCR) shall be no less than 22kA verified by testing supervised by a Nationally Recognized Testing Laboratory, not by calculation.

5. 2000A-4000A Amp Models

a. The rear chamber which houses the permanent connections will have mechanical lugs.

1) For 2000A, there shall be six (6) single (#2 AWG to 600 MCM) mechanical lugs.

2) For 2400A, there shall be eight (8) single (#2 AWG to 600 MCM) mechanical lugs.

3) For 2800A, there shall be nine (9) single (#2 AWG to 600 MCM) mechanical lugs.

4) For 3200A, there shall be ten (10) single (#2 AWG to 600 MCM) mechanical lugs.

5) For 3600A, there shall be eleven (11) single (#2 AWG to 600 MCM) mechanical lugs.

6) For 4000A, there shall be twelve (12) single (#2 AWG to 600 MCM) mechanical lugs.

b. The front of the panel shall have the cam type single pole connectors as specified above:

1) For 2000A, there shall be three (5) rows of up to 5 single pole connections.

2) For 2400A, there shall be four (6) rows of up to 5 single pole connections.

3) For 2800A, there shall be three (7) rows of up to 5 single pole connections.

4) For 3200A, there shall be four (8) rows of up to 5 single pole connections.

5) For 3600A, there shall be three (9) rows of up to 5 single pole connections.

6) For 4000A, there shall be four (10) rows of up to 5 single pole connections.

c. Withstand Current Rating (WCR) shall be no less than 100kA verified by testing supervised by a Nationally Recognized Testing Laboratory, not by calculation.

d. Phase Rotation Monitor

e. Two wire auto start

D. Compliance

1. The 400-4000 Amp quick connect Input panel must be listed to UL 1008 under Annex J as a Transfer Switch Accessory. Output Panel must be listed to UL 891 for Panelboards.

2. "Built to the standard" shall not be allowed: the quick connect panels shall be tested in accordance with and listed to UL 1008 or UL 891 standards.

3. UL 50 Listed enclosures may be used but only listed to UL 50 shall not be acceptable.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Design each fastener and support to carry load indicated by seismic requirements and according to seismic-restraint details. See Division 26 Section "Vibration and Seismic Controls for Electrical Systems."

B. Floor-Mounting Switch: Anchor to floor by bolting.

1. Concrete Bases: 4 inches (100 mm) high, reinforced, with chamfered edges. Extend base no more than 4 inches (100 mm) in all directions beyond the maximum dimensions of switch, unless otherwise indicated or unless required for seismic support. Construct concrete bases according to Division 26 Section "Hangers and Supports for Electrical Systems."

C. Identify components according to Division 26 Section "Identification for Electrical Systems."

D. Set field-adjustable intervals and delays, relays, and engine exerciser clock.

3.2 CONNECTIONS

A. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

B. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.3 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections. Report results in writing.

B. Perform tests and inspections and prepare test reports.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installation, including connections, and to assist in testing.

2. After installing equipment and after electrical circuitry has been energized, test for compliance with requirements.

3. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.

4. Measure insulation resistance phase-to-phase and phase-to-ground with insulation-resistance tester. Use test voltages and procedure recommended by manufacturer. Comply with manufacturer's specified minimum resistance.

    a. Check for electrical continuity of circuits and for short circuits.

    b. Inspect for physical damage, proper installation and connection, and integrity of barriers, covers, and safety features.

    c. Verify that manual transfer warnings are properly placed.

    d. Perform manual transfer operation.

5. After energizing circuits, demonstrate interlocking sequence and operational function for each switch at least three times.

    a. Simulate power failures of normal source to automatic transfer switches and of emergency source with normal source available.

    b. Simulate loss of phase-to-ground voltage for each phase of normal source.

    c. Verify time-delay settings.

    d. Verify pickup and dropout voltages by data readout or inspection of control settings.

    e. Perform contact-resistance test across main contacts and correct values exceeding 500 microhms and values for 1 pole deviating by more than 50 percent from other poles.

    f. Verify proper sequence and correct timing of automatic engine starting, transfer time delay, retransfer time delay on restoration of normal power, and engine cool-down and shutdown.

6. Ground-Fault Tests: Coordinate with testing of ground-fault protective devices for power delivery from both sources.

    a. Verify grounding connections and locations and ratings of sensors.

C. Coordinate tests with tests of generator and run them concurrently.

D. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation and contact resistances and time delays. Attach a label or tag to each tested component indicating satisfactory completion of tests.

E. Remove and replace malfunctioning units and retest as specified above.

F. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each switch. Remove all access panels so joints and connections are accessible to portable scanner.

1. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

2. Record of Infrared Scanning: Prepare a certified report that identifies switches checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.4 COMMISSIONING

A. Comply with requirements specified in Division 1.

B. Engage a factory-authorized service representative to supervise and assist with startup service. Complete installation and startup check according to the approved manufacturer's written instructions.

3.5 TRAINING AND SERVICE

A. Comply with Section 26 00 01.

B. Conduct four 4-hour training session. Train the Owner’s maintenance personnel on procedures and schedules related to start up and shutdown, troubleshooting, servicing, and preventive maintenance.

End of Section

DO NOT REMOVE
THIS PAGE INTENTIONALLY LEFT BLANK

Section 26 41 13

(TRADE CONTRACT REQUIRED AS PART OF SECTION 26 00 01)

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. PUBLICLY BID TRADE CONTRACT REQUIREMENTS: As provided under Section 26 00 01 - ELECTRICAL and supplemented under the Bidding Requirements, Contract Forms, and Conditions of the Contract, and applicable parts of Division 1 - GENERAL REQUIREMENTS.

1. Work of this Trade Contract includes all individual specification sections listed in Section 26 00 01.

1.2 RELATED DOCUMENTS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications

1.3 DESCRIPTION

A. Provide lightning protection system and related work in accordance with Contract Documents.

B. Scope of Work includes:

1. Provide early streamer emission (ESE) lightning protection system for building.

C. Related Work of other Sections:

1. Roof flashing
2. Non-metallic conduit
3. Surge Suppression
4. Grounding

1.4 QUALITY ASSURANCE

A. Codes: Comply with the Building Code of the State and standards listed.

B. Standards:

1. Underwriters Laboratories Inc.
   a. UL 96
2. Manufacturer’s Installation Standard
   a. HBP-21
3. The lightning protection system shall be designed by the engineering staff of the manufacturer of the equipment proposed to be installed.

C. Qualifications:

1. Installer’s Qualifications:

a. The installation shall be made by or under the supervision of a licensed electrical contractor.

D. Certification:

1. Applied Research Laboratories (ARL) shall certify that the lightning protection system has been installed in accordance with the design and specification requirements.

a. Applied Research Laboratories Inspection. Send completed ARL Certification Application Form to:

1) Applied Research Laboratories, 5371 N. W. 161st Street, Miami, FL 33014

2) Correction of Work: Areas indicating non-conformance with Manufacturer's Installation Standard HBP-21 shall be corrected by the installing contractor at no additional cost to the owner.

3) After completion of ARL inspection and acceptance, provide the owner with ARL Certification, Manufacturer's guarantee, warranty and $10,000,000 insurance coverage.

E. Testing:

1. A resistance-to-ground test of the completed system shall be performed using IEEE "Fall of Potential Method".

a. Resistance-to-ground reading shall not exceed 10 ohms.

1.5 SUBMITTALS

A. Submittal Package: Complete shop drawings showing the type, size and locations of all equipment, grounds and cable routings shall be submitted to the architect for approval prior to start of work.

B. Submit shop drawings and product data as specified below.

1. Shop Drawings: Detailed scale drawings of the complete system as proposed to be installed.

2. Product Data:

a. Catalog cut sheets and installation instructions

b. Bill of materials

1.6 WARRANTY

A. Comply with Section 260001.

B. The Electrical Trade Contractor shall warranty that all materials furnished shall be free from defects of material for a period of one year from the date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Manufacturers

1. Heary Bros. Lightning Protection Co. Inc.

2. Lightning Preventor of America.
3. Thompson Lightning Protection, Inc.
4. Or approved equal.

B. All materials for this installation shall be as defined by Underwriters Laboratories UL 96.

C. Copper shall be of the grade ordinarily required for commercial electrical Work, generally designated as being 98 percent conductivity when annealed.

1. Copper components shall not be used on aluminum surfaces.

D. Air terminal:

1. Early Streamer Emission (ESE) air terminal
   a. 5/8” x 12” chrome plated copper
   b. Chrome plated copper support structure and sphere
   c. Threaded air terminal

E. Conductors:

1. Copper Cable
   a. Copper 28 strands of 14 gauge copper ropelay wire, 115,000 circular mils, weighing not less than 375 lbs. per 1000 ft.
   b. The structural steel may be used in lieu of down conductors.
      1) Every other column or an average of 60’-0” intervals shall be bonded and connected to the ground system.

F. Attachments:

1. Fasteners shall be of suitable configuration for the intended application and of the same material as the conductor. Nails, screws or bolts employed to secure the fasteners shall be stainless steel.

G. Connections and Splices:

1. Connectors and splices shall be of suitable configuration and type for the intended application and of the same materials as the conductor.

H. Ground Rods:

1. 3/4” x 10’-0” copper-bond ground rods with two-bolt copper ground rod clamp.
2. One delta ground grid shall be installed for each down conductor.
3. 24” x 24” x 20 gauge copper ground plates may be used in lieu of ground rods if soil conditions do not allow driving of ground rods.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install the lightning protection system as required to obtain ARL certification.

B. The system shall consist of a mast-type system on the highest roof. The system shall include air terminal, mast, grounding cable, ground rods and splices.

C. Cables on roof shall be exposed and shall be fastened every 3’-0” max.

D. Downlead cables to ground rods shall be in 1” non-metallic conduit concealed within building construction.

E. Downlead cables shall not be brought directly through the roof. Conduit through pitch pockets or proper roof flashings shall be utilized for this purpose.

F. The roofing contractor shall furnish and install all proper roof flashings.

G. The electrical contractor shall furnish and install all necessary conduit for concealed down conductors.

H. Copper components shall not be connected to aluminum surfaces except by means of a bimetal connector.

3.2 COORDINATION

A. The lightning protection installer shall work with other trades to insure a correct, neat and unobtrusive installation.

B. A sound bond shall be made to the main water service, and to all other building grounding systems, including both telephone and electrical.

C. Proper surge arresters shall be installed on the power and telephone service by either the utility or the electrical contractor, as applicable.

1. Install surge arresters on electric service entrance secondary conductors.

3.3 INSPECTION AND LISTING LABORATORY

A. The installing contractor shall provide a videotape of the installation, including but not limited to; air terminal, mast mounting, bonding connections (waterline & structural steel), down conductors, ground rods/grids, test results and all buried, concealed or inaccessible connections and components.

1. The videotape and resistance-to-ground test results shall be forwarded to the lightning protection system manufacturer for review.

2. Upon completion of the installation, ARL shall inspect the installation (via videotape) for compliance with Manufacturer’s Installation Standard HBP-21.

End of Section

Section 26 50 00

STAGE AND HOUSE LIGHTING AND CONTROLS

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. The Trade Contractor for this Section shall examine all Drawings and all Sections of the Specification for requirements therein that may affect the Work of this Section, not just those Drawings and Specifications particular to the Work of this Section. The Work of this Section is shown primarily on the following listed Drawings:

a. Architectural
b. Electrical
c. Security
d. Audiovisual
e. Theatrical Lighting
f. Theatrical Rigging

B. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.

C. Examine all other Sections of the Specifications for requirements that affect work of this Section whether or not such work is specifically mentioned in this Section.

D. Coordinate work with that of all other trades affecting or affected by work of this Section. Cooperate with such trades to assure the steady progress of all work under the Contract.

1.2 EXAMINATION OF SITE AND DOCUMENTS

A. Bidders are expected to examine and to be thoroughly familiar with all contract documents and with the conditions under which work will be carried out. The Awarding Authority (Owner) will not be responsible for errors, omissions and/or charges for extra work arising from General Contractor's or Trade Contractor's failure to familiarize themselves with the Contract Documents or existing conditions. By submitting a bid, the Bidder agrees and warrants that he has had the opportunity to examine the site and the Contract Documents, that he is familiar with the conditions and requirements of both and where they require, in any part of the work a given result to be produced, that the Contract Documents are adequate and that he will produce the required results.

1.3 SUMMARY

A. The work of this section includes all labor, materials, equipment and services required for the manufacture, delivery, coordination and installation of performance lighting control and distribution systems as indicated on the Drawings and schedules.

B. Section Includes

a. Engineering, manufacture, furnishing, coordination and commissioning of performance lighting power and control system including, but not limited to, the following:

1. Motorized circuit breaker panels

2. Distribution faceplates and devices
3. Control faceplates and devices
4. Control console and accessories
5. System accessories
6. Lighting fixtures
7. Configuration of system
8. User training

C. Products Supplied But Not Installed Under This Section
    a. Products installed by the Electrical Contractor
        1. Motorized circuit breaker panels
        2. Switched power distribution including connectors strips and faceplates
        3. Products installed by the Theatrical Rigging Contractor and wired by the Electrical Contractor
            a. Electric batten connector strips

1.4 RELATED WORK SPECIFIED ELSEWHERE

A. Carefully examine all of the Contract Documents for requirements which affect the Work of this Section.

B. Other Specification Sections which directly relate to the Work of this Section include, but are not limited to, the following:
    a. Section 01 00 00 - General Requirements
    b. Section 11 06 10 - Stage Rigging and Curtains
    c. Section 26 00 01 – Electrical
    d. Section 27 41 16 – Integrated Audiovisual Systems

1.5 REFERENCES

A. National Fire Protection Association (NFPA)
    a. NFPA70 - National Electrical Code
    b. NFPA 110 – Standard for Emergency and Standby Power Systems

B. American National Standards Institute (ANSI)
    a. E1.11-2004 - USITT DMX512-A
    b. E1.17-2006, Entertainment Technology – Multipurpose Network Control Protocol Suite (ACN)
    c. E1.20-2006, Entertainment Technology – Remote Device Management over USITT DMX512
    d. E1.27-1-2006, Entertainment Technology – Standard for Portable Control Cables for Use with ISUTT DMX512/1990 and E1.11 Products

C. Institute of Electrical and Electronics Engineers (IEEE)
    a. 802.3 – Ethernet
    b. 802.11 – Wireless LAN

D. Underwriters Laboratories (UL)
   a. 498 – Attachment Plugs and Receptacles
   b. 891 - Switchboards
   c. 924 – Emergency Lighting and Power Equipment
   d. 1008 – Transfer Switch Equipment

1.6 BID SUBMITTALS

A. Qualifications
   a. Manufacturer shall have been continuously engaged in the design and manufacture of performing lighting dimming and control equipment for at least ten years.
   b. Bidder shall be a system contractor, normally engaged in the full time business of lighting system installation. Provide evidence that the bidder has been in business for at least five years prior to bid date and has completed projects of similar size and scope.
   c. Bidder shall have personnel qualified to service all the equipment contained within this specification based within two hours travel time to the site.
   d. References, including names and telephone numbers of individuals who may be contacted, showing satisfactory completion of five or more projects similar in scope and type to that specified herein.
   e. Evidence of ability and affirmation of intent to meet the guarantee and service requirements stated herein.
   f. Each vendor shall include a description of the professional and technical experiences background, qualifications and expertise of the organization's key personnel assigned to this project. The description shall show that bidder possesses the demonstrated skills and experience in specific areas of the project scope. In addition, Bidder shall identify a project manager for the project and shall provide resumes of all personnel who shall be assigned to this project. Bidder shall estimate the percentage of time each individual shall be working on this project.

B. Alternates
   a. With system bid price, submit prices for equipment and installation of additional or reduced quantities of equipment as stated herein. Unless otherwise stated, all items herein are part of the base bid system.

1.7 DEFINITIONS

A. Furnish – Purchase and/or fabricate the item and deliver to site.

B. Install – Perform the physical installation of the item on the site.

C. Provide – Furnish and install item or items, complete with any and all required accessories.

1.8 SUBMITTALS

A. Provide submittals in accordance with requirements of Section 01315 - Submittals.

B. Product Data
   a. Submit complete Bill of Materials including spare parts, quantities, manufacturer and model numbers.
   b. Submit manufacturer's catalog cut sheets for all products used in the system.

C. Shop Drawings

a. Submit 11 inch by 17 inch sheets. All sheets shall be the same size. Include title sheet listing all drawings in the submittal.

b. Show all assembly instructions, termination details, cable numbers and other information required to ensure proper installation of the equipment.

c. Show all materials, finishes, metal gauges, dimensional information, electrical and mechanical connections, provision for work by others and related information.

d. Show DMX wiring and addressing scheme for related architectural lighting.

e. Indicate deviations from this Specification and label with minimum 1/4” high text: “Variation from Spec.”

f. Revise drawings with changes marked on the reviewed submittal and any changes made during manufacturing or due to coordination with other trades. Send a revised shop drawing to Architect at the time of the first delivery of equipment.

g. Installation of equipment shall not begin until shop drawings have been approved by the Architect.

h. Touch panel layouts.

D. Quality Assurance/Control

a. Submittals

1. Verify wire type, count and routing for all low-voltage wiring between components.

2. Confirm conduit sizes and routing within 30 days of contract award.

b. Test Reports

1. Prior to scheduling a final checkout the Manufacturer’s field technician shall submit to the Architect a letter stating that the system has been installed correctly is fully operational.

E. Closeout Submittals

1. Prepare and submit complete Operations and Maintenance Manuals in accordance with the requirements in Division 1.
2. Submit one (1) bound set to the Architect for review. Make revisions as directed by the Architect and submit revised manual as follows:
3. Three (3) bound sets to the Owner
4. One (1) bound set to the Architect.
5. Operations and Maintenance Manual shall contain:

a. As-built shop drawings showing all systems, interconnections and components as installed.

b. Operating instructions for all equipment

c. Compiled list of all periodic maintenance required for all components of the system

d. Printed copy of initial system configuration

e. Warranty information

f. Emergency and regular technical support telephone contact information.

g. USB stick with all applicable software, system configuration information and maintenance and instruction manuals

1.9 QUALITY ASSURANCE

A. All work and materials in this section shall comply with the following:

a. National Electrical Code NFPA 70

b. Applicable state and local construction codes

c. Tested by a Nationally Recognized Testing Laboratory such as UL or ETL.

B. Pre-installation Meetings

a. Attend coordination meetings as required to ensure installation is coordinated with other trades.

1.10 DELIVERY, STORAGE, AND HANDLING

A. Delivery, storage and handling shall be coordinated with the Electrical Contractor and meet all the requirements set forth in Division 1.

B. Packing, Shipping, Handling, and Unloading

a. Securely package all equipment in factory fabricated wooden or cardboard containers for delivery.

b. Package and handle all equipment to prevent breakage, denting and scratching of finishes. Damaged equipment shall not be installed. Replace with new units from manufacturer.

C. Storage and Protections

a. Store all equipment in a substantially complete, “broom clean”, secure and conditioned space.

b. Store all equipment in its original packaging until installation.

1.11 WARRANTY

A. Warrant systems and equipment to be free from defective components, faulty workmanship and improper adjustment for two (2) years from the date of Owner’s final acceptance of system.

B. During the warranty period repair or replace defective items within ten business days of the defect being reported. If temporary replacement equipment is required it shall be provided to the Owner at no cost.

C. Correct conditions that could present a safety hazard within forty-eight hours of notification.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. The following are the acceptable manufacturers for the primary power and control components of the system:

1. Electronic Theatre Controls (ETC)
   3031 Pleasant View Road
   Middleton, WI 53562
   800.688.4116
   www.etcconnect.com
2. Strand Lighting
   6603 Darin Way
   Cypress, CA 90630
   714.230.8200
   www.strandlighting.com

2.2 MOTORIZED CIRCUIT BREAKER PANEL

A. General
   1. Provide Ethernet-controlled AC switching panel with individual circuit over-current protection.

B. Control
   1. Control: Single universe of DMX over Ethernet
   2. Provide panel with contact-closured triggered emergency override scene recall.

C. Electrical
   1. Provide with 20A circuit breakers.
   2. Provide with integrated main circuit breaker to match electrical feed shown on Drawings.
   3. Provide panel with 100% neutral capacity.

D. Spare
   1. Provide with 10% spare breakers where space is available in panel.

E. Provide
   1. ETC Sensor IQ
   2. Equal

2.3 ARCHITECTURAL LIGHTING PROCESSOR (AP)

A. Provide unit designed for operation with supplied circuit breaker panels.

B. Provide unit with Ethernet connection to the lighting control network for configuration and control.

C. Provide unit capable of backing up settings to removable media.

D. Provide unit with two DMX ports, each of which may be configured as input or output.

E. Provide unit with 1024 channels of control.

F. Provide unit to support all specified interface stations.

G. Provide unit with RS-232 interface to AV Control System Processor if direct Ethernet connection is not supported.

H. Provide unit in rack-mount enclosure.

I. Mount unit in Lighting Control Rack.
   1. ETC Unison P-ACP w/ERn2-RM-120 enclosure
   2. Equal

2.4 AUDITORIUM CONTROL CONSOLE

1. Control Channels: 32,768
2. DMX Channels: 1,024
3. Cues: 10,000
4. Cue Lists: 1
5. Presets: 1,000
6. Groups: 1,000
7. Effects: 1,000
8. Macros: 1,000
9. Hard disk storage
10. USB port for storage, pointing and keyboard devices

11. Hue / saturation color and gel picker color mixing.
12. RDM enabled
13. Physical faders: 40

b. Interface Options
1. Support the following local interfaces:
a. AC input.
b. Keyboard and mouse
c. Two independently configurable Ethernet 802.3af compliant ports
d. Two touch-enabled displays

c. Physical
1. Console power shall be 95 – 240V AC at 50 or 60Hz, supplied via a detachable power cord.

d. Acceptable Products
1. ETC Element 2, 60 – 1K
2. Strand Equal
a. Quantity: 1

2.5 AUDITORIUM CONTROL CONSOLE ACCESSORIES

A. Provide wi-fi based hand-held 8-inch touch panel remote in ruggedized case for use as remote control for console. Provide with desktop charging stand, hand strap, and rechargeable battery.

B. Provide keyboard, mouse, dustcover, power cord, manual.

C. Provide two 24” single-touch flat-panel LCD monitors on tilting and height-adjustable stands for console.

D. Provide 25-foot Ethernet cable and 25-foot DMX control cable.

E. Uninterruptible power supply

F. Dimmable gooseneck worklight.

2.6 ARCHITECTURAL CONTROL PANELS

A. Entry Panel (EP)
1. Provide control station per drawings.
2. Provide back box for surface mount locations.
3. Provide in finish per schedule.

B. Preset Panel (PP)
1. Provide four-button, station.
2. Provide back box for surface mount locations.
3. Provide in finish per schedule.

C. Fader Panel (FP)
1. Provide twelve-button, seven-fader control station for installation in a four-gang electrical box or rack panel.
2. Provide back box for surface mount locations.
3. Provide rack panel for rack-mount locations.
4. Provide in finish per schedule.
5. Custom legend per Drawings.

D. Touch Panel (TP)

1. Provide 7-inch touch panel for installation in custom back box or rack panel.
2. Provide back box for surface and flush mount locations.

2.7 NETWORK COMPONENTS

A. Ethernet Switch (ES)

1. Provide managed network switch(es) as required for operation of the network system. Provide switches with the following properties:
2. Twenty-four (24) managed dual speed auto-sensing ports supporting 100BaseT and 10Base-T.
3. All ports on the switch shall provide Power Over Ethernet.
4. Support for multicast Ethernet
5. IGMP snooping compatible
6. Mount in standard 19 inch equipment rack.
7. Acceptable Manufacturers:
    a. Pathways connectivity
    b. Cisco
    c. HP ProCurve
    d. Juniper
    e. Equal

B. Ethernet Patch Bay

1. Provide Category 5e patch bay as required for termination of all lighting network UTP runs in the equipment rack.
2. Provide patch cords as required for connection to the Ethernet Switch.
3. Mount patch bay in standard 19” equipment rack.

C. Cable Management

1. Provide rack-mounted brush-type cable management.
2. Mount unit between Ethernet switch and Ethernet patch bay.

2.8 CONTROL DEVICES

A. General

1. Provide back boxes for all surface and pipe mounted devices and all devices that will not fit in a standard electrical gang box.
2. Provide all required mounted hardware for surface and pipe mounted back boxes.
3. Label back boxes and faceplates with unique designations printed on removable adhesive labels to correspond to shop drawings.

B. Portable Two-Port Ethernet Node

1. Ethernet node shall translate Ethernet-based control protocol into two DMX-512 ports capable of being inputs or outputs.
2. Node shall be powered via its Ethernet connection using Power Over Ethernet.
3. Provide 10’ Category 5e rough service extension cable with Neutrik Ethercon connectors with each node.
4. Provide one 5’ long male to male turnaround XLR-type cable to allow node to be used as DMX input.
5. Provide node with c-clamp for mounting to pipe.
    a. Quantity: 1

C. Portable One-Port Ethernet Node

1. Ethernet node shall translate Ethernet-based control protocol into DMX-512.
2. Node shall be powered via its Ethernet connection using Power Over Ethernet.
3. Provide 10’ Category 5e rough service extension cable with Neutrik Ethercon connectors with each node.
4. Provide 5’ long male to male turnaround XLR-type cable to allow node to be used as DMX input.
5. Provide node with c-clamp for mounting to pipe.
    a. Quantity: 2

D. Ethernet Node, Rack Mounted (E4)
1. Ethernet node shall translate Ethernet-based control protocol into DMX-512.
2. Provide node with four rear-facing DMX outputs.
3. Provide with rack-mount hardware.

E. Ethernet Node, Eight Port (E8)
1. Ethernet node shall translate Ethernet-based control protocol into DMX-512/RDM.
2. Provide node with eight rear-facing DMX outputs.
3. Provide with rack-mount hardware.

F. Emergency Bypass Detection
1. Provide UL924 listed power loss sensor kit to trigger DMX Bypass Unit. Provide with rack-mounted restore switch to allow user to manually restore normal operation when normal power returns. Provide with over-current protected sensing circuit.
    a. ETC EBDK w/ EBDK-SWITCH
    b. Equal

G. DMX Bypass Controller
1. Provide UL924 listed DMX controller to trigger “full-on” for emergency LED architectural fixtures on trigger from Power Loss Sensor.
    a. ETC DEBC-6
    b. Equal

H. Dimmer
1. Provide DMX-controlled, RDM-enabled, 600-watt single-circuit phase-adaptive dimmer for use with either magnetic or electronic dimming loads.
2. Provide with surface-mount electrical enclosure.
    a. ETC UFD
    b. Equal

I. Portable House Lighting Console
1. Provide portable lighting control station in table-top enclosure with 7-inch touch panel.
2. Provide with 15-foot permanently attached cable with hard service connector.
3. Provide in finish per Architect selected from manufacturer’s full range of standard finishes.

2.9 LIGHTING CONTROL RACK

A. Provide wall-mount swing-out equipment rack to contain lighting control network equipment.

B. Provide rack with 2 rack unit storage drawer.

C. Size rack as required by system components plus 4 rack spaces unused and covered with blank panel for future expansion.

D. Provide with locking front door, rack light and blank panels as required.
   1. Middle Atlantic DWR Series
   2. Lowell Mfg. L250 series

2.10 DISTRIBUTION DEVICES

A. Provide power and control distribution devices as shown on the Drawings.
   1. All devices shall be constructed of sheet metal. Provide all required mounting hardware.
   2. Provide flush, surface or pipe mount as indicated on the Drawings.
   3. All devices shall be provided with terminal strips for interconnection to the power system wiring.
   4. Outlet and Pigtail Boxes shall be fabricated from 18-gauge cold rolled steel with 16 gauge covers. They shall be finished with fine-textured, scratch-resistant, powder coat. Color per Architect.
   5. Circuit numbers shall be ¾" labels with white letters on black background. Pigtails and outlets shall be spaced on as shown on the Drawings.
   6. Provide hanger brackets for connector strips as required.
   7. Coordinate with theatrical rigging contractor.
   8. Label back boxes and faceplates with unique designations printed on removable adhesive labels to correspond to shop drawings.
   9. Provide device with RJ-45 Ethercon and 5-pin XLR receptacles as indicated on Drawings.
   10. Provide tap complete with back box, faceplate and any required mounting hardware.
   11. Label receptacle(s) with designation corresponding to termination of network cable in Ethernet patch bay.
   12. Provide devices with finishes per schedule.

B. Provide intermediate connection panels as required for Category cable distribution to suspended electrics.

C. Provide hard-service Category cables for distribution to suspended electrics.

2.11 AUDITORIUM LIGHTING FIXTURES

A. General
   a. Furnish all fixtures with installed edison connector on power cable, c-clamp, 10' DMX cable, and black safety cable.

B. LED Ellipsoidal Reflector Spotlight – Body
   1. Provide color-changing LED ellipsoidal body suitable for interchangeable lenses, using 150 watts power (maximum) and with DMX in and through, power in and through and pattern holder. Provide unit with 20,000-hour LED life, RGB color mixing and variable control profiles.
   2. Provide fixtures that provides a minimum of 5,300 Lumens while producing 3000 Kelvin white light.
      a. ETC ColorSource Spot
      b. Strand Equal
      c. Altman Equal
         1. Quantity: 40

C. 19 Degree Lens Tube
   1. ETC 419 LT
   2. Altman Equal

a. Quantity: 12

D. 26 Degree Lens Tube
1. ETC 426 LT
2. Altman Equal
a. Quantity: 18

E. 36 Degree Lens Tube
1. ETC 436 LT
2. Altman Equal
3. Quantity: 18

F. 50 Degree Lens Tube
1. ETC 450 LT
2. Altman Equal
3. Quantity: 4

G. Parabolic Aluminized Reflector (PAR) LED Wash Light
1. Provide LED wash fixture with color mixing, DMX in and thru, power in and thru, hanging yoke. Provide with seven lens set including round and oblong fields.
a. ETC ColorSource PAR
b. Altman Spectra PAR 100
c. Martin Rush PAR 2 RGBW Zoom
1. Quantity: 18

H. Cyclorama LED Light
1. Provide cyc light suitable for lighting 50 foot wide, 20-foot high cyclorama at 4-foot distance. Provide unit with any required diffusion to achieve smooth cyc coverage.
a. ETC ColorSource Cyc
b. Altman Spectra Cyc
c. Equal
1. Quantity: 12

I. Follow Spot
1. Provide 600-watt, cool-white LED follow-spot appropriate for 90-foot throw with approximately 7 degree to 13 degree zoom and 50,000 light source life. Provide unit with iris, mechanical douser, and boomerang color changer. Provide with 25 foot power cable. Provide with adjustable yoke and tripod floor stand.
a. Robert Juliat Oz
b. Canto Astro 500
c. Equal
i) Quantity: 2

2.12 ACCESSORIES

A. Side Arms
1. Provide 24-inch side arms with two sliding tees for use on “box boom” positions.
2. Provide side arm with clamp and secondary support brace, designed to attach to vertical pipe. C-clamp attachment is not acceptable.
3. Install side arms 22 inches apart.
4. Provide:

a. City Theatrical #204
b. Equal
    1. Quantity: 10

B. Template Holders
    a. A-size Template Holder
        1. Quantity: 16

C. Black Safety Cable (spare)
    a. Quantity: 30

D. Extension Cables
1. Provide 12/3 SO edison extension cables with color-coded length marker and knotted tie line in length as quantities below
    a. 5 foot: 15
    b. 10 foot: 20
    c. 25 foot: 10
    d. 50 foot: 6
    e. 100 foot: 4
2. Provide molded edison three-fer.
    a. Quantity: 24
3. Provide power “thru” cable with PowerCon male to Powercon Female, or as appropriate for fixtures.
    a. 5 foot: 15
    b. 10 foot: 20
4. Provide hard-service DMX extension cables with color-coded length marker and knotted tie-line in lengths and quantities below:
    a. 5 foot: 15
    b. 10 foot: 10
    c. 25 foot: 5
    d. 50 foot: 5
    e. 100 foot: 3
5. Ethercon Ethernet Extension Cables
    a. Provide black heavy-duty Cat5e extension cable with Neutrik Ethercon connectors and quantities below.
    b. Acceptable Products
        1. Lex Products CAT5-EC
        2. Equal
            a. 5 foot: 5
            b. 10 foot: 2
            c. 25 foot: 2
            d. 50 foot: 3

E. Lens Storage Bin
1. Provide plastic bin with securable cover to store all diffusion elements associated with theatrical lighting fixtures.

F. Storage Hamper
   1. Provide sixteen-bushel canvas storage hamper with steel frame, heavy-duty castors and hinged plywood top for storage of spare instruments and cable.
      a. Steele Canvas Model 82
      b. Equal
         1. Quantity: 4

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas where performance switching and control equipment is to be installed and verify that conditions are satisfactory for installation, complying with both the Manufacturer's requirement and this specification.

3.2 INSTALLATION

A. Coordinate installation of system with Electrical Contractor

B. Load circuit conductors shall be continuous from the panel board to the back box. Do not splice conductors.

C. Coordinate control with Audiovisual System Contractor:
   a. Create presets within control processor for recall by audiovisual control system.
   b. Coordinate IP addressing scheme with Audiovisual Contractor and Owner to allow lighting network to connect to Owner's and Audiovisual network.

D. Lighting fixtures:
   a. Deliver lighting fixtures to designated area
   b. Unpack all fixtures, remove packing materials

E. Programming
   a. Program touch panel for full control and modification of house lighting and stage lighting presets.
   b. Program separate page for relay control.
   c. Patch fixtures into console per light plot with fixture profiles.

F. Architectural Lighting Fixtures
   a. Coordinate and integrate architectural addressing scheme with Electrical Contractor.
   b. Address all lighting fixtures.

3.3 TOUCH PANEL THEORY OF OPERATION

A. Modes
   1. Default
      a. Console or panel control of house and stage lighting.
      b. All stations active.
   2. Show
      a. Console or panel control of house lighting.

b. Establish lower limit on house and aisle and egress path light dimming to ensure code-required level of illumination at all times.

c. Lockout of entry stations. Reset entry stations to active at 11:00 PM each night.

3. Night

a. Allow all lights to be turned off.

B. Relay Control

1. Page for control of relays in groups:

a. Distribution devices

b. House lights

c. Convenience outlets

C. House Light Control

1. Presets:

a. House Full

b. House 75%

c. House 50%

d. House 25%

e. House Out

2. Faders

a. Individual faders for each zone of house light control

D. Stage Lighting Control

1. Fader control of three “specials” for use with video presentations

E. Recall of 16 presets.

1. User shall be able to change name of presets.
2. User shall be able to change content of preset via scene capture.

3.4 FIELD QUALITY CONTROL

A. Post-Completion Inspection Report

1. Test power outlets for correct electrical termination and for correct control.
2. Confirm that all architectural lighting fixtures that are controlled by the theatrical control system are fully operational.

B. Manufacturers’ Field Services

1. Provide the services of a Manufacture-certified field service technician to verify the installation and operation of the control system.

3.5 SYSTEM CHECKOUT

A. After receipt of the Post-Completion Inspection Report, the Architect will schedule an inspection and operational test of the system.

B. Make all loose equipment specified for the lighting system available at time of checkout.

C. Provide full and uninterrupted access to stage, auditorium and technical areas required for commissioning tests. Occasional blackouts of the lighting will be required during this checkout.

D. During commissioning the Owner's Designated Representative will verify that system operation is per specifications. Provide a representative on-site to assist in the commissioning of the system and fix minor problems as they are discovered.

E. Provide a Manufacturer's certified field service technician shall be present during all tests and inspections and available for system programming.

F. Provide personnel to operate equipment and perform adjustments as necessary.

G. Provide access to equipment as required.

3.6 DEMONSTRATION AND TRAINING

A. Training to be performed only after system has been commissioned, checked-out by Architect, and punch list completed.

B. Provide eight hours of training in two separate sessions, by factory-authorized personnel, for end-users in the operation of the system.

End of Section

DO NOT REMOVE
THIS PAGE INTENTIONALLY LEFT BLANK

Section 26 51 00

INTERIOR LIGHTING

(TRADE CONTRACT REQUIRED AS PART OF SECTION 26 00 01)

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. PUBLICLY BID TRADE CONTRACT REQUIREMENTS: As provided under Section 26 00 01 - ELECTRICAL and supplemented under the Bidding Requirements, Contract Forms, and Conditions of the Contract, and applicable parts of Division 1 - GENERAL REQUIREMENTS.

1. Work of this Trade Contract includes all individual specification sections listed in Section 26 00 01.

1.2 RELATED DOCUMENTS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications

1.3 SUMMARY

A. This Section includes the following:

1. Interior lighting fixtures, lamps, and ballasts.
2. Emergency lighting units.
3. Exit signs.
4. Lighting fixture supports.

1.4 REFERENCES

A. ANSI/NFPA 70, National Electrical Code

B. IEEE C62.41, Guide on the Surge Environment in Low-Voltage (1000 V and Less) AC Power Circuits

C. FCC 47 CFR Part 15, Federal Code Of Regulation (CFR) testing standard for electronic equipment

D. IESNA LM-79, Electrical and Photometric Measurements of Solid-State Lighting Products

E. IESNA LM-80, Approved Method for Measuring Lumen Maintenance of LED Light Sources

F. IESNA TM-15, Luminaire Classification System for Outdoor Luminaires

G. IESNA TM-21-11, Projecting Long Term Lumen Maintenance of LED Light Sources

H. UL1598, Standard for Safety of Luminaires

I. NEMA SSL 3-2010, High-Power White LED Binning for General Illumination

1.5 DRAWINGS

A. The drawings, which constitute a part of these specifications, indicate the general location of the luminaires.

B. Specifications and drawings are for assistance and guidance, but exact locations, distances and levels will be governed by actual field conditions. Contractor is directed to make field surveys as part of his work prior to submitting system layout drawings.

1.6 QUALITY ASSURANCE

A. Luminaires shall be fully assembled and individually electrically tested prior to shipment.

B. Manufacturers of LED luminaires shall demonstrate a suitable testing program incorporating high heat, high humidity and thermal shock test regimens to ensure system reliability and to substantiate lifetime claims.

C. The sole use of IESNA LM-80 data to predict luminaire lifetime is not acceptable.

D. At time of manufacture, electrical and light technical properties shall be recorded for each luminaire. At a minimum, this should include lumen output, CCT, and CRI. Each luminaire shall utilize a unique serial numbering scheme. Technical properties must be made available for a minimum of 5 years after the date of manufacture.

1.7 SUBMITTALS

A. Submit product data on luminaires. Product data to include, but not limited to materials, finishes, approvals, photometric performance, and dimensional information.

B. LM79 report for each luminaire from a NVLAP accredited photometric laboratory.

C. Photometric layouts are required prior to the approval of the product data. Provide point-by-point calculations for the entire building. Calculations showing typical areas shall not be acceptable.

1. Provide photometric layout using industry approved lighting software.

1.8 SUBSTITUTIONS

A. The light fixture package specified on the drawings has been certified by a third party employed by the Owner/Utility Company for the purpose of computing utility company rebates to the owner.

1. The Electrical Trade Contractor will employ and pay for the services of the third party designated by the Utility Company to evaluate the substituted fixture package and to compute utility company rebates to the owner.

2. The Utility Company rebates to the Owner shall be equal to or greater than the specified fixture package.

3. Once the substituted package is certified it shall be submitted to the Engineer for approval.

a. Provide point-by-point lighting calculations of the entire building and site.

b. Provide Total Light Power Density (LPD) per floor and for the whole building.

c. The LPD of the substituted luminaires shall be less than or equal to the specified luminaires.

4. Provide a side-by-side comparison between the specified and the substituted fixtures include the following criteria:

a. Input Watts

b. Voltage

c. Output Lumens

d. Energy Star Rating

e. DLC approval

f. Total Light Power Density (LPD) per floor and for the whole building.

1.9 WARRANTY

A. Comply with Section 260001.

B. The Electrical Trade Contractor shall warranty that all materials furnished shall be free from defects of material for a period of one year from the date of Substantial Completion.

C. Luminaires shall be provided with a 5-year warranty covering, LEDs, drivers and paint finish.

PART 2 - PRODUCTS

2.1 LIGHTING FIXTURES

A. Manufacturers

1. Cooper Lighting.
2. Philips Lighting.
3. Vanguard Lighting.
4. Or approved equal.

B. Shall be in accordance with NFPA, UL, as shown on drawings, and as specified.

C. Sheet Metal:

1. Shall be formed to prevent warping and sagging. Housing, trim and lens frame shall be true, straight (unless intentionally curved), and parallel to each other as designed.
2. Wireways and fittings shall be free of burrs and sharp edges, and shall accommodate internal and branch circuit wiring without damage to the wiring.
3. When installed, any exposed fixture housing surface, trim frame, door frame, and lens frame shall be free of light leaks.
4. Hinged door frames shall operate smoothly without binding. Latches shall function easily by finger action without the use of tools.

D. Drivers and lamps shall be serviceable while the fixture is in its normally installed position. Drivers shall not be mounted to removable reflectors or wireway covers unless so specified.

E. Recessed fixtures mounted in an insulated ceiling shall be listed for use in insulated ceilings.

F. Mechanical Safety: Lighting fixture closures (lens doors, trim frame, hinged housings, etc.) shall be retained in a secure manner by captive screws, chains, aircraft cable, captive hinges, or fasteners such that they cannot be accidentally dislodged during normal operation or routine maintenance.

G. Metal Finishes:

1. The manufacturer shall apply standard finish (unless otherwise specified) over a corrosion-resistant primer, after cleaning to free the metal surfaces of rust, grease, dirt and other deposits. Edges of pre-finished sheet metal exposed during forming, stamping or shearing processes shall be finished in a similar corrosion resistant manner to match the adjacent surface(s). Fixture finish shall be free of stains or evidence of rusting, blistering, or flaking, and shall be applied after fabrication.

2. Interior light reflecting finishes shall be white with not less than 85 percent reflectances, except where otherwise shown on the drawing.

3. Exterior finishes shall be as shown on the drawings.

H. Lighting fixtures shall have a specific means for grounding metallic wireways and housings to an equipment grounding conductor.

2.2 LED EXIT LIGHT FIXTURES

A. Exit light fixtures shall meet applicable requirements of NFPA and UL.

B. Exit signs shall be edge-lit, white or mirror panel (clear panel exit sign shall not be permitted) with 90-minute backup battery power.

C. There shall be no radioactive material used in the fixtures.

D. Directional Arrows: Provide directional arrows as part of the inscription panel where required or as shown on drawings. Directional arrows shall be the "chevron-type" of similar size and width as the letters and meet the requirements of NFPA 101.

2.3 LED LIGHT FIXTURES

A. General:

1. LED light fixtures shall be in accordance with IES, NFPA, UL, as shown on the drawings, and as specified.

2. LED light fixtures shall be Reduction of Hazardous Substances (RoHS)-compliant.

3. LED drivers shall include the following features unless otherwise indicated:

a. Minimum efficiency: 85% at full load.

b. Minimum Operating Ambient Temperature: -20° C. (-4° F.)

c. Input Voltage: 120 - 277V (±10%) at 60 Hz.

d. Integral short circuit, open circuit, and overload protection.

e. Power Factor: $\geq$ 0.95.

f. Total Harmonic Distortion: $\leq$ 20%.

g. Comply with FCC 47 CFR Part 15.

4. LED modules shall include the following features unless otherwise indicated:
    a. Comply with IES LM-79 and LM-80 requirements.
    b. Minimum CRI 85 and color temperature 3000° K unless otherwise specified in LIGHTING FIXTURE SCHEDULE.
    c. Minimum Rated Life: 50,000 hours per IES L70.
    d. Light output lumens as indicated in the LIGHTING FIXTURE SCHEDULE.

B. LED Downlights:
1. Housing, LED driver, and LED module shall be products of the same manufacturer.

C. LED Troffers:
1. LED drivers, modules, and reflector shall be accessible, serviceable, and replaceable from below the ceiling.
2. Housing, LED driver, and LED module shall be products of the same manufacturer.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Installation shall be in accordance with the NEC, manufacturer's instructions, and as shown on the drawings or specified.

B. Align, mount, and level the lighting fixtures uniformly.

C. Wall-mounted fixtures shall be attached to the studs in the walls, or to a 20 gauge metal backing plate that is attached to the studs in the walls. Lighting fixtures shall not be attached directly to gypsum board.

D. Lighting Fixture Supports:
1. Shall provide support for all of the fixtures. Supports may be anchored to channels of the ceiling construction, to the structural slab or to structural members within a partition, or above a suspended ceiling.
2. Shall maintain the fixture positions after cleaning and relamping.
3. Shall support the lighting fixtures without causing the ceiling or partition to deflect.
4. Hardware for troffers:
    a. Hardware devices shall independently support the fixture from the building structure at two opposite points.

E. Furnish and install the new lamps as specified for all lighting fixtures installed under this project, and for all existing lighting fixtures reused under this project.

F. The electrical and ceiling trades shall coordinate to ascertain that approved lighting fixtures are furnished in the proper sizes and installed with the proper devices (hangers, clips, trim frames, flanges, etc.), to match the ceiling system being installed.

G. Bond lighting fixtures to the grounding system as specified in Division 26.

H. At completion of project, replace all defective components of the lighting fixtures at no cost to the Owner.

3.2 ACCEPTANCE CHECKS AND TESTS

A. Perform the following:

1. Visual Inspection:

a. Verify proper operation by operating the lighting controls.

b. Visually inspect for damage to fixtures, lenses, reflectors, diffusers, and louvers. Clean fixtures, lenses, reflectors, diffusers, and louvers that have accumulated dust, dirt, or fingerprints during construction.

2. Electrical tests:

a. Exercise dimming components of the lighting fixtures over full range of dimming capability by operating the control devices(s) in the presence of the Engineer/Commissioning Agent. Observe for visually detectable flicker over full dimming range, and replace defective components at no cost to the Owner.

b. Burn-in all lamps that require specific aging period to operate properly, prior to occupancy by the Owner. Burn-in period to be 40 hours minimum, unless specifically recommended otherwise by the lamp manufacturer. Burn-in dimmed fluorescent and compact fluorescent lamps for at least 100 hours at full voltage, unless specifically recommended otherwise by the lamp manufacturer.

c. Replace any lamps and ballasts which fail during burn-in.

3.3 FOLLOW-UP VERIFICATION

A. Upon completion of acceptance checks and tests, the Electrical Subcontractor shall show by demonstration in service that the lighting systems are in good operating condition and properly performing the intended function.

3.4 TRAINING AND SERVICE

A. Comply with Section 26 00 01.

B. Conduct two 4-hour training sessions. Train the Owner’s maintenance personnel on procedures and schedules related to start up and shutdown, troubleshooting, servicing, and preventive maintenance.

End of Section

Section 26 56 00

EXTERIOR LIGHTING

(TRADE CONTRACT REQUIRED AS PART OF SECTION 26 00 01)

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. PUBLICLY BID TRADE CONTRACT REQUIREMENTS: As provided under Section 26 00 01 - ELECTRICAL and supplemented under the Bidding Requirements, Contract Forms, and Conditions of the Contract, and applicable parts of Division 1 - GENERAL REQUIREMENTS.

1. Work of this Trade Contract includes all individual specification sections listed in Section 26 00 01.

1.2 RELATED DOCUMENTS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications

1.3 SUSTAINABLE DESIGN REQUIREMENTS

A. Comply with Section 01 81 13.

B. Sustainable Design Intent: Comply with project requirements intended to achieve sustainable design, measured and documented according to the MA-CHPS 2009 rating system.

C. Contractor is responsible for compliance with and completion of all required documentation for all of the following MA-CHPS Credits:

1. Sites SS.C11: Light Pollution Reduction.

a. Intent: Reduce development impacts on the nocturnal environment. Provide the following:

1) A site lighting plan showing the location of all exterior lighting fixtures, including those mounted on buildings. Plan should show the Lighting Boundary and indicate any fixtures that are believed to be exempt per Exceptions to SS.C11.2 and SS.C11.3.

2) A lighting fixture schedule with complete specifications for each fixture type.

3) Mounting heights for all fixtures shown either on the plan or the fixture schedule.

4) Cut sheets for all exterior lighting fixtures.

5) BUG ratings for all non-exempt fixtures (may be shown on fixture schedule).

6) If using section 5.1 Up light, Table 2 option, submit a spreadsheet showing each non-exempt fixture type and its lumen output and zonal lumens above horizontal each multiplied by the quantity of the fixture,

and the ratio of total lumens above horizontal to total fixture lumens, expressed as a percentage.

7) A declaration of the Lighting Zone that project is in.

8) A signed letter from the project's site lighting designer confirming that to the best of their knowledge the requirements of this credit have been met.

1.4 SUMMARY

A. This Section includes the following:

1. Exterior luminaires with lamps and ballasts.

2. Poles and accessories.

B. See Division 26 Section "Interior Lighting" for exterior luminaires normally mounted on exterior surfaces of buildings.

1.5 STRUCTURAL ANALYSIS CRITERIA FOR POLE SELECTION

A. Dead Load: Weight of luminaire and its horizontal and vertical supports and supporting structure, applied as stated in AASHTO LTS-4.

B. Ice Load: Load of 3 lbf/sq. ft. (143.6 Pa), applied as stated in AASHTO LTS-4.

C. Wind Load: Pressure of wind on pole and luminaire, calculated and applied as stated in AASHTO LTS-4.

1. Wind speed for calculating wind load for poles 50 feet (15 m) or less in height is 110 mph (177 km/h).

1.6 REFERENCES

A. ANSI/NFPA 70, National Electrical Code

B. IEEE C62.41, Guide on the Surge Environment in Low-Voltage (1000 V and Less) AC Power Circuits

C. FCC 47 CFR Part 15, Federal Code of Regulation (CFR) testing standard for electronic equipment

D. IESNA LM-79, Electrical and Photometric Measurements of Solid-State Lighting Products

E. IESNA LM-80, Approved Method for Measuring Lumen Maintenance of LED Light Sources

F. IESNA TM-15, Luminaire Classification System for Outdoor Luminaires

G. IESNA TM-21-11, Projecting Long Term Lumen Maintenance of LED Light Sources

H. UL1598, Standard for Safety of Luminaires

I. NEMA SSL 3-2010, High-Power White LED Binning for General Illumination

1.7 DRAWINGS

A. The drawings, which constitute a part of these specifications, indicate the general location of the luminaires.

B. Specifications and drawings are for assistance and guidance, but exact locations, distances and levels will be governed by actual field conditions. Contractor is directed to make field surveys as part of his work prior to submitting system layout drawings.

1.8 QUALITY ASSURANCE

A. Luminaires shall be fully assembled and individually electrically tested prior to shipment.

B. Manufacturers of LED luminaires shall demonstrate a suitable testing program incorporating high heat, high humidity and thermal shock test regimens to ensure system reliability and to substantiate lifetime claims.

C. The sole use of IESNA LM-80 data to predict luminaire lifetime is not acceptable.

D. At time of manufacture, electrical and light technical properties shall be recorded for each luminaire. At a minimum, this should include lumen output, CCT, and CRI. Each luminaire shall utilize a unique serial numbering scheme. Technical properties must be made available for a minimum of 5 years after the date of manufacture.

1.9 SUBMITTALS

A. Submit product data on luminaires. Product data to include, but not limited to materials, finishes, approvals, photometric performance, and dimensional information.

B. LM79 report for each luminaire from a NVLAP accredited photometric laboratory.

C. Photometric layouts are required prior to the approval of the product data. Provide point-by-point calculations to include all exterior light fixtures.

1. Provide photometric layout using industry approved lighting software.

1.10 SUBSTITUTIONS

A. The light fixture package specified on the drawings has been certified by a third party employed by the Owner/Utility Company for the purpose of computing utility company rebates to the owner.

1. The Electrical Trade Contractor will employ and pay for the services of the third party designated by the Utility Company to evaluate the substituted fixture package and to compute utility company rebates to the owner.

2. The Utility Company rebates to the Owner shall be equal to or greater than the specified fixture package.

3. Once the substituted package is certified it shall be submitted to the Engineer for approval.

a. Provide point-by-point lighting calculations of the entire building and site.

b. Provide Total Light Power Density (LPD) per floor and for the whole building.

c. The LPD of the substituted luminaires shall be less than or equal to the specified luminaires.

4. Provide a side-by-side comparison between the specified and the substituted fixtures include the following criteria:

a. Input Watts

b. Voltage

c. Output Lumens

d. Energy Star Rating

e. DLC approval

f. Total Light Power Density (LPD) per floor and for the whole building.

1.11 DELIVERY, STORAGE AND HANDLING

A. Deliver luminaires and components carefully to avoid breakage, bending and scoring finishes. Do not install damaged equipment.

B. Store luminaires and accessories in original cartons and in clean dry space; protect from weather and construction traffic.

1.12 WARRANTY

A. Comply with Section 260001.

B. The Electrical Trade Contractor shall warranty that all materials furnished shall be free from defects of material for a period of one year from the date of Substantial Completion.

C. Luminaires shall be provided with a 5-year warranty covering, LEDs, drivers and paint finish.

PART 2 - PRODUCTS

2.1 LIGHTING FIXTURES

A. Manufacturers

1. Cooper Lighting.
2. Vanguard Lighting.
3. Philips Lighting.
4. Or approved equal.

B. Shall be in accordance with NFPA, UL, as shown on drawings, and as specified.

2.2 LED LUMINAIRES

A. General: Except as otherwise indicated, provide LED luminaires, of types and sizes indicated on fixture schedules.

B. Material and specifications for each luminaire are as follows:

1. Each Luminaire shall consist of an assembly that utilizes LEDs as the light source. In addition, a complete luminaire shall consist of a housing, LED array, and electronic driver (power supply).
2. Each luminaire shall be rated for a minimum operational life of 50,000 hours at an average operating time of 11.5 hours per night at 40ºC (104ºF).
3. Reported lumen maintenance shall be greater than 90% per TM-21-11 after 60,000 hours of luminaire operation in an ambient environment from 15ºC (59ºF) to 40ºC (104ºF).

4. The rated operating temperature range shall be -40°C (-40ºF) to +40°C (104ºF).
5. Each luminaire is capable of operating above 104°F (40°C), but not expected to comply with photometric requirements at elevated temperatures.
6. Photometry must be compliant with IESNA LM-79.
7. Each luminaire shall meet all parameters of this specification throughout the minimum operational life when operated at the average nighttime temperature.
8. The individual LEDs shall be constructed such that a catastrophic loss or the failure of one LED will not result in the loss of the entire luminaire.
9. Luminaire shall be constructed such that LED modules may be replaced or repaired without replacement of whole luminaire.
10. Each luminaire shall be listed with Underwriters Laboratory, Inc. under UL1598 for luminaires, or an approved equivalent standard from a nationally recognized testing laboratory.

C. Technical Requirements

1. Electrical
   a. The luminaire shall not consume power in the off state.
   b. Operation Voltage: The luminaire shall operate from a 60 HZ ±3 HZ AC line over a voltage ranging from 108 VAC to 305 VAC. The fluctuations of line voltage shall have no visible effect on the luminous output.
   c. Power Factor: The luminaire shall have a power factor of 0.9 or greater.
   d. THD: Total harmonic distortion (current and voltage) induced into an AC power line by a luminaire shall not exceed 20 percent.
   e. Surge Suppression: The luminaire on-board circuitry shall include surge protection devices (SPD) to withstand high repetition noise transients as a result of utility line switching, nearby lightning strikes, and other interference. The SPD protects the luminaire from damage and failure for common and differential mode transient peak currents up to 10 kA (minimum). SPD conforms to UL 1449. SPD performance has been tested per procedures in ANSI/IEEE C62.41-2:2002 category C high exposure and ANSI C136.2 10kV BIL. The SPD shall fail in such a way as the Luminaire will no longer operate. The SPD shall be field replaceable.
   f. Operational Performance: The LED circuitry shall prevent visible flicker to the unaided eye over the voltage range specified above.
   g. RF Interference: LED Drivers must meet Class A emission limits referred in Federal Communications Commission (FCC) Title 47, Subpart B, Section 15 regulations concerning the emission of electronic noise.
2. Photometric Requirements
   a. Optical Assemblies: LEDs shall be provided with discreet over optical elements to provide an IESNA Type II, III or V distribution. Additional distributions for glare control shall be utilized when direct source must be mitigated. Mitigation must take place without external shielding elements. Optical assemblies shall have a minimum efficiency of 85% regardless of distribution type. All LEDs and optical assemblies shall be mounted parallel to the ground. All LEDs shall provide the same optical pattern such that catastrophic failures of individual LEDs will not constitute a loss in the distribution pattern.

b. Luminaire shall be dark sky rated.

c. Light Color/Quality: The luminaire shall have a correlated color temperature (CCT) of 4,000K +/-275K. The color rendition index (CRI) shall be a nominal 70.

d. The optical assembly of the luminaire shall be protected against dust and moisture intrusion per the requirements of IP-66 (minimum) to protect all optical components.

3. Thermal Management

a. The thermal management (of the heat generated by the LEDs) shall be of sufficient capacity to assure proper operation of the luminaire over the expected useful life.

b. The LED manufacturer's maximum thermal pad temperature for the expected life shall not be exceeded.

c. Thermal management shall be passive by design. The use of fans or other mechanical devices shall not be allowed.

d. The luminaire shall have a minimum heat sink surface such that LED manufacturer's maximum junction temperature is not exceeded at maximum rated ambient temperature.

e. The heat sink material shall be aluminum.

4. Physical and Mechanical Requirements

a. Heavy-wall die cast aluminum end caps shall enclose the housing and die-cast aluminum heat sinks. The extruded aluminum driver enclosure shall be thermally isolated from the LED array to ensure cooler operating temperatures of the driver. A unique interlocking housing and heat sink shall provide scalability with superior structural rigidity. LED drivers shall be mounted to a removable driver tray for ease of maintenance. Housing shall be designed to prevent the buildup of water on the top of the housing. Each optical assembly shall be field rotatable and shall have "street side" and "house side" cast into the optics to indicate beam pattern. Each optic shall be electrically connected with a quick disconnect plug and secured to the housing with four stainless steel screws.

b. Luminaire shall include an extruded aluminum arm bracket with internal bolt guides to allow for easy positioning of fixture during assembly and direct attachment to the side of square or round drilled poles. An optional mast arm adaptor shall be available to accommodate 1¼" to 2" ID pipe (1 5/8" to 2 3/8" OD).

c. The housing shall meet the requirements for NEMA/UL wet location, be UL listed and the color shall be by the Architect.

d. Luminaire options to include a NEMA photocontrol receptacle and dimming driver.

e. The assembly and manufacturing process for the LED luminaire shall be designed to assure all internal components are adequately supported to withstand mechanical shock and vibration. Luminaire shall withstand vibration, meeting ANSI C136.31 American Standard for Roadway and Area Lighting Equipment – Luminaire Vibration for normal and bridge operation (3G minimum).

5. Materials

a. Housing and door frame shall be aluminum with a nominal 2.5 mil thick paint finish able to withstand a 3000 hour salt spray test as specified in ASTM Designation: B117.

b. Each refractor or lens shall be made from UV inhibited high impact optical grade material and be resistant to scratching.

2.3 LIGHTING CONTACTOR

A. NEMA ICS 2, mechanically held contactor. Rate contactor as indicated. Provide in NEMA 4 enclosure conforming to NEMA ICS 6. Contactor shall have silver alloy double-break contacts and coil clearing contacts for mechanically held contactor] and shall require no arcing contacts. Provide contactor with on-off selector switch.

2.4 TIME SWITCH

A. Astronomic microprocessor-based electronic type, multi-channel, arranged to turn "ON" at sunset or "OFF" at sunrise with an adjustable plus or minus 1-99 minute offset. Switch shall automatically change the sunset/sunrise related settings each day in accordance with seasonal changes of sunset and sunrise. Provide switch rated as indicated having battery backup for programming to maintain accurate time for up to 15 hours following power failure. Time switch shall automatically switch to and from daylight saving mode, shall display time in 24-hour format, and each channel shall be capable of momentary contact output with an adjustable duration. Housing for the time switch shall be surface-mounted, NEMA 1 enclosure conforming to NEMA ICS 6.

2.5 PHOTOCELL SWITCH

A. UL 773 or UL 773A, hermetically sealed cadmium-sulfide or silicon diode type cell rated single pole double-throw (spdt) contacts for mechanically held contactors rated 1000 watts designed to fail to the ON position. Switch shall turn on at or below 32 lux 3 footcandles and off at 2 to 10 footcandles. A time delay shall prevent accidental switching from transient light sources. Provide switch:

1. In a high-impact-resistant, noncorroding and nonconductive molded plastic housing with a fixture mounted, locking-type receptacle conforming to NEMA C136.10 and rated 1800 VA, minimum.

2. In a cast weatherproof aluminum housing with adjustable window slide, rated 1800 VA, minimum.

3. In a U.V. stabilized polycarbonate housing with swivel arm and adjustable window slide, rated 1800 VA, minimum.] [d. Integral to the luminaire, rated 1000 VA, minimum.

2.6 POLES

A. Provide poles designed for wind loading in accordance with AASHTO LTS while supporting luminaires and all other appurtenances indicated. The effective projected areas of luminaires and appurtenances used in calculations shall be specific for the actual products provided on each pole. Poles shall be anchor-base type designed for use with underground supply conductors. Poles shall have oval-shaped handhole having a minimum clear opening of 65 by 130 mm (2.5 by 5 inches) 2.5 by 5 inches. Handhole cover shall be secured by stainless steel captive screws. Metal poles shall have an internal grounding connection accessible from the handhole near the bottom of each pole. Scratched, stained, chipped, or dented poles shall not be installed.

B. Aluminum Poles

1. Provide aluminum poles manufactured of corrosion resistant aluminum alloys conforming to AASHTO LTS for Alloy 6063-T6 or Alloy 6005-T5 for wrought alloys and Alloy 356-T4 (3,5) for cast alloys. Poles shall be seamless extruded or spun seamless type with minimum 4.8 mm (0.188 inch) 0.188 inch wall thickness. Provide a pole grounding connection designed to prevent electrolysis when used with copper ground wire. Tops of shafts shall be fitted with a round or tapered cover. Base shall be anchor bolt mounted, made of cast 356-T6 aluminum alloy in accordance with ASTM B 108/B 108M and shall be machined to receive the lower end of shaft. Joint between shaft and base shall be welded. Base cover shall be cast 356-T6 aluminum alloy in accordance with ASTM B 108/B 108M. Hardware, except anchor bolts, shall be either 2024-T4 anodized aluminum alloy or stainless steel.[Aluminum poles and brackets for walkway lighting shall have finish to match fixtures and shall not be painted. Manufacturer's standard provision shall be made for protecting the finish during shipment and installation. Minimum protection shall consist of spirally wrapping each pole shaft with protective paper secured with tape and shipping small parts in boxes.

2.7 BRACKETS AND SUPPORTS

A. NEMA C136.3, NEMA C136.13, and ANSI C136.21, as applicable. Pole brackets shall be not less than 31.75 mm (1 1/4 inch) 1 1/4 inch galvanized steel pipe secured to pole. Slip-fitter or pipe-threaded brackets may be used, but brackets shall be coordinated to luminaires provided, and brackets for use with one type of luminaire shall be identical. Brackets for pole-mounted street lights shall correctly position luminaire no lower than mounting height indicated. Mount brackets not less than 7320 mm 24 feet above street. Special mountings or brackets shall be as indicated and shall be of metal which will not promote galvanic reaction with luminaire head.

2.8 POLE FOUNDATIONS

A. Anchor bolts shall be steel rod having a minimum yield strength of 344.5 MPa (50,000 psi) 50,000 psi; the top 305 mm (12 inches) 12 inches of the rod shall be galvanized in accordance with ASTM A 153/A 153M. Concrete shall be as specified in Division 03.

PART 3 - EXECUTION

3.1 LUMINAIRE INSTALLATION

A. Install lamps in each luminaire.

B. Fasten luminaire to indicated structural supports.

1. Use fastening methods and materials selected to resist seismic forces defined for the application and approved by manufacturer.

C. Adjust luminaires that require field adjustment or aiming.

3.2 POLE INSTALLATION

A. Align pole foundations and poles for optimum directional alignment of luminaires and their mounting provisions on the pole.

B. Clearances: Maintain the following minimum horizontal distances of poles from surface and underground features, unless otherwise indicated on Drawings:

1. Fire Hydrants and Storm Drainage Piping: 60 inches (1520 mm).
2. Water, Gas, Electric, Communication, and Sewer Lines: 10 feet (3 m).

C. Concrete Pole Foundations: Set anchor bolts according to anchor-bolt templates furnished by pole manufacturer. Concrete materials, installation, and finishing requirements are specified in Division 03 Section "Cast-in-Place Concrete."

D. Foundation-Mounted Poles: Mount pole with leveling nuts and tighten top nuts to torque level recommended by pole manufacturer.

1. Use anchor bolts and nuts selected to resist seismic forces defined for the application and approved by manufacturer.
2. Grout void between pole base and foundation. Use nonshrink or expanding concrete grout firmly packed to fill space.
3. Install base covers, unless otherwise indicated.
4. Use a short piece of 1/2-inch- (13-mm-) diameter pipe to make a drain hole through grout. Arrange to drain condensation from interior of pole.

E. Embedded Poles with Tamped Earth Backfill: Set poles to depth below finished grade indicated on Drawings, but not less than one-sixth of pole height.

1. Dig holes large enough to permit use of tampers in the full depth of hole.
2. Backfill in 6-inch (150-mm) layers and thoroughly tamp each layer so compaction of backfill is equal to or greater than that of undisturbed earth.

F. Embedded Poles with Concrete Backfill: Set poles in augured holes to depth below finished grade indicated on Drawings, but not less than one-sixth of pole height.

1. Make holes 6 inches (150 mm) in diameter larger than pole diameter.
2. Fill augured hole around pole with air-entrained concrete having a minimum compressive strength of 3000 psi (20 MPa) at 28 days, and finish in a dome above finished grade.
3. Use a short piece of 1/2-inch- (13-mm-) diameter pipe to make a drain hole through concrete dome. Arrange to drain condensation from interior of pole.
4. Cure concrete a minimum of 72 hours before performing work on pole.

G. Poles and Pole Foundations Set in Concrete Paved Areas: Install poles with minimum of 6-inch- (150-mm-) wide, unpaved gap between the pole or pole foundation and the edge of adjacent concrete slab. Fill unpaved ring with pea gravel to a level 1 inch (25 mm) below top of concrete slab.

H. Raise and set poles using web fabric slings (not chain or cable).

3.3 BOLLARD LUMINAIRE INSTALLATION

A. Align units for optimum directional alignment of light distribution.

B. Install on concrete base with top 4 inches (100 mm) above finished grade or surface at bollard location. Cast conduit into base, and shape base to match shape of bollard base. Finish by troweling and rubbing smooth. Concrete materials, installation, and finishing are specified in Division 03 Section "Cast-in-Place Concrete."

3.4 INSTALLATION OF INDIVIDUAL GROUND-MOUNTING LUMINAIRES

A. Install on concrete base with top 4 inches (100 mm) above finished grade or surface at luminaire location. Cast conduit into base, and finish by troweling and rubbing smooth. Concrete materials, installation, and finishing are specified in Division 03 Section "Cast-in-Place Concrete."

3.5 CORROSION PREVENTION

A. Aluminum: Do not use in contact with earth or concrete. When in direct contact with a dissimilar metal, protect aluminum by insulating fittings or treatment.

B. Steel Conduits: Comply with Division 26 Section "Raceway and Boxes for Electrical Systems." In concrete foundations, wrap conduit with 0.010-inch- (0.254-mm-) thick, pipe-wrapping plastic tape applied with a 50 percent overlap.

3.6 GROUNDING

A. Ground metal poles and support structures according to Division 26 Section "Grounding and Bonding for Electrical Systems."

1. Install grounding conductor pigtail in the base for connecting luminaire to grounding system.

3.7 TRAINING AND SERVICE

A. Comply with Section 26 00 01.

B. Conduct two 4-hour training sessions. Train the Owner’s maintenance personnel on procedures and schedules related to start up and shutdown, troubleshooting, servicing, and preventive maintenance.

End of Section

Section 26 56 68

EXTERIOR ATHLETIC FIELD LIGHTING

(TRADE CONTRACT REQUIRED AS PART OF SECTION 26 00 01)

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. PUBLICLY BID TRADE CONTRACT REQUIREMENTS: As provided under Section 26 00 01 - ELECTRICAL and supplemented under the Bidding Requirements, Contract Forms, and Conditions of the Contract, and applicable parts of Division 1 - GENERAL REQUIREMENTS.

1. Work of this Trade Contract includes all individual specification sections listed in Section 26 00 01.

1.2 RELATED DOCUMENTS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications

1.3 WORK INCLUDED

A. Work covered by this section of the specifications shall conform to the contract documents, engineering plans as well as state and local codes.

B. The purpose of these specifications is to define the lighting system performance and design standards for Worcester South High Community School Multi Fields using an LED Lighting source. The manufacturer / contractor shall supply lighting equipment to meet or exceed the standards set forth in these specifications.

C. The sports lighting will be for the following venues:

1. Football Field
2. Practice Football Field
3. Tennis Courts

D. The primary goals of this sports lighting project are:

1. Guaranteed Light Levels: Selection of appropriate light levels impact the safety of the players and the enjoyment of spectators. Therefore, light levels are guaranteed to not drop below specified target values for a period of 25 years.
2. Environmental Light Control: It is the primary goal of this project to minimize spill light to adjoining properties and glare to the players, spectators and neighbors. The LED design should provide better control than a good HID design.
3. Life-cycle Cost: In order to reduce the operating budget, the preferred lighting system shall be energy efficient and cost effective to operate. All maintenance costs shall be eliminated for the duration of the warranty.
4. Control and Monitoring: To allow for optimized use of labor resources and avoid unneeded operation of the facility, customer requires a remote on/off control system for the lighting system. Fields should be proactively monitored to detect luminaire

outages over a 25-year life cycle. All communication and monitoring costs for 25-year period shall be included in the bid.

1.4 LIGHTING PERFORMANCE

A. Illumination Levels and Design Factors: Playing surfaces shall be lit to an average target illumination level and uniformity as specified in the chart below. Lighting calculations shall be developed, and field measurements taken on the grid spacing with the minimum number of grid points specified below. Appropriate light loss factors shall be applied and submitted for the basis of design. Average illumination level shall be measured in accordance with the IESNA LM-5-04 (IESNA Guide for Photometric Measurements of Area and Sports Lighting Installations). Illumination levels shall not to drop below desired target values in accordance to IES RP-6-15, Page 2, Maintained Average Illuminance and shall be guaranteed for the full warranty period.

Area of Lighting	**Average Target Illumination Levels**	**Maximum to Minimum Uni-formity Ratio**	**Grid Points**	**Grid Spacing**
Football	50 FC	2 : 1	72	30’ X 30’
Stands	5 FC	3 : 1	80	10’ X 10’
Practice Football	30 FC	2.5 : 1	42	30’ X 30’
Tennis 1 – 2	50 FC	2 : 1	30	20’ X 20’
Tennis 3-5	50 FC	2 : 1	45	20’ X 20’

B. Hours of usage: Designs shall be based on the following hours of usage

Area of Lighting	**Annual Usage Hours**	**25 year Usage Hours**
Football and Practice Football	200	5,000
Tennis Courts	500	12,500

C. Color: The lighting system shall have a minimum color temperature of 5700K and a CRI of 75.

D. Mounting Heights: To ensure proper aiming angles for reduced glare and to provide better playability, minimum mounting heights shall be as described below. Higher mounting heights may be required based on photometric report and ability to ensure the top of the field angle is a minimum of 10 degrees below horizontal.

# of Poles	Pole Designation	Pole Height
2	F1, F2	70’
2	F3, F4,	80’
4	P1, P2	60’
6	T1, T2, T3, T4, T5, T6	50’

1.5 ENVIRONMENTAL LIGHT CONTROL

A. Light Control Luminaires: All luminaires shall utilize spill light and glare control devices including, but not limited to, internal shields, louvers and external shields. No symmetrical beam patterns are accepted.

B. The first page of a photometric report for all luminaire types proposed showing horizontal and vertical axial candle power shall be provided to demonstrate the capability of achieving the specified performance. Reports shall be certified by a qualified independent testing laboratory with a minimum of five years’ experience or by a manufacturer’s laboratory with a current accreditation under the National Voluntary Laboratory Accreditation Program for Energy Efficient Lighting Products. A summary of the horizontal and vertical aiming angles for each luminaire shall be included with the photometric report.

C. Lighting manufacturer shall supply photometrics with a LEED Boundary line for horizontal footcandles, vertical footcandles, Light levels shall be taken at 30-foot intervals and 3-feet above grade.

1.6 LIFE-CYCLE COSTS

A. Manufacturer shall submit a 25-year life cycle cost calculation as outlined in the required submittal information.

B. Preventative and Spot Maintenance: Manufacturer shall provide all preventative and spot maintenance, including parts and labor for 25 years from the date of equipment shipment. Individual outages shall be repaired when the usage of any field is materially impacted. Owner agrees to check fuses in the event of a luminaire outage.

1.7 SUBMITTALS

A. Listing of all information being submitted must be included on the table of contents. List the name of the manufacturer’s local representative and his/her phone number.

B. Qualifications of the Testing Agency who will perform illumination tests upon completion of the project.

C. Drawing(s) showing field layouts with pole locations.

D. Lighting design drawing(s) showing:

1. Field Name, date, file number, prepared by.

2. Outline of field(s) being lighted, as well as pole locations referenced to the center of the field (x & y), Illuminance levels at grid spacing specified.

3. Pole height, number of fixtures per pole, horizontal and vertical aiming angles, as well as luminaire information including wattage, lumens and optics.

4. Height of light test meter above field surface.

5. Summary table showing the number and spacing of grid points; average, minimum and maximum illuminance levels in foot candles (fc); uniformity including maximum to minimum ratio, coefficient of variance (CV), coefficient of utilization (CU) uniformity gradient; number of luminaries, total kilowatts, average tilt factor; light loss factor.

E. Lighting design drawing showing initial spill light levels along the boundary line (defined on bid drawings) in footcandles. Light levels shall be taken at 30-foot intervals along the boundary line. Readings shall be taken with the meter orientation at both horizontal and aimed towards the most intense bank of lights.

F. Environmental glare impact scans must be submitted showing the maximum candela from the field edge on a map of the surrounding area until 500 candela or less is achieved.

G. Provide first page of photometric report for all luminaire types being proposed showing candela tabulations as defined by IESNA Publication LM-35-02. Photometric data shall be certified by laboratory with current National Voluntary Laboratory Accreditation Program or an independent testing facility with over 5 years' experience.

H. Provide performance guarantee including a written commitment to undertake all corrections required to meet the performance requirements noted in these specifications at no expense to the owner. Light levels must be guaranteed to not fall below target levels for warranty period.

I. Pole structural calculations and foundation design showing foundation shape, depth backfill requirements, rebar and anchor bolts (if required). Pole base reaction forces shall be shown on the foundation drawing along with soil bearing pressures. Design must be stamped by a structural engineer in the state of Massachusetts.

J. Manufacturer of the control and monitoring system shall provide written definition and schematics for automated control system to include monitoring. They will also provide ten (10) references of customers currently using proposed system in the state of Massachusetts.

K. Manufacturer bidding an alternate product must include a revised electrical distribution plan including changes to service entrance, panels and wire sizing, signed by a licensed Electrical Engineer in the state of Massachusetts.

L. Provide written warranty information including all terms and conditions. Provide ten (10) references of customers currently under specified warranty in the state of Massachusetts.

M. Manufacturer to provide a list of ten (10) projects where the technology and specific fixture proposed for this project has been installed in the state of Massachusetts. Reference list will include project name, project city, installation date, and if requested, contact name and contact phone number.

N. Complete bill of material and current brochures/cut sheets for all product being provided.

O. Manufacturer shall list all items that do not comply with the specifications. If in full compliance, tab may be omitted.

P. Document life-cycle cost calculations as defined in the specification. Identify energy costs for operating the luminaires. Maintenance cost for the system must be included in the warranty. All costs should be based on 25 Years.

Q. Substitutions: In the event that the luminaires are substituted from those specified on the drawings provide a side-by-side comparison between the specified and the substituted fixtures including but not limited to the following criteria:

1. Input Watts
2. Voltage
3. Output Lumens
4. Energy Star Rating
5. DLC approval
6. Point-by-point calculations
7. Total Light Power Density (LPD).
    a. The LPD of the substituted luminaires shall be less than or equal to the specified luminaires.

1.8 DELIVERY, STORAGE AND HANDLING

A. Deliver luminaires and components carefully to avoid breakage, bending and scoring finishes. Do not install damaged equipment.

B. Store luminaires and accessories in original cartons and in clean dry space; protect from weather and construction traffic.

1.9 WARRANTY

A. The Electrical Trade Contractor shall warranty that all materials furnished shall be free from defects of material for a period of one year from the date of Substantial Completion.

B. Provide a 3-year maintenance preventive maintenance plan. The plan shall include one site visit per year after the warranty period to verify that the system is working per the specifications and to proactively perform maintenance, repairs, and replacements to prevent failures before they occur

C. Manufacturer’s Warranty

1. 25-Year Warranty: Each manufacturer shall supply a signed warranty covering the entire system for 25 years from the date of shipment. Warranty shall guarantee specified light levels. Manufacturer shall maintain specifically-funded financial reserves to assure fulfillment of the warranty for the full term. Warranty does not cover weather conditions events such as lightning or hail damage, improper installation, vandalism or abuse, unauthorized repairs or alterations, or product made by other manufacturers.
2. Maintenance: Manufacturer shall monitor the performance of the lighting system, including on/off status, hours of usage and luminaire outage for 25 years from the date of equipment shipment. Parts and labor shall be covered such that individual luminaire outages will be repaired when the usage of any field is materially impacted. Owner agrees to check fuses in the event of a luminaire outage.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Musco

B. Sportsbeams

C. Eaton

D. Or approved equal

2.2 BASIS OF DESIGN

A. The basis of design product shall be Musco's Light-Structure System™ with TLC for LED™

2.3 SPORTS LIGHTING SYSTEM CONSTRUCTION

A. Manufacturing Requirements: All components shall be designed and manufactured as a system. All luminaires, wire harnesses, drivers and other enclosures shall be factory assembled, aimed, wired and tested.

B. Durability: All exposed components shall be constructed of corrosion resistant material and/or coated to help prevent corrosion. All exposed carbon steel shall be hot dip galvanized per ASTM A123. All exposed aluminum shall be powder coated with high performance polyester or anodized. All exterior reflective inserts shall be anodized, coated, and protected from direct environmental exposure to prevent reflective degradation or corrosion. All exposed hardware and fasteners shall be stainless steel of 18-8 grade or better, passivated and coated with aluminum-based thermosetting epoxy resin for protection against corrosion and stress corrosion cracking. Structural fasteners may be carbon steel and galvanized meeting ASTM A153 and ISO/EN 1461 (for hot dipped galvanizing), or ASTM B695 (for mechanical galvanizing). All wiring shall be enclosed within the cross-arms, pole, or electrical components enclosure.

C. System Description: Lighting system shall consist of the following:

1. Galvanized steel poles and cross-arm assembly.
2. Non-approved pole technology:
    a. Square static cast concrete poles will not be accepted.
    b. Direct bury steel poles which utilize the extended portion of the steel shaft for their foundation will not be accepted due to potential for internal and external corrosive reaction to the soils and long term performance concerns.
3. Lighting systems shall use concrete foundations.
    a. For a foundation using a pre-stressed concrete base embedded in concrete backfill the concrete shall be air-entrained and have a minimum compressive design strength at 28 days of 3,000 PSI. 3,000 PSI concrete specified for early pole erection, actual required minimum allowable concrete strength is 1,000 PSI. All piers and concrete backfill must bear on and against firm undisturbed soil.
    b. For anchor bolt foundations or foundations using a pre-stressed concrete base in a suspended pier or reinforced pier design pole erection may occur after 7 days. Or after a concrete sample from the same batch achieves a certain strength.

4. Manufacturer will supply all drivers and supporting electrical equipment

    a. Remote drivers and supporting electrical equipment shall be mounted approximately 10 feet above grade in aluminum enclosures. The enclosures shall be touch-safe and include drivers and fusing with indicator lights on fuses to notify when a fuse is to be replaced for each luminaire. Disconnect per circuit for each pole structure will be located in the enclosure.

    b. If using an integral driver fixture, must provide easy access to pole top for routine maintenance, service platforms shall be provided for each pole. Floor of service platform shall be approximately 26 inches by 62 inches for a 2 Light Bar; 26 inches by 115 inches for a 4 Light Bar; and 26 inches by 170 inches for a 6 Light Bar. Centered in the platform shall be an access door hinged to open to the rear. The mounting supports on the platform shall be C3x5 channel and C4x7.25 channel. The floor shall be all welded construction. Pole Climbing Steps and Safety Cable - To provide for easy routine maintenance and to provide for workers' safety, pole climbing steps and safety cable will be supplied. Steel climbing steps shall begin approximately 15 feet above ground and shall be staggered on 15 inch centers to top of pole. Steps shall be grade 5-3/4 inches by 7 inch long round head bolts, hot-dip galvanized meeting ASTM-A307. Bolts shall be fastened to brackets welded to the pole by two ¾ inch square nuts. Poles shall be equipped with 3/8 inch galvanized safety cable at step initiation and attached at top and bottom with welded brackets. Safety Harness - To provide for workers' safety during routine maintenance, an OSHA approved safety harness and climbing device assembly shall be supplied to the owner for use with safety cable assembly attached to the pole.

5. Manufacturer shall provide surge protection at the pole equal to or greater than 40 kA for each line to ground (Common Mode) as recommended by IEEE C62.41.2_2002.

6. Wire harness complete with an abrasion protection sleeve, strain relief and plug-in connections for fast, trouble-free installation.

7. All luminaires, visors, and cross-arm assemblies shall withstand 150 mph winds and maintain luminaire aiming alignment.

8. Control cabinet to provide remote on-off control and monitoring of the lighting system.

9. Manufacturer shall provide lightning grounding as defined by NFPA 780 and be UL Listed per UL 96 and UL 96A.

    a. Integrated grounding via concrete encased electrode grounding system.

    b. If grounding is not integrated into the structure, the manufacturer shall supply grounding electrodes, copper down conductors, and exothermic weld kits. Electrodes and conductors shall be sized as required by NFPA 780.The grounding electrode shall be minimum size of 5/8 inch diameter and 8 feet long, with a minimum of 10 feet embedment. Grounding electrode shall be connected to the structure by a grounding electrode conductor with a minimum size of 2 AWG for poles with 75 feet mounting height or less, and 2/0 AWG for poles with more than 75 feet mounting height.

D. Safety: All system components shall be UL listed for the appropriate application.

2.4 ELECTRICAL

A. Electric Power Requirements for the Sports Lighting Equipment:

1. Electric power: 480 Volt, 3 Phase

2. Maximum total voltage drop: Voltage drop to the disconnect switch located on the poles shall not exceed three (3) percent of the rated voltage.

B. Energy Consumption: The kW consumption for the field lighting system shall be 89 kW.

2.5 STRUCTURAL PARAMETERS

A. Wind Loads: Wind loads shall be based on the 2015 International Building Code. Wind loads to be calculated using ASCE 7-10, an ultimate design wind speed of 130 and exposure category C.

B. Pole Structural Design: The stress analysis and safety factor of the poles shall conform to 2013 AASHTO Standard Specification for Structural Supports for Highway Signs, Luminaires, and Traffic Signals (LTS-6).

C. Foundation Design: The foundation design shall be based on soil parameters as outlined in the geotechnical report provided by the Owner. If no geotechnical information is available, the foundation design shall be based on soils that meet or exceed those of a Class 5 material as defined by 2015 IBC Table 1806.2.

D. Foundation Drawings: Project specific foundation drawings stamped by a registered engineer in the state where the project is located are required. The foundation drawings must list the moment, shear (horizontal) force, and axial (vertical) force at ground level for each pole. These drawings must be submitted at time of bid to allow for accurate pricing.

2.6 CONTROL

A. Instant On/Off Capabilities: System shall provide for instant on/off of luminaires.

B. Lighting contactor cabinet(s) constructed of NEMA Type 4 aluminum, designed for easy installation with contactors, labeled to match field diagrams and electrical design. Manual off-on-auto selector switches shall be provided.

C. Remote Lighting Control System: System shall allow owner and users with a security code to schedule on/off system operation via a web site, phone, fax or email up to ten years in advance. Manufacturer shall provide and maintain a two-way TCP/IP communication link. Trained staff shall be available 24/7 to provide scheduling support and assist with reporting needs.

1. The owner may assign various security levels to schedulers by function and/or fields. This function must be flexible to allow a range of privileges such as full scheduling capabilities for all fields to only having permission to execute “early off” commands by phone. Scheduling tool shall be capable of setting curfew limits.

2. Controller shall accept and store 7-day schedules, be protected against memory loss during power outages, and shall reboot once power is regained and execute any commands that would have occurred during outage.

D. Remote Monitoring System: System shall monitor lighting performance and notify manufacturer if individual luminaire outage is detected so that appropriate maintenance can be scheduled. The controller shall determine switch position (manual or auto) and contactor status (open or closed).

E. Management Tools: Manufacturer shall provide a web-based database and dashboard tool of actual field usage and provide reports by facility and user group. Dashboard shall also show current status of luminaire outages, control operation and service. Mobile application will be provided suitable for IOS, Android and Blackberry devices.

1. Hours of Usage: Manufacturer shall provide a means of tracking actual hours of usage for the field lighting system that is readily accessible to the owner.

a. Cumulative hours: shall be tracked to show the total hours used by the facility

b. Report hours saved by using early off and push buttons by users.

F. Communication Costs: Manufacturer shall include communication costs for operating the controls and monitoring system for a period of 25 years.

PART 3 - EXECUTION

3.1 SOIL QUALITY CONTROL

A. It shall be the Contractor's responsibility to notify the Owner if soil conditions exist other than those on which the foundation design is based, or if the soil cannot be readily excavated. Contractor may issue a change order request / estimate for the Owner's approval / payment for additional costs associated with:

1. Providing engineered foundation embedment design by a registered engineer in the State of Massachusetts for soils other than specified soil conditions;

2. Additional materials required to achieve alternate foundation;

3. Excavation and removal of materials other than normal soils, such as rock, caliche, etc.

3.2 DELIVERY TIMING

A. Delivery Timing Equipment On-Site: The equipment must be on-site 6-8 weeks from receipt of approved submittals and receipt of complete order information.

3.3 FIELD QUALITY CONTROL

A. Illumination Measurements:

1. Testing Agency: The manufacturer shall engage a qualified testing agency to perform tests and inspections and prepare test reports.

2. Upon substantial completion of the project and in the presence of the Testing Agency, Contractor, Project Engineer, Owner's Representative, and Manufacturer's Representative, illumination measurements shall be taken and verified by the Testing Agency. The illumination measurements shall be conducted in accordance with IESNA LM-5-04.

B. Field Light Level Accountability

1. Light levels are guaranteed not to fall below the target maintained light levels for the entire warranty period of 25 Years.

2. The contractor/manufacturer shall be responsible for an additional inspection one year from the date of commissioning of the lighting system and will utilize the owner's light meter in the presence of the owner.

3. The contractor/manufacturer will be held responsible for any and all changes needed to bring these fields back to compliance for light levels and uniformities. Contractor/Manufacturer will be held responsible for any damage to the fields during these repairs.

C. Correcting Non-Conformance: If, in the opinion of the Owner or his appointed Representative, the actual performance levels including footcandles and uniformity ratios are not in conformance with the requirements of the performance specifications and submitted information, the Manufacturer shall be required to make adjustments to meet specifications and satisfy Owner.

3.4 COMMISSIONING

A. Comply with requirements specified in Division 1.

B. Engage a factory-authorized service representative to supervise and assist with startup service. Complete installation and startup check according to the approved manufacturer's written instructions.

3.5 TRAINING AND SERVICE

A. Comply with Section 26 00 01.

B. Conduct four 4-hour training sessions. Train the Owner’s maintenance personnel on procedures and schedules related to start up and shutdown, troubleshooting, servicing, and preventive maintenance.

End of Section

SECTION 27 08 00

COMMISSIONING OF COMMUNICATION SYSTEMS

PART 1 – GENERAL

1.01 RELATED DOCUMENTS

A. Drawing and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this section.

1.02 SUMMARY

A. This section includes commissioning process requirements for communication systems, assemblies and equipment.

B. Related Sections:

1. Division 01 Section “General Commissioning Requirements” for general commissioning process requirements.

1.03 DESCRIPTION

A. Refer to Division 01 Section “General Commissioning Requirements” for the description of commissioning.

1.04 DEFINITIONS

A. Refer to Division 01 Section “General Commissioning Requirements” for definitions.

1.05 SUBMITTALS

A. Refer to Division 01 Section “General Commissioning Requirements” for CxA’s role.

B. Refer to Division 01 Section “Submittals” for specific requirements. In addition, provide the following:

C. Certificates of readiness

D. Certificates of completion of installation, prestart, and startup activities

E. O&M manuals

F. Test Reports.

1.06 QUALITY ASSURANCE

A. Test Equipment Calibration Requirements: Contractors will comply with test manufacturer’ calibration procedures and intervals. Recalibrate test instruments immediately after instruments have been repaired resulting from being dropped or damaged. Affix calibration tags to test instruments. Furnish calibration records to CxA upon request.

1.07 COORDINATION

A. Refer to Division 01 Section “General Commissioning Requirements” for requirements pertaining to coordination during the commissioning process.

PART 2 – PRODUCTS

2.01 TEST EQUIPMENT

A. All standard testing equipment required to perform startup, initial checkout and functional performance testing shall be provided by the Contractor for the equipment being tested. For example, the communication contractor of Division 27 shall ultimately be responsible for all standard testing equipment for the communication system in Division 27. A sufficient quantity of two-way radios shall be provided by each subcontractor.

B. Special equipment, tools and instruments (specific to a piece of equipment and only available from vendor) required for testing shall be included in the base bid price to the Owner and left on site, except for stand-alone data logging equipment that may be used by the CxA.

C. Proprietary test equipment and software required by any equipment manufacturer for programming and/or start-up, whether specified or not, shall be provided by the manufacturer of the equipment. Manufacturer shall provide the test equipment, demonstrate its use, and assist in the commissioning process as needed. Proprietary test equipment (and software) shall become the property of the Owner upon completion of the commissioning process.

D. All testing equipment shall be of sufficient quality and accuracy to test and/or measure system performance with the tolerances specified in the Specifications. If not otherwise noted, the following minimum requirements apply: Temperature sensors and digital thermometers shall have a certified calibration within the past year to an accuracy of 0.5°F and a resolution of + or - 0.1°F. Pressure sensors shall have an accuracy of + or - 2.0% of the value range being measured (not full range of meter) and have been calibrated within the last year.

PART 3 – EXECUTION

3.01 GENERAL DOCUMENTATION

A. With assistance from the installing contractors, the CxA will prepare Pre-Functional Checklists for all commissioned components, equipment, and systems.

B. **Red-lined Drawing**: The communication system contractor will verify all equipment, systems, instrumentation, wiring and components are shown correctly on red-lined drawing. Preliminary red-lined drawings must be made available to the Commissioning Team for use prior to the start of Functional Performance Testing. Changes, as a result of Functional Testing, must be incorporated into the final as-built drawings, which will be created from the red-lined drawings. The contracted party, as defined in the Contract Documents will create the as-built drawings.

C. **Operation and Maintenance Data**: Communication System Contractor will provide a copy of O&M literature within 45 days of each submittal acceptance for use during the commissioning process for all commissioned equipment and systems. The CxA will review the O&M literature once for conformance to project requirements. The CxA will receive a copy of the final approved O&M literature once corrections have been made by the Contractor.

D. **Demonstration and Training**: Communication System Contractor will provide demonstration and training as required by the specifications. A complete training plan and schedule must be submitted by the contractor to the CxA four weeks (4) prior to any training. A training agenda for each training session must be submitted to the CxA one (1) week prior to the training session.

3.02 COMMUNICATION SYSTEM CONTRACTOR'S RESPONSIBILITIES

A. Perform commissioning tests at the direction of the CxA.

B. Attend construction phase controls coordination meetings.

C. Participate in communication systems, assemblies, equipment, and component maintenance orientation and inspection as directed by the CxA.

D. Provide information requested by the CxA for final commissioning documentation.

E. Include requirements for submittal data, operation and maintenance data, and training in each purchase order or sub-contract written.

F. Prepare preliminary schedule for Communication system orientations and inspections, operation and maintenance manual submissions, training sessions, equipment start-up task completion for owner. Distribute preliminary schedule to commissioning team members.

G. Update schedule as required throughout the construction period.

H. Assist the CxA in all verification and functional performance tests.

I. Provide measuring instruments and logging devices to record test data, and provide data acquisition equipment to record data for the complete range of testing for the required test period.

J. Gather operation and maintenance literature on all equipment, and assemble in binders as required by the specifications. Submit to CxA 45 days after submittal acceptance.

K. Coordinate with the CxA to provide 48-hour advance notice so that the witnessing of equipment and system start-up and testing can begin.

L. Participate in, and schedule vendors and contractors to participate in the training sessions.

M. Provide written notification to the CM/GC and CxA that the following work has been completed in accordance with the contract documents, and that the equipment, systems, and sub-system are operating as required.

1. Communication Systems (example: cabling, routers, switches, fiber patch panels, software, fiber-optic cable, server racks, CAT 5E cable, CAT 6 cable, CAT 6a cable, computers, etc. to provide entire communication network) and all other equipment furnished under this Division.

N. The equipment supplier shall document the performance of his equipment.

O. Provide a complete set of red-lined drawings to the CxA prior to the start of Functional Performance Testing.

P. Equipment Suppliers

1. Provide all requested submittal data, including detailed start-up procedures and specific responsibilities of the Owner, to keep warranties in force.
2. Assist in equipment testing per agreements with contractors.
3. Provide information requested by CxA regarding equipment sequence of operation and testing procedures.

Q. Refer to Division 01 Section “General Commissioning Requirements” for additional Contractor responsibilities.

3.03 CxA’S RESPONSIBILITIES

A. Refer to Division 01 Section “General Commissioning Requirements” for CxA’s Responsibilities.

3.04 TESTING PREPARATION

A. Certify in writing to the CxA that communication systems, subsystems, and equipment have been installed, calibrated, and started and are operating according to the Contract Documents.

B. Certify in writing to the CxA that communication instrumentation and controls have been completed and calibrated, that they are operating according to the Contract Documents, and that pretest set points have been recorded.

C. Certify in writing that testing procedures have been completed and that testing reports have been submitted, discrepancies corrected, and corrective work approved.

D. Place systems, subsystems, and equipment into operating mode to be tested (e.g., normal shutdown, normal auto position, normal manual position, unoccupied cycle, emergency power, and alarm conditions).

E. Inspect and verify the position of each device and interlock identified on checklist.

F. Testing Instrumentation: Install measuring instruments and logging devices to record test data as directed by the CxA.

3.05 GENERAL TESTING REQUIREMENTS

A. Provide technicians, instrumentation, and tools to perform commissioning test at the direction of the CxA.

B. Scope of Communication systems testing shall include the entire communication equipment installation, from the incoming equipment throughout the distribution system. Testing shall include all equipment and devices.

C. Test all operating modes, interlocks, control responses, and responses to abnormal or emergency conditions, and verify proper response of building automation system controllers and sensors.

D. The CxA along with the communications contractor(s) and other contracted subcontractors, shall prepare detailed testing plans, procedures, and checklists for communication systems, subsystems, and equipment.

E. Tests will be performed using design conditions whenever possible.

F. Simulated conditions may need to be imposed using an artificial load when it is not practical to test under design conditions. Before simulating conditions, calibrate testing instruments. Provide equipment to simulate loads. Set simulated conditions as directed by the CxA and document simulated conditions and methods of simulation. After tests, return settings to normal operating conditions.

G. The CxA may direct that set points be altered when simulating conditions is not practical.

H. The CxA may direct that sensor values be altered with a signal generator when design or simulating conditions and altering set points are not practical.

I. If tests cannot be completed because of a deficiency outside the scope of the Communication system, document the deficiency and report it to the Owner. After deficiencies are resolved, reschedule tests.

J. If the testing plan indicates specific seasonal testing, complete appropriate initial performance tests and documentation and schedule seasonal tests.

3.06 COMMUNICATION SYSTEMS, SUBSYSTEMS, AND EQUIPMENT TESTING PROCEDURES

A. **Equipment Testing and Acceptance Procedures:** Testing requirements are specified in individual Division 27 sections. Provide submittals, test data, inspector record and certifications to the CA.

B. **Communication System Testing:** Field testing plans and testing requirements are specified in Division 27 Sections. Assist the CxA with preparation of testing plans.

C. **Communication System Testing:** Provide technicians, instrumentation, tools and equipment to test performance of designated systems and devices at the direction of the CxA. The CxA shall determine the sequence of testing and testing procedures for each equipment item to be tested.

D. The work included in the commissioning process involves a complete and thorough evaluation of the operation and performance of all components, systems and sub-systems. The following equipment and systems shall be evaluated:
   1. Master clock system
   2. Public address system
   3. Coordination and functionality with the Building Automation System/Building Management Controls System, if applicable

3.07 DEFICIENCIES/NON-CONFORMANCE, COST OF RETESTING, FAILURE DUE TO MANUFACTURER DEFECT

A. Refer to Division 01 Section “General Commissioning Requirements” for requirements pertaining to deficiencies/non-conformance, cost of retesting, or failure due to manufacturer defect.

3.08 APPROVAL

A. Refer to Division 01 Section “General Commissioning Requirements” for approval procedures.

3.09 DEFERRED TESTING

A. Refer to Division 01 Section “General Commissioning Requirements” for requirements pertaining to deferred testing.

3.10 OPERATION AND MAINTENANCE MANUALS

A. The Operation and Maintenance Manuals shall conform to Contract Documents requirements as stated in Division 01.

B. Refer to Division 01 Section “General Commissioning Requirements” for the AE and CxA roles in the Operation and Maintenance Manual contribution, review and approval process.

3.11 TRAINING OF OWNER PERSONNEL

A. Refer to Division 01 Section “General Commissioning Requirements” for requirements pertaining to training.

END OF SECTION

DO NOT REMOVE
THIS PAGE INTENTIONALLY LEFT BLANK

Section 27 11 00

COMMUNICATIONS EQUIPMENT ROOM FITTINGS

(TRADE CONTRACT REQUIRED AS PART OF SECTION 26 00 01)

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. PUBLICLY BID TRADE CONTRACT REQUIREMENTS: As provided under Section 26 00 01 - ELECTRICAL and supplemented under the Bidding Requirements, Contract Forms, and Conditions of the Contract, and applicable parts of Division 1 - GENERAL REQUIREMENTS.

1. Work of this Trade Contract includes all individual specification sections listed in Section 26 00 01.

1.2 RELATED DOCUMENTS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications

1.3 WORK INCLUDED

A. Section Includes:

1. Telecommunications mounting elements.
2. Backboards.
3. Telecommunications pathways.
4. Grounding.

B. Related Sections:

1. Division 27 Section "Communications Backbone Cabling" for voice and data cabling associated with system panels and devices.
2. Division 27 Section "Communications Horizontal Cabling" for voice and data cabling associated with system panels and devices.

1.4 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Shop Drawings: For communications equipment room fittings. Include plans, elevations, sections, details, and attachments to other work.

1. Detail equipment assemblies, and location and size of each field connection.
2. Equipment racks and cabinets: Include workspace requirements and access for cable connections.
3. Grounding: Indicate location of grounding bus bar and its mounting detail.

C. Qualification Data: For Installer, qualified layout technician, installation supervisor, and field inspector.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: Cabling Installer must have personnel certified by BICSI on staff.

1. Layout Responsibility: Preparation of Shop Drawings shall be under the direct supervision of RCDD.

2. Installation Supervision: Installation shall be under the direct supervision of Registered Technician, who shall be present at all times when Work of this Section is performed at Project site.

3. Field Inspector: Currently registered by BICSI as RCDD to perform the on-site inspection.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Telecommunications Pathways and Spaces: Comply with TIA-569-A.

D. Grounding: Comply with ANSI-J-STD-607-A.

1.6 PROJECT CONDITIONS

A. Environmental Limitations: Do not deliver or install equipment frames and cable trays until spaces are enclosed and weather tight, wet work in spaces is complete and dry, and work above ceilings is complete.

1.7 COORDINATION

A. Coordinate layout and installation of communications equipment with Owner's telecommunications and LAN equipment and service suppliers. Coordinate service entrance arrangement with local exchange carrier.

1. Meet jointly with telecommunications and LAN equipment suppliers, local exchange carrier representatives, and Owner to exchange information and agree on details of equipment arrangements and installation interfaces.

2. Record agreements reached in meetings and distribute them to other participants.

3. Adjust arrangements and locations of distribution frames, cross-connects, and patch panels in equipment rooms to accommodate and optimize arrangement and space requirements of telephone switch and LAN equipment.

1.8 WARRANTY

A. Comply with Section 260001.

B. The Electrical Trade Contractor shall warranty that all materials furnished shall be free from defects of material for a period of one year from the date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PATHWAYS

A. General Requirements: Comply with TIA-569.

B. Cable Support: NRTL labeled for support of Category 6A cabling, designed to prevent degradation of cable performance and pinch points that could damage cable.

1. Support brackets with cable tie slots for fastening cable ties to brackets.
2. Lacing bars, spools, J-hooks, J-Pros, J-Mods and D-rings.
3. Straps and other devices.

C. Conduit and Boxes: Comply with requirements specified in Division 26.

1. Outlet boxes shall be no smaller than 4 inches (100 mm) wide, 3 inches (75 mm) high, and 2-1/2 inches (64 mm) deep. Provide single-gang raise covers.
2. In rated walls provide boxes listed for use in fire rated walls.
3. Back-to-back device boxes shall be staggered so that only one box occupies the wall cavity between two studs. Provide 1” EMT conduit stub with pull string above the accessible ceiling.

D. Wire Mesh Basket Trays:

1. Manufacturers:
   a. Basofil.
   b. Cablofil Inc.
   c. Cooper B-Line, Inc.
   d. Or approved equal
2. Wire Mesh Basket Trays
   a. Provide wire basket of types and sizes indicated; with all required splicing and mounting hardware. Construct units with T-weld edges and smooth surfaces; in compliance with applicable standards; and with the following additional construction features.
      1) All straight section longitudinal wires shall be constructed with a continuous top wire safety edge. Safety edge must be T-welded on all tray sizes.
      2) Wire basket cross-wire to be constructed with either flat shaped wire design or with round wire design, as directed by engineer.
         a) Flat shaped cross wire design shall provide additional surface area for cable weight support and to avoid pressure points and strain on cables.
         b) Round shaped cross wire design may be used in general purpose applications where cable weight and strain are not concerns.
   b. Materials and Finishes: Material and finish specifications for Carbon Steel Wire and Pre-Galvanized steel wire are as follows:
      1) Pre-galvanized Zinc: Straight section shall be made from pre-galvanized steel meeting the minimum mechanical properties of ASTM A 641. Material must be cleaned after fabrication to remove any soot, manufacturing residue/oils, or metallic particles.
   c. Wire basket shall be made of high strength steel wires and formed into a standard 2 inch by 4-inch wire mesh pattern with intersecting wires welded together. All mesh sections must have at least one bottom longitudinal wire along entire length of straight section.
   d. Wire basket sizes shall conform to the following nominal criteria:

1) Straight sections shall be furnished in standard 118-inch lengths.

2) Wire diameter shall be 0.195" (5mm) minimum on all mesh sections up to 16 linear inches. Wire diameter line wire shall be 0.234" (6mm) minimum on all mesh sections in excess of 16 linear inches. Wire diameter shall be minimum size of 4.5mm on stainless steel.

3) Wire basket shall have a 4-inch usable loading depth (4), (6), (8), (10), (12), (14), (16), (18), (20), (22), (24), (26), (28) inches wide.

4) All fillings shall be field formed, from straight sections, in accordance with manufacturer's instructions.

5) All Tray sections and splicing assemblies shall be UI7C-UL Classified as an Equipment Ground Conductor (EGC).

6) Wire mesh basket tray supports shall be ceiling trapeze type, center support, trapeze clips, or wall brackets.

7) Special accessories shall be furnished as required to protect, support and install a wire basket support system.

e. Provide wire mesh basket trays where shown on the drawings. The main trunk shall be 18 inches wide by 4 inches deep.

f. Provide 18 inches wide by 4 inches deep wire mesh basket trays in all telecommunications rooms and server rooms housing telecommunications equipment and cable punchdowns.

2.2 BACKBOARDS

A. Backboards: Plywood, fire-retardant treated, 3/4 by 48 by 96 inches (19 by 1220 by 2440 mm). Comply with requirements for plywood backing panels specified in Division 06 Section "Rough Carpentry."

2.3 GROUNDING

A. Comply with requirements of ANSI/J-STD-607-A.

B. Busbar

1. Telecommunications main grounding busbar (TMGB)

a. The TMGB shall be a predrilled copper busbar provided with holes for use with standard sized lugs and shall be listed by a nationally recognized testing laboratory (NRTL). The minimum size of the TMGB shall be 6 mm (0.25 in) thick by 100 mm (4 in) wide by a length that is determined by the number of connections (including future growth) that will be required to be made to the busbar (see ANSI/J-STD-607-A). The TMGB shall be insulated from its support attachment a minimum of 50 mm (2 in). Minimum length shall be 14 in.

2. Telecommunications grounding busbar (TGB)

a. The TGB shall be a predrilled copper busbar provided with holes for use with standard sized lugs (see figure 3) and shall be Listed by an NRTL The minimum size of the TGB shall be 6 mm (0.25 in) thick by 50 mm (2 in) wide by a length that is determined by the number of connections (including future growth) that will be required to be made to the busbar (see ANSI/I-STD-607-A). The TGB shall be insulated from its support attachment a minimum of 50 mm (2 in). Minimum length shall be 10 in.

C. Bonding to the electrical power system

1. The telecommunication bonding and grounding system shall be bonded to the power grounding system either at the service panel grounding busbar or the electrical grounding electrode, as described in ANSI/J-STD-607-A.

D. Bonding conductor

1. Bonding conductors shall be insulated stranded copper or flat braided copper and shall be Listed for the space in which they are intended to be placed according to the NEC® (e.g., plenum spaces, riser spaces), unless otherwise specified. When conductors are insulated, the jacket shall be green, green with a yellow stripe, or marked with green tape or a green adhesive label.

E. Telecommunications bonding backbone (TBB)

1. The TBB connects the TMGB to the telecommunications grounding busbars (TGBs). The TBB shall be a continuous green insulated copper conductor that should be sized no less than 3/0 AWG.

F. Grounding equalizer (GE)

1. The GE connects the telecommunications grounding busbar(s) in the same-floor telecommunications rooms (TRs) on the first, top, and every third floor in a multistory building. The GE shall be a continuous green insulated copper conductor that should be sized no less than 3/0 AWG.

2. NOTE: Cable shields do not satisfy the requirements for a GE.

G. Bonding connections

1. Bonding connections shall be made by means of a compression connector or an exothermic weld. Compression connectors shall have only one conductor installed unless designed or Listed for more conductors. Compression and exothermically welded connections are irreversible, can withstand multiple fault currents, and will not loosen. Mechanical connections are only allowed when connecting a conductor to equipment, raceways, cable trays, water pipe, and similar appurtenances or when a compression or exothermic connection cannot be made. Connections to the TMGB/TGB shall use exothermically welded connections or two-hole lug connectors. Two-hole lug connections can be compression connectors or exothermically welded connectors.

H. Connections to the TMGB/TGB

1. Electrical distribution panel (EDP)

a. When an EDP is located in the same room as the TMGB/TGB, that EDP's equipment grounding bus or the panel board enclosure shall be bonded to the TMGB/TGB using green insulated bonding conductors sized no less than 6 AWG to a maximum 3/0 AWG.

2. Building steel

a. Where building steel is accessible and in the same room as the TMGB/TGB, the TMGB/TGB shall be bonded to building steel using a minimum 6 AWG green insulated conductor. When the building steel is external to the room but readily accessible, it should be bonded to the TMGB/TGB. Building steel should be tested to verify its ground conductivity to earth.

b. NOTE: Modern building construction techniques will ground building steel to the main ac power entrance or another grounding source. Ensure that when

working in existing buildings that the building steel is bonded to a suitable ground source (e.g., electrical power grounding electrode[s], building ground ring).

3. Conduit

   a. In order to limit the potential difference between telecommunications conduits and telecommunications conduits and power conduits, the telecommunications conduits shall be bonded to the TMGB/TGB.

4. Telecommunications equipment bonding conductor (TEBC)

   a. The TEBC shall be exothermically welded or connected, using either a compression style or exothermic style two-hole lug, to the connection point on the TMGB/TGB.

5. Bonding equipment, racks and cabinets

   a. The TMGB/TGB shall be bonded to equipment, racks and cabinets using a minimum 6 AWG green insulated conductor.

6. All cable tray, ladder rack, and access floors shall be grounded/bonded to the Telecommunications Grounding Busbar (TGB). All aforementioned telecommunications components shall be grounded/bonded to the TGB using stranded 6 AWG green insulated conductor. Cable tray and ladder rack runs shall be grounded/bonded per the manufacturer's instructions. At a minimum the cable tray and ladder rack shall be grounded/bonded to the building steel every 50 ft.

2.4 LABELING

A. Comply with TIA-606-A and UL 969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers.

PART 3 - EXECUTION

3.1 ENTRANCE FACILITIES

A. Contact telecommunications service provider and arrange for installation of demarcation point, protected entrance terminals, and a housing when so directed by service provider.

B. Install underground pathways complying with recommendations in TIA-569-A, "Entrance Facilities" Article.

3.2 INSTALL UNDERGROUND ENTRANCE PATHWAY COMPLYING WITH DIVISION 26 SECTION "RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS."INSTALLATION

A. Comply with NECA 1.

B. Comply with BICSI TDMM for layout and installation of communications equipment rooms.

C. Cable Trays: Comply with NEMA VE 2 and TIA-569-A-7.

D. Bundle, lace, and train conductors and cables to terminal points without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.

3.3 FIRESTOPPING

A. Penetration pathways required for low voltage cabling shall meet the following requirements:

1. Meet the hourly fire-rating of fire rated wall and or floor penetrated.
2. Be tested for the surrounding construction and cable types involved.
3. Have UL Systems permitting cable loads from; “Zero to 100% Visual Fill.” This requirement eliminates need for fill-ratio calculations to be made by cable technicians to ensure cable load is within maximum allowed by UL System.
4. Not have inner fabric liner that tightens around and compresses cables tightly together encouraging potential cable damage or interference.
5. Be “Zero-Maintenance”, zero-maintenance is defined as; No action required by cabling technician to open and/or close pathway for cable moves, adds or changes, such as, but not limited to:
    a. Opening or closing of doors.
    b. Spinning rings to open or close fabric liner.
    c. Removal and or replacement of any material such as, but not limited to, firestop caulk, putty, pillows, bags, foam muffins, foam, foam plugs, foam blocks, or foam closures of any sort.
    d. Evaluation Services Report (ESR) from an accredited Nationally Recognized Third-party Laboratory certifying compliance with this definition of “Zero-Maintenance” and all relevant codes and standards.
6. Penetration pathways shall be engineered such that two or more devices may be ganged together for larger cable capacities.
7. Penetration pathways shall be engineered to be re-enterable so they can be retrofitted and removed from around existing cables without cutting and re-splicing them.
8. Cable Pathway Devices passing vertically through floors shall have equal F & T Rating.
9. Affix adhesive wall label immediately adjacent to devices to communicate to future cable technicians, authorities having jurisdiction and others the manufacturer of the device and the corresponding.

B. Fire Rated Cable Pathways: Gangable device modules capable of being retrofitted around existing cables and comprised of steel raceway with intumescent foam pads allowing 0 to 100 percent cable fill and requiring no additional action in the form of plugs, twisting closure, putty, pillow, or sealant to achieve fire and leakage ratings.
    1. Manufacturers
        a. Specified Technologies Inc. (STI) EZ-Path Fire Rated Pathway
        b. Legrand FlameStopper thru-wall fittings
        c. Hilti Speed Sleeve CP 653
        d. Or approved equal
    2. Basis of Design
        a. The system specified is based upon products by STI and represents the performance standard upon which any equivalent solution shall be based.
            1) 4” – EZ-Path Series 44+
            2) 2” – EZ-Path Series 22
    3. Applications

a. Telecommunications room floor penetrations:

1) Provide a minimum of 4-4” fire rated penetrations unless otherwise noted.

b. Telecommunications room ceiling penetrations:

1) Provide a minimum of 4-4” fire rated penetrations unless otherwise noted.

c. Telecommunications room wall penetrations:

1) Provide a minimum of 4-4” fire rated penetrations unless otherwise noted.

d. Rooms accessible from corridors:

1) Provide a minimum of 1-2” fire rated penetration from the corridor to each classroom or office unless otherwise noted.

e. Classrooms:

1) Provide a minimum of 1-2” fire rated penetration from the corridor to each classroom or office unless otherwise noted.

f. Fire rated corridor walls in corridors:

1) Provide a minimum of 4-4” fire rated penetrations unless otherwise noted.

3.4 GROUNDING

A. Install grounding according to BICSI TDMM, "Grounding, Bonding, and Electrical Protection" Chapter.

B. Comply with ANSI-J-STD-607-A.

C. Bond metallic equipment to the grounding bus bar, using not smaller than No. 6 AWG equipment grounding conductor.

3.5 IDENTIFICATION

A. Identify system components, wiring, and cabling complying with TIA-606-A. Comply with requirements in Division 26 Section "Identification for Electrical Systems." Comply with requirements in Division 09 Section "Interior Painting" for painting backboards. For fire-resistant plywood, do not paint over manufacturer's label.

B. See Division 27 Section "Communications Horizontal Cabling" for additional identification requirements. See Evaluations for discussion of TIA standard as it applies to this Section. Paint and label colors for equipment identification shall comply with TIA-606-A for Class 2 level of administration.

C. Labels shall be preprinted or computer-printed type.

End of Section

Section 27 13 00

COMMUNICATIONS BACKBONE CABLING

(TRADE CONTRACT REQUIRED AS PART OF SECTION 26 00 01)

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. PUBLICLY BID TRADE CONTRACT REQUIREMENTS: As provided under Section 26 00 01 - ELECTRICAL and supplemented under the Bidding Requirements, Contract Forms, and Conditions of the Contract, and applicable parts of Division 1 - GENERAL REQUIREMENTS.

1. Work of this Trade Contract includes all individual specification sections listed in Section 26 00 01.

1.2 RELATED DOCUMENTS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications

1.3 WORK INCLUDED

A. Section Includes:

1. Pathways.
2. UTP cable.
3. 50/125-micrometer, optical fiber cabling.
4. 62.5/125-micrometer, optical fiber cabling.
5. Single mode optical fiber cabling.
6. Cable connecting hardware, patch panels, and cross-connects.
7. Cabling identification products.

B. Related Sections:

1. Division 27 for voice and data cabling associated with system panels and devices.

1.4 DEFINITIONS

A. BICSI: Building Industry Consulting Service International.

B. Cross-Connect: A facility enabling the termination of cable elements and their interconnection or cross-connection.

C. EMI: Electromagnetic interference.

D. IDC: Insulation displacement connector.

E. LAN: Local area network.

F. RCDD: Registered Communications Distribution Designer.

G. UTP: Unshielded twisted pair.

1.5 CODES AND STANDARDS

A. Complete installation shall meet or exceed the latest edition of following standards:

1. TIA-568: Commercial building telecommunications wiring standard and all current addenda.

2. TIA-569: Commercial building standard for telecommunications pathways and spaces.

3. TIA-606: Administration standard for telecommunications infrastructure of commercial buildings.

4. TIA-607: Commercial building grounding and bonding requirements for telecommunications.

5. ANSI, ASTM, UL, NEMA, IEEE and FCC standards as applicable.

6. BICSI Telecommunications Distribution Methods Manual, current edition.

1.6 BACKBONE CABLING DESCRIPTION

A. Backbone cabling system shall provide interconnections between telecommunications closet/room, data center, and entrance facilities (demark room) in the telecommunications cabling system structure. Cabling system consists of backbone cables, intermediate and main cross-connects, mechanical terminations, and patch cords or jumpers used for backbone-to-backbone cross-connection.

B. Backbone cabling cross-connects may be located in communications equipment rooms or at entrance facilities. Bridged taps and splitters shall not be used as part of backbone cabling.

1.7 PERFORMANCE REQUIREMENTS

A. General Performance: Backbone cabling system shall comply with transmission standards in TIA-568, when tested according to test procedures of this standard.

1.8 SUBMITTALS

A. Comply with requirements specified in Division 01.

B. Shop Drawings

1. Prior to assembling or installing the system, the Contractor shall provide complete shop drawings which include the following:

a. Architectural floor plans indicating all system device locations.

b. Full schematic wiring information for all devices. Wiring information shall include cable type, cable length, conductor routings, quantities, and point-to-point termination schedules.

c. Complete system one-line block diagram.

d. Statement of the system sequence of operation.

e. Riser diagrams showing interconnections.

f. Detail drawings showing installation and mounting.

g. Calculations detailing 25% spare capacity of each circuit.

2. All drawings shall be fully dimensioned.

3. Operating License: Submit evidence of application for FCC Radio Station Authorization prior to installing equipment. Furnish the license or a copy of the application for the license, to the Owner/End User prior to operating the equipment. The original license must be delivered to the Owner/End User.

C. As-Built Drawings

1. At the conclusion of the project, the Contractor shall provide “as built” drawings. The “as built” drawings shall be a continuation of the Contractors shop drawings as modified, augmented, and reviewed during the installation, check out and acceptance phases of the project. All drawings shall be fully dimensioned and prepared in DWG format using the latest version of AutoCAD.

2. The as-built drawings shall incorporate all updated system riser diagrams prepared in DWG format using the latest version of AutoCAD.

D. Manuals

1. At the conclusion of the project, the Contractor shall provide copies of the manuals as described herein. Each manual’s contents shall be identified on the cover. The manual shall include names, addresses, and telephone numbers of each system integrator installing equipment and systems and the nearest service representatives for each item of equipment for each system. The manuals shall have a table of contents and labeled sections. The manuals shall include all modifications made during installation, checkout, and acceptance. The manuals shall contain the following:

a. Functional Design Manual

1) The functional design manual shall identify the operational requirements for the system and explain the theory of operation, design philosophy, and specific functions. A description of hardware and software functions, interfaces, and requirements shall be included for all system operating modes.

b. Hardware Manual

1) The hardware manual shall describe all equipment furnished including:

a) General description and specifications

b) Installation and check out procedures

c) Equipment layout and electrical schematics to the component level

d) System layout drawings and schematics

e) Alignment and calibration procedures

f) Manufacturers repair parts list indicating sources of supply

c. Software Manual

1) The software manual shall describe the functions of all software and shall include all other information necessary to enable proper loading, testing, and operation. The manual shall include:
   a) Definition of terms and functions
   b) Use of system and applications software
   c) Initialization, start up, and shut down
   d) Alarm reports
   e) Reports generation
   f) Data base format and data entry requirements
   g) Directory of all disk files

2. Operators Manual
   a. The operator's manual shall fully explain all procedures and instructions for the operation of the system including:
      1) Computers and peripherals
      2) System start up and shut down procedures
      3) Use of system, command, and applications software
      4) Recovery and restart procedures
      5) Graphic alarm presentation
      6) Use of report generator and generation of reports
      7) Data entry
      8) Operator commands
      9) Alarm messages and reprinting formats
      10) System access requirements

3. Maintenance Manual
   a. The maintenance manual shall include descriptions of maintenance for all equipment including inspection, periodic preventive maintenance, fault diagnosis, and repair or replacement of defective components.

1.9 QUALITY ASSURANCE

A. Installer Qualifications: Cabling Installer must have personnel certified by BICSI on staff.
   1. Layout Responsibility: Preparation of Shop Drawings and Cabling Administration Drawings, and field testing program development by an RCDD.
   2. Installation Supervision: Installation shall be under the direct supervision of Registered Technician, who shall be present at all times when Work of this Section is performed at Project site.
   3. Testing Supervisor: Currently certified by BICSI as an RCDD to supervise on-site testing.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Telecommunications Pathways and Spaces: Comply with TIA-569.

D. Grounding: Comply with ANSI-J-STD-607.

1.10 DELIVERY, STORAGE, AND HANDLING

A. Test cables upon receipt at Project site.

1. Test optical fiber cable to determine the continuity of the strand end to end. Use optical loss test set.

2. Test optical fiber cable while on reels. Use an optical time domain reflectometer to verify the cable length and locate cable defects, splices, and connector, including the loss value of each. Retain test data and include the record in maintenance data.

3. Test each pair of UTP cable for open and short circuits.

1.11 PROJECT CONDITIONS

A. Environmental Limitations: Do not deliver or install cables and connecting materials until wet work in spaces is complete and dry, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.

1.12 COORDINATION

A. Coordinate layout and installation of telecommunications pathways and cabling with Owner's telecommunications and LAN equipment and service suppliers.

B. The ceiling cavity is being used as plenum return. Provide plenum rated cables, conduit, backboxes in all plenum rated ceilings, rated walls, penetrations though wall, floors and ceilings and where required by Local, State or Federal Codes.

1.13 QUALIFICATION OF SYSTEM

A. Acceptable proposed systems will be covered by a two-part certification program provided by a single manufacturer and that manufacturer's certified Contractor. Manufacturer shall administer a follow on program through the Contractor to provide support and service to the purchaser. The first part is an assurance program, which provides that the certified system will support the applications for which it is designed, during the life time warranty of the certified system.

B. The second portion of the certification is a life time warranty provided by the manufacturer and the vendor on all products within the system (cords, telecommunications outlet/connectors, cables, cross-connects, patch panels, etc.).

C. In the event that the certified system ceases to support the certified application(s), whether at the time of cutover, during normal use or when upgrading (e.g. ATM), the manufacturer and Contractor shall commit to promptly implement corrective action.

D. Documentation proving the cabling system's compliance to the End-to-End Link Performance recommendations, as listed in TIA-568 shall be provided by the Contractor prior to the structured cabling system being installed.

E. The cabling system must conform to the current issue of industry standard TIA-568. All performance requirements of this document must be followed. As well, workmanship and

installation methods used shall be equal to or better than that found in the BICSI (Building Industry Consulting Service International) TDMM manual.

F. The Owner demands strict adherence to the performance specifications listed in TIA-568 series standards.

G. Manufacturer shall maintain ISO Quality Control registration for the facilities that manufacturer the product used in this cabling system.

1.14 WARRANTY

A. Comply with Section 260001.

B. The Electrical Trade Contractor shall warranty that all materials furnished shall be free from defects of material for a period of one year from the date of Substantial Completion.

PART 2 - PRODUCTS

2.1 RACKS

A. 4-Post 84”H x 19”W x 30”D with 6” vertical cable management. Provide as shown on the contract drawings. Provide 4-post racks in Server Rooms. Coordinate rack requirements with various system vendors and provide appropriate rack for each system.

2.2 UTP CABLE

A. Manufacturers

1. Berk-Tek.
2. General Cable.
3. Panduit.
4. Or approved equal.

B. Basis of Design

1. The system specified is based upon products by Berk-Tek and represents the performance standard upon which any equivalent solution shall be based.

C. Description: 100-ohm, 4-pair UTP, formed into 25-pair binder groups covered with a blue thermoplastic jacket.

1. Comply with ICEA S-90-661 for mechanical properties.
2. Comply with TIA-568 for performance specifications.
3. Comply with TIA-568, Category 5e, Category 6 and Category 6A.
4. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444 and NFPA 70 for the following types:
    a. Communications, General Purpose: Type CM or CMG.
    b. Communications, Plenum Rated: Type CMP, complying with NFPA 262.
    c. Communications, Riser Rated: Type CMR, complying with UL 1666.
    d. Communications, Limited Purpose: Type CMX.

e. Multipurpose: Type MP or MPG.

f. Multipurpose, Plenum Rated: Type MPP, complying with NFPA 262.

g. Multipurpose, Riser Rated: Type MPR, complying with UL 1666.

5. Basis of design recommendations:

a. Voice/Data: Category 6 – Berk-Tek Cable Plenum (LANmark-2000); Outdoor (10139885).

b. Category 3 high pair count: Berk-Tek Cable

1) 25-Pair plenum (10032036)

2) 50-Pair plenum (10032112)

3) 100-Pair plenum (10032113)

4) 200-Pair plenum (10032123)

5) 300-Pair plenum (10032124)

2.3 UTP HARDWARE

A. Basis of design recommendations:

1. Leviton 41AB2-1F4 100-Pair 110-punchdown block kit.

2. Leviton 41AB2-3F4 300-Pair 110-punchdown block kit.

2.4 NETWORK PROTECTION

A. Manufacturers:

1. Porta Systems Corp.

2. Circa Telecom

3. EDCO

4. Or approved equal

B. Basis of design

1. The system specified is based upon products by Porta Systems Corp. and represents the performance standard upon which any equivalent solution shall be based.

C. Provide lighting protection for all copper lines entering each building.

D. Design recommendations (Porta Systems Corp.):

1. 24100-110-F110P 100-pair building entrance termination with solid state protectors.

2.5 OPTICAL FIBER CABLE

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Berk-Tek.

2. Mohawk.

3. General Cable.

4. Or approved equal.

B. Basis of Design

1. The system specified is based upon products by Berk-Tek and represents the performance standard upon which any equivalent solution shall be based.

C. Description: Multimode, 50/125-micrometer, laser optimized, optical fiber cable.

1. Comply with ICEA S-83-596 for mechanical properties.
2. Comply with TIA-568 for performance specifications.
3. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444, UL 1651, and NFPA 70 for the following types:
    a. General Purpose, Nonconductive: Type OFN or OFNG.
    b. Plenum Rated, Nonconductive: Type OFNP, complying with NFPA 262.
    c. Riser Rated, Nonconductive: Type OFNR, complying with UL 1666.
    d. General Purpose, Conductive: Type OFC or OFCG.
    e. Plenum Rated, Conductive: Type OFCP, complying with NFPA 262.
    f. Riser Rated, Conductive: Type OFCR, complying with UL 1666.
4. Maximum Attenuation: 3.50 dB/km at 850 nm; 1.5 dB/km at 1300 nm.
5. Minimum Modal Bandwidth: 160 MHz-km at 850 nm; 500 MHz-km at 1300 nm.
6. Multimode fiber shall be terminated in type SC connectors (verify with Owner).

D. Description: Multimode, 62.5/125-micrometer, laser optimized, optical fiber cable.

1. Comply with ICEA S-83-596 for mechanical properties.
2. Comply with TIA-568 for performance specifications.
3. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444, UL 1651, and NFPA 70 for the following types:
    a. General Purpose, Nonconductive: Type OFN or OFNG.
    b. Plenum Rated, Nonconductive: Type OFNP, complying with NFPA 262.
    c. Riser Rated, Nonconductive: Type OFNR, complying with UL 1666.
    d. General Purpose, Conductive: Type OFC or OFCG.
    e. Plenum Rated, Conductive: Type OFCP, complying with NFPA 262.
    f. Riser Rated, Conductive: Type OFCR, complying with UL 1666.
4. Maximum Attenuation: 3.50 dB/km at 850 nm; 1.5 dB/km at 1300 nm.
5. Minimum Modal Bandwidth: 160 MHz-km at 850 nm; 500 MHz-km at 1300 nm.
6. Multimode fiber shall be terminated in type SC connectors (verify with Owner).

E. Description: Single mode, 8.3/125- micrometer, optical fiber cable.

1. Comply with ICEA S-83-596 for mechanical properties.
2. Comply with TIA-568 for performance specifications.

3. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444, UL 1651, and NFPA 70 for the following types:
    a. General Purpose, Nonconductive: Type OFN or OFNG.
    b. Plenum Rated, Nonconductive: Type OFNP, complying with NFPA 262.
    c. Riser Rated, Nonconductive: Type OFNR, complying with UL 1666.
    d. General Purpose, Conductive: Type OFC or OFCG.
    e. Plenum Rated, Conductive: Type OFCP, complying with NFPA 262.
    f. Riser Rated, Conductive: Type OFCR, complying with UL 1666.
4. Single mode fiber shall be terminated in type SC connectors (verify with Owner).

F. Jacket:
1. Jacket Color: Aqua for 50/125-micrometer cable; Orange for 62.5/125-micrometer cable and Yellow for single mode fiber.
2. Cable cordage jacket, fiber, unit, and group color shall be according to TIA-598.
3. Imprinted with fiber count, fiber type, and aggregate length at regular intervals not to exceed 40 inches (1000 mm).

G. Design recommendations:
1. Inside Plant Single Mode Fiber, Berk-Tek Cable No.:
    a. PDPxxxAB0707 (Plenum Distribution)
2. Inside Plant Multimode 50 Micron OM4 Fiber, Berk-Tek Cable No.:
    a. PDPKxxxFB3010/25-I/O-C4(AQU) (Plenum Distribution)
3. Inside Plant Multimode 62.5 Micron Fiber, Berk-Tek Cable No.:
    a. PDPxxxCB3510/25 (Plenum Distribution)
4. Inside/Outside Plant Single Mode Fiber, Berk-Tek Cable No.:
    a. PDPxxxAB0707-HEBLA (Plenum Distribution)
5. Inside/Outside Plant Multimode 50 Micron OM4 Fiber, Berk-Tek Cable No.:
    a. PDPKxxxFB3010/25-I/O-C4(AQU) (Plenum Distribution)
6. Inside/Outside Plant Multimode 62.5 Micron Fiber, Berk-Tek Cable No.:
    a. PDPxxxCB3510/25-I/O (Plenum Distribution)

2.6 OPTICAL FIBER CABLE HARDWARE

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Leviton.
2. Panduit.
3. Hubbell.
4. Or approved equal.

B. Basis of Design

1. The system specified is based upon products by Leviton and represents the performance standard upon which any equivalent solution shall be based.

C. Cable Connecting Hardware: Meet the Optical Fiber Connector Intermateability Standards (FOCIS) specifications of TIA-604. Comply with TIA-568.

1. Quick-connect, simplex and duplex, Type SC connectors. Insertion loss not more than 0.75 dB.
2. Type SFF connectors may be used in termination racks, panels, and equipment packages.

D. Basis of design recommendations:

1. Leviton 5R2UM-F06, rack mount distribution enclosure, 2RU.
2. Leviton 5F100-62C, single mode 12-strandS with SC connectors.
3. Leviton 5F100-6AC, multimode 50 Micron 12-strands with SC connectors.
4. Leviton 5F100-6BC, multimode 62.5 Micron 12-strands with SC connectors.

E. Patch Cords: Provide patch cords for all fiber ports in each telecommunications closet.

1. Leviton UPDSC-SXX, SC-SC single mode patch cord.
2. Leviton 50LDSC-MXX, laser optimized OM4 duplex, SC-SC 50 Micron multimode patch cord.
3. Provide patch cord for each port, minimum length shall one 1 meter. Coordinate exact lengths with the Owner.

2.7 COAXIAL CABLE

A. Manufacturers:

1. Berk-Tek.
2. General Cable
3. Belden
4. Or approved equal.

B. Basis of Design

1. The system specified is based upon products by Berk-Tek and represents the performance standard upon which any equivalent solution shall be based.

C. General Coaxial Cable Requirements: Broadband type, recommended by cable manufacturer specifically for broadband data transmission applications. Coaxial cable and accessories shall have 75-ohm nominal impedance with a return loss of 20 dB maximum from 7 to 806 MHz

D. RG-11/U: NFPA 70.

1. No. 14 AWG, solid, copper-covered steel conductor.
2. Gas-injected, foam-PE insulation.
3. Quad shielded with 100 percent aluminum polyester tape and 60 percent aluminum braid.

4. Jacketed with sunlight-resistant, black PVC or PE.
5. Suitable for outdoor installations in ambient temperatures ranging from minus 40 to plus 85 deg C.

E. 500 Hardline: NFPA 70.

1. Gas-injected, foam-PE insulation.
2. Jacketed with sunlight-resistant, PE.
3. Suitable for outdoor installations in ambient temperatures ranging from minus 40 to plus 85 deg C.

F. NFPA and UL compliance, listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 1655, and with NFPA 70 "Radio and Television Equipment" and "Community Antenna Television and Radio Distribution" Articles. Types are as follows:

1. CATV Cable: Type CATV.
2. CATV Plenum Rated: Type CATVP, complying with NFPA 262.
3. CATV Riser Rated: Type CATVR, complying with UL 1666.
4. CATV Limited Rating: Type CATVX.

G. Cabling Requirements:

1. All coaxial cable shall be swept from 5 MHz-3 GHz.
2. Main trunk cables should be CATVR rated RG-11 cable, swept from 5 MHz-3 GHz. Hard line cable .500 or larger is also acceptable.
3. Underground cable runs that connect separate buildings must use flooded type cable and be in conduit.
4. RG-11 or hard-line cable should be used for runs up to 500 feet. Hard-line cable is required for runs of 500 feet or more.
5. Cable runs should not contain splices.
6. Use plenum-grade CATVP cable in plenum ceilings.
7. RG-11 coaxial cable can use compression-type or hex-crimp connectors with a crimped center conductor pin.
8. All cable pulls prior to termination must leave a 3-foot service loop.
9. Coaxial cable type and installation must meet NEC codes for fire safety.
10. All weather-exposed cables must be the flooded type.
11. RG-59 type cable is not acceptable.

2.8 COAXIAL CABLE HARDWARE

A. Manufacturers

1. Leviton.
2. Panduit.
3. Hubbell

4. Or approved equal.

B. Basis of Design

1. The system specified is based upon products by Leviton and represents the performance standard upon which any equivalent solution shall be based.

2.9 GROUNDING

A. Comply with requirements in Division 26.

B. Comply with ANSI-J-STD-607-A.

2.10 IDENTIFICATION PRODUCTS

A. Comply with TIA-606 and UL 969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers.

2.11 SOURCE QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to evaluate cables.

B. Factory test cables on reels according to TIA-568.

C. Factory test UTP cables according to TIA-568.

D. Factory test multimode optical fiber cables according to TIA-526 and TIA-568.

E. Cable will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 ENTRANCE FACILITIES

A. Coordinate backbone cabling with the protectors and demarcation point provided by communications service provider.

B. Provide lightning protection for all copper backbone cables entering or leaving a telecommunications closet/room.

3.2 WIRING METHODS

A. Wiring Method: Install cables in raceways and cable trays except within consoles, cabinets, desks, and counters and except in accessible ceiling spaces, in attics, and in gypsum board partitions where unenclosed wiring method may be used. Conceal raceway and cables except in unfinished spaces.

1. Install plenum cable in environmental air spaces, including plenum ceilings.

2. Comply with requirements for raceways and boxes specified in Division 26.

B. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.

C. Wiring within Enclosures: Bundle, lace, and train cables within enclosures. Connect to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools.

3.3 INSTALLATION OF PATHWAYS

A. Cable Trays: Comply with NEMA VE 2 and TIA-569.

B. Comply with requirements for demarcation point, pathways, cabinets, and racks specified in Division 27. Drawings indicate general arrangement of pathways and fittings.

C. Comply with TIA-569 for pull-box sizing and length of conduit and number of bends between pull points.

D. Comply with requirements in Division 26 for installation of conduits, wireways and raceways.

E. Install manufactured conduit sweeps and long-radius elbows whenever possible.

F. Pathway Installation in Communications Equipment Rooms:

1. Position conduit ends adjacent to a corner on backboard where a single piece of plywood is installed, or in the corner of room where multiple sheets of plywood are installed around perimeter walls of room.
2. Install cable trays to route cables if conduits cannot be located in these positions.
3. Secure conduits to backboard when entering room from overhead.
4. Extend conduits 3 inches (76 mm above finished floor.
5. Install metal conduits with grounding bushings and connect with grounding conductor to grounding system.

G. Backboards: Install backboards with 96-inch (2440-mm) dimension vertical. Butt adjacent sheets tightly, and form smooth gap-free corners and joints.

3.4 INSTALLATION OF CABLES

A. Comply with NECA 1.

B. General Requirements for Cabling:

1. Comply with TIA-568.
2. Comply with BICSI ITSIM, Ch. 6, "Cable Termination Practices."
3. Install IDC termination hardware unless otherwise indicated.
4. Terminate all conductors; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, cross-connects, and patch panels.
5. Cables may not be spliced. Secure and support cables at intervals not exceeding 30 inches (760 mm) and not more than 6 inches (150 mm) from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
6. Install lacing bars to restrain cables, to prevent straining connections, and to prevent bending cables to smaller radii than minimums recommended by manufacturer.
7. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in

BICSI ITSIM, "Cabling Termination Practices" Chapter. Use lacing bars and distribution spools.

8. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.
9. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used for heating.
10. In the communications equipment room, install a 10-foot- (3-m-) long service loop on each end of cable.
11. Pulling Cable: Comply with BICSI ITSIM, Ch. 4, "Pulling Cable." Monitor cable pull tensions.

C. UTP Cable Installation:

1. Comply with TIA-568.
2. Do not untwist UTP cables more than 1/2 inch (12 mm) from the point of termination to maintain cable geometry.

D. Optical Fiber Cable Installation:

1. Comply with TIA-568.
2. Cable may be terminated on connecting hardware that is rack or cabinet mounted.

E. Open-Cable Installation:

1. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.
2. Suspend UTP cable not in a wireway or pathway, a minimum of 8 inches (200 mm) above ceilings by cable supports not more than 60 inches (1524 mm) apart.
3. Cable shall not be run through structural members or in contact with pipes, ducts, or other potentially damaging items.

F. Installation of Cable Routed Exposed under Raised Floors:

1. Install plenum-rated cable only.
2. Install cabling after the flooring system has been installed in raised floor areas.
3. Coil cable 6 feet (1800 mm) long not less than 12 inches (300 mm) in diameter below each feed point.

G. Group connecting hardware for cables into separate logical fields.

H. Separation from EMI Sources:

1. Comply with BICSI TDMM and TIA-569 recommendations for separating unshielded copper voice and data communication cable from potential EMI sources, including electrical power lines and equipment.
2. Separation between open communications cables or cables in nonmetallic raceways and unshielded power conductors and electrical equipment shall be as follows:
    a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 5 inches (127 mm).

b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 12 inches (300 mm).

c. Electrical Equipment Rating More Than 5 kVA: A minimum of 24 inches (610 mm).

3. Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:

a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 2-1/2 inches (64 mm).

b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 6 inches (150 mm).

c. Electrical Equipment Rating More Than 5 kVA: A minimum of 12 inches (300 mm).

4. Separation between communications cables in grounded metallic raceways and power lines and electrical equipment located in grounded metallic conduits or enclosures shall be as follows:

a. Electrical Equipment Rating Less Than 2 kVA: No requirement.

b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 3 inches (76 mm).

c. Electrical Equipment Rating More Than 5 kVA: A minimum of 6 inches (150 mm).

5. Separation between Communications Cables and Electrical Motors and Transformers, 5 kVA or HP and Larger: A minimum of 48 inches (1200 mm).

6. Separation between Communications Cables and Fluorescent Fixtures: A minimum of 5 inches (127 mm).

3.5 TESTING, IDENTIFICATION AND ADMINISTRATION

A. Comply with Section 27 17 10 and Section 27 17 20 for testing, identification and administration of the backbone cabling infrastructure.

3.6 FIRESTOPPING

A. Comply with requirements in Division 07.

B. Comply with TIA-569, Annex A, "Firestopping."

C. Comply with BICSI TDMM, "Firestopping Systems" Article.

3.7 GROUNDING

A. Install grounding according to BICSI TDMM, "Grounding, Bonding, and Electrical Protection" Chapter.

B. Comply with ANSI-J-STD-607-A.

C. Locate grounding bus bar to minimize the length of bonding conductors. Fasten to wall allowing at least 2-inch (50-mm) clearance behind the grounding bus bar. Connect grounding bus bar with a minimum No. 4 AWG grounding electrode conductor from grounding bus bar to suitable electrical building ground.

D. Bond metallic equipment to the grounding bus bar, using not smaller than No. 6 AWG equipment grounding conductor.

3.8 COMMISSIONING

A. Comply with requirements specified in Division 1.

B. Engage a factory-authorized service representative to supervise and assist with startup service. Complete installation and startup checks according to the approved manufacturer's written instructions.

3.9 TRAINING AND SERVICE

A. Comply with Section 26 00 01.

B. Conduct two 4-hour training sessions. Train the Owner’s maintenance personnel on procedures and schedules related to start up and shutdown, troubleshooting, servicing, and preventive maintenance.

End of Section

Section 27 15 00

COMMUNICATIONS HORIZONTAL CABLING

(TRADE CONTRACT REQUIRED AS PART OF SECTION 26 00 01)

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. PUBLICLY BID TRADE CONTRACT REQUIREMENTS: As provided under Section 26 00 01 - ELECTRICAL and supplemented under the Bidding Requirements, Contract Forms, and Conditions of the Contract, and applicable parts of Division 1 - GENERAL REQUIREMENTS.

1. Work of this Trade Contract includes all individual specification sections listed in Section 26 00 01.

1.2 RELATED DOCUMENTS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications

1.3 WORK INCLUDED

A. Section Includes:

1. Pathways.
2. UTP cabling.
3. 50/125-micrometer, optical fiber cabling.
4. Single mode optical fiber cabling.
5. Cable connecting hardware, patch panels, and cross-connects.
6. Telecommunications outlet/connectors.
7. Cabling system identification products.
8. Cable management system.

B. Related Sections:

1. Division 27 for voice and data cabling associated with system panels and devices.
2. Division 27 for low voltage cabling.

1.4 DEFINITIONS

A. Basket Cable Tray: A fabricated structure consisting of wire mesh bottom and side rails.

B. BICSI: Building Industry Consulting Service International.

C. Cross-Connect: A facility enabling the termination of cable elements and their interconnection or cross-connection.

D. EMI: Electromagnetic interference.

E. IDC: Insulation displacement connector.

F. Ladder Cable Tray: A fabricated structure consisting of two longitudinal side rails connected by individual transverse members (rungs).

G. LAN: Local area network.

H. Outlet/Connectors: A connecting device in the work area on which horizontal cable or outlet cable terminates.

I. RCDD: Registered Communications Distribution Designer.

J. UTP: Unshielded twisted pair.

1.5 CODES AND STANDARDS

A. Complete installation shall meet or exceed the latest edition of following standards:

1. TIA-568: Commercial building telecommunications wiring standard and all current addenda.

2. TIA-569: Commercial building standard for telecommunications pathways and spaces.

3. TIA-606: Administration standard for telecommunications infrastructure of commercial buildings.

4. TIA-607: Commercial building grounding and bonding requirements for telecommunications.

5. ANSI, ASTM, UL, NEMA, IEEE and FCC standards as applicable.

6. BICSI Telecommunications Distribution Methods Manual, current edition.

1.6 HORIZONTAL CABLING DESCRIPTION

A. Horizontal cable and its connecting hardware provide the means of transporting signals between the telecommunications outlet/connector and the horizontal cross-connect located in the telecommunications closet/room. This cabling and its connecting hardware are called "permanent link," a term that is used in the testing protocols.

1. Horizontal cabling shall contain no more that one transition point or consolidation point between the horizontal cross-connect and the telecommunications outlet/connector.

2. Bridged taps and splices shall not be installed in the horizontal cabling.

3. Splitters shall not be installed as part of the optical fiber cabling.

B. A work area is approximately 100 sq. ft. (9.3 sq. m), and includes the components that extend from the telecommunications outlet/connectors to the station equipment.

C. The maximum allowable horizontal cable length is 295 feet (90 m). This maximum allowable length does not include an allowance for the length of 16 feet (4.9 m) to the workstation equipment. The maximum allowable length does not include an allowance for the length of 16 feet (4.9 m) in the horizontal cross-connect.

1.7 PERFORMANCE REQUIREMENTS

A. General Performance: Horizontal cabling system shall comply with transmission standards in TIA-568, when tested according to test procedures of this standard.

1.8 SUBMITTALS

1. Comply with requirements in Division 01.

B. Installer Qualifications: Cabling Installer must have personnel certified by BICSI on staff.

1. Layout Responsibility: Preparation of Shop Drawings and Cabling Administration Drawings, and field testing program development by an RCDD.

2. Installation Supervision: Installation shall be under the direct supervision of Registered Technician, who shall be present at all times when Work of this Section is performed at Project site.

3. Testing Supervisor: Currently certified by BICSI as an RCDD to supervise on-site testing.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

D. Telecommunications Pathways and Spaces: Comply with TIA-569.

E. Grounding: Comply with ANSI-J-STD-607.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Test cables upon receipt at Project site.

1. Test optical fiber cable to determine the continuity of the strand end to end. Use optical loss test set.

2. Test optical fiber cables while on reels. Use an optical time domain reflectometer to verify the cable length and locate cable defects, splices, and connector; including the loss value of each. Retain test data and include the record in maintenance data.

3. Test each pair of UTP cable for open and short circuits.

1.10 PROJECT CONDITIONS

A. Environmental Limitations: Do not deliver or install cables and connecting materials until wet work in spaces is complete and dry, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.

1.11 COORDINATION

A. Coordinate layout and installation of telecommunications pathways and cabling with Owner's telecommunications and LAN equipment and service suppliers.

B. Coordinate telecommunications outlet/connector locations with location of power receptacles at each work area.

C. It is this Electrical Subcontractor’s responsibility to refer to Architectural and Mechanical drawings and/or conduct a physical walk thru at the site to determine the plenum rating of all the ceilings. Provide plenum rated cables, conduit, backboxes in all plenum rated ceilings, rated walls, penetrations though wall, floors and ceilings and where required by Local, State or Federal Codes.

1.12 QUALIFICATION OF SYSTEM

A. Acceptable proposed systems will be covered by a two-part certification program provided by a single manufacturer and that manufacturer's certified Subcontractor. Manufacturer shall administer a follow-on program through the Subcontractor to provide support and service to the purchaser. The first part is an assurance program, which provides that the certified system will support the applications for which it is designed, during the life time warranty of the certified system.

B. The second portion of the certification is a life time warranty provided by the manufacturer and the vendor on all products within the system (cords, telecommunications outlet/connectors, cables, cross-connects, patch panels, etc.).

C. In the event that the certified system ceases to support the certified application(s), whether at the time of cutover, during normal use or when upgrading (e.g. ATM), the manufacturer and Subcontractor shall commit to promptly implement corrective action.

D. Documentation proving the cabling system's compliance to the End-to-End Link Performance recommendations, as listed in ANSITIA-568 shall be provided by the Subcontractor prior to the structured cabling system being installed.

E. The cabling system must conform to the current issue of industry standard TIA-568. All performance requirements of this document must be followed. As well, workmanship and installation methods used shall be equal to or better than that found in the BICSI (Building Industry Consulting Service International) TDMM manual.

F. The Owner demands strict adherence to the performance specifications listed in TIA-568 series standards.

G. Manufacturer shall maintain ISO Quality Control registration for the facilities that manufacturer the product used in this cabling system.

1.13 WARRANTY

A. Comply with Section 260001.

B. The Electrical Trade Contractor shall warranty that all materials furnished shall be free from defects of material for a period of one year from the date of Substantial Completion.

PART 2 - PRODUCTS

2.1 RACKS

A. 2-Post 84" H x 19" W x 18" D with 6" vertical cable management. Provide as shown on the contract drawings for telecommunications cabling punch down. Provide in all telecommunications rooms and closets. Coordinate rack requirements with various system vendors and provide appropriate rack for each system.

2.2 UTP CABLE

A. Manufacturers

1. Berk-Tek
2. General Cable
3. Mohawk
4. Or approved equal.

B. Basis of design based upon products by Berk-Tek.

C. Description: 100-ohm, 4-pair UTP, formed into 25-pair binder groups covered with a blue thermoplastic jacket.

1. Comply with ICEA S-90-661.
2. Comply with TIA-568-B.1.
3. Comply with TIA-568-B.2.
4. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444 and NFPA 70 for the following types:
   a. Communications, General Purpose: Type CM or CMG.
   b. Communications, Plenum Rated: Type CMP, complying with NFPA 262.
   c. Communications, Riser Rated: Type CMR, complying with UL 1666.
   d. Communications, Limited Purpose: Type CMX.
   e. Multipurpose: Type MP or MPG.
   f. Multipurpose, Plenum Rated: Type MPP, complying with NFPA 262.
   g. Multipurpose, Riser Rated: Type MPR, complying with UL 1666.

D. Design recommendations:

1. Voice/Data: Category 6A Plenum Rated Cable
   a. Indoor:
      1) Blue (Data): Berk-Tek 10130484 LANmark-10G2

2) White (VoIP): Berk-Tek 10137384 LANmark-10G2
3) Yellow (Security): Berk-Tek 10138767 LANmark-10G2
4) Grey (Fax/Analog): Berk-Tek 11096831 LANmark-10G2
5) Violet (Clock/PA): Berk-Tek 10140145 LANmark-10G2
6) Green (WAP): Berk-Tek 11083158 LANmark-XTP

b. Outdoor:
1) Berk-Tek 10139885. LANmark6 Cat 6.

2. Category 3 high pair count: Berk-Tek Cable
a. 25-Pair plenum 10032036
b. 50-Pair plenum 10032112
c. 100-Pair plenum 10032113
d. 200-Pair plenum 10032123
e. 300-Pair plenum 10032124

3. Non-plenum rated cables shall not be acceptable.

2.3 UTP CABLE HARDWARE

A. Manufacturers
1. Leviton
2. Panduit Corp
3. Hubbell
4. Or approved equal

B. Basis of design based upon products by Leviton.

C. UTP Cable Connecting Hardware: Tool-free type, using Component Rated Category 6A modules.

D. Shielded Cable Connecting Hardware: Must be Component Rated Category 6A.

E. Connecting Blocks: Punch down style for Category 6A. Provide blocks for the number of cables terminated on the block, plus 25 percent spare. Integral with connector bodies, including plugs and jacks where indicated.

F. Cross-Connect: Modular array of connecting blocks arranged to terminate building cables and permit interconnection between cables.

G. Number of Terminals per Field: One for each conductor in assigned cables.

H. Patch Panel: Component Rated Category 6A 110 style panels to include a rear cable management/strain relief bracket.

I. Number of Jacks per Field: One for each four-pair UTP cable indicated.

J. Jacks and Jack Assemblies: Tool-free, color-coded, eight-position modular receptacle units using Component Rated Category 6A modules.

K. Patch Cords: Factory-made by the connecting hardware manufacturer, four-pair cables in 60-inch (900 mm) lengths; terminated with eight-position modular plug at each end.

L. UTP patch cords shall be color-coded. Patch cords shall have a snagless design.

M. UTP patch cords shall have transparent slimline boots and be color-coded for circuit identification.

N. Provide patch cord for each workstation outlet and each port in the telecommunications rooms.

O. Basis of design recommendations (Leviton).

1. Wall Plates:
    a. 43080-1S1 - 1 port stainless steel faceplate
    b. 43080-1S2 - 2 port stainless steel faceplate
    c. 43080-1S3 - 3 port stainless steel faceplate
    d. 43080-1S4 - 4 port stainless steel faceplate
    e. 4108W-1SP - wall phone faceplate
2. 41AB2-1F4 100-Pair 110-punchdown block kit.
3. 41AB2-3F4 300-Pair 110-punchdown block kit.
4. Category 6A Component Rated jack modules
    a. 6AUJK-S*6 UTP Connectors with shutters
        1) * = L – Blue (Data)
        2) * = Y – yellow (Security)
        3) * = W – White (VoIP)
        4) * = G – Grey (Fax)
        5) * = P – Purple (Clock/PA)
        6) * = V – Green (WAP)
    b. Provide icons to match jack modules.
    c. Jack modules with field installed shutters shall not be acceptable.
5. 41084-FWF F - connector modules
6. 6AS10-xx* (coordinate with owner on lengths-xx) Category 6A Component Rated patch cord
    a. UTP patch cord color coding:
        1) Data: Blue. (L)
        2) Security: Yellow (Y)
        3) Voice: White. (W)

4) Fax: Grey (G)

5) Clock/PA: Purple (P)

6) Wireless Access Points (WAP): Green (V)

b. UTP patch cord lengths:

1) 25% 3 ft.

2) 25% 5 ft.

3) 50% 7 ft.

7. 6A587-U48 CAT 6A 48-port modular angled jack panel

a. Arrange patch panels to allow for mounting of the chassis switch in between the patch panels rather than mounting the switch on the bottom of the rack or in a separate.

b. Coordinate rack layout with Worcester Public Schools (WPS) IT department.

8. 4980L-VFR – vertical cable management panel (front and rear)

2.4 COAXIAL CABLE

A. Manufacturers

1. Tappan
2. General Cable
3. Belden
4. Or approved equal

B. Basis of design products based on Tappan.

C. General Coaxial Cable Requirements: Broadband type, recommended by cable manufacturer specifically for broadband data transmission applications. Coaxial cable and accessories shall have 75-ohm nominal impedance.

D. RG-6/U: NFPA 70, Type CATV or CM.

1. No. 16 AWG, solid, copper-covered steel conductor; gas-injected, foam-PE insulation.
2. Quad shielded with 100 percent aluminum-foil shield and 60 percent aluminum braid.
3. Swept to 3GHz.
4. Jacketed with black PVC or PE.
5. Suitable for indoor installations.

E. RG-11/U: NFPA 70.

1. No. 14 AWG, solid, copper-covered steel conductor.
2. Gas-injected, foam-PE insulation.

3. Quad shielded with 100 percent aluminum polyester tape and 60 percent aluminum braid.

4. Jacketed with sunlight-resistant, black PVC or PE.

F. NFPA and UL compliance, listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 1655, and with NFPA 70 "Radio and Television Equipment" and "Community Antenna Television and Radio Distribution" Articles. Types are as follows:

1. CATV Cable: Type CATV.

2. CATV Plenum Rated: Type CATVP, complying with NFPA 262.

3. CATV Riser Rated: Type CATVR, complying with UL 1666.

4. CATV Limited Rating: Type CATVX.

G. Cabling Requirements:

1. All coaxial cable shall be swept from 5 MHz-3 GHz.

2. Main trunk cables should be CATVR rated RG-11 cable, swept from 5 MHz-3 GHz. Hard line cable .500 or larger is also acceptable.

3. Underground cable runs that connect separate buildings must use flooded type cable and be in conduit.

4. RG-6 cable should be used for runs up to 200 feet. RG-11 cable should be used for runs up to 500 feet. Hard-line cable is required for runs of 500 feet or more.

5. Cable runs should not contain splices.

6. Use plenum-grade CATVP cable in plenum ceilings.

7. Compression type fittings should be used for RG-6 coaxial cable connectors. RG-11 coaxial cable can use compression-type or hex-crimp connectors with a crimped center conductor pin.

8. All cable pulls prior to termination must leave a 3-foot service loop.

9. Coaxial cable type and installation must meet NEC codes for fire safety.

10. All weather-exposed cables must be the flooded type.

11. RG-59 type cable is not acceptable.

2.5 COAXIAL CABLE HARDWARE

A. Manufacturers

1. Panduit Corp

2. The Siemons Compan

3. Systimax

4. Or approved equal.

B. Basis of design products based on Panduit Corp.

C. Coaxial-Cable Connectors: Type F, 75 ohms.

D. Design recommendations (Panduit Corp.):

1. CPPLA48WBLY angled, modular patch panel.
2. CMFIW F-Type module.

2.6 GROUNDING

A. Comply with requirements in Division 26.

B. Comply with ANSI-J-STD-607-A.

2.7 IDENTIFICATION PRODUCTS

A. Comply with TIA-606 and UL 969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers.

2.8 LABELING

A. When labeling Jacks and Panels you will follow this example: “room number – port in room” i.e. 123-1, 123-2, 123-3 and so on. When labeling Wireless Access Points, the word “WAP” will be labeled on the line above the jack number. This allows IT department to track issues from the closets to the classrooms without needing to go through each room to track down were a drop is.

B. Coordinate labeling with the IT department.

C. Coordinate and obtain a written approval of room names and numbers from the Architect prior to labeling the ports.

D. All patch panel and station terminations are to be electronically labeled with a P-touch or similar device, no handwritten labeling is accepted.

2.9 SOURCE QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to evaluate cables.

B. Factory test cables on reels according to TIA-568.

C. Factory test UTP cables according to TIA-568.

D. Factory test multimode optical fiber cables according to TIA-526 and TIA-568.

E. Cable will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 ENTRANCE FACILITIES

A. Coordinate backbone cabling with the protectors and demarcation point provided by communications service provider.

3.2 WIRING METHODS

A. Wiring Method: Install cables in raceways and cable trays except within consoles, cabinets, desks, and counters and except in accessible ceiling spaces, in attics, and in gypsum board partitions where unenclosed wiring method may be used. Conceal raceway and cables except in unfinished spaces.

1. Install plenum cable in environmental air spaces, including plenum ceilings.

2. Comply with requirements for raceways and boxes specified in Division 26.

B. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.

C. Wiring within Enclosures: Bundle, lace, and train cables within enclosures. Connect to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools.

3.3 INSTALLATION OF PATHWAYS

A. Cable Trays: Comply with NEMA VE 2 and TIA-569.

B. Comply with requirements for demarcation point, pathways, cabinets, and racks specified in Division 27. Drawings indicate general arrangement of pathways and fittings.

C. Comply with TIA-569 for pull-box sizing and length of conduit and number of bends between pull points.

D. Comply with requirements in Division 26 for installation of conduits, raceways and wireways.

E. Install manufactured conduit sweeps and long-radius elbows whenever possible.

F. Pathway Installation in Communications Equipment Rooms:

1. Position conduit ends adjacent to a corner on backboard where a single piece of plywood is installed, or in the corner of room where multiple sheets of plywood are installed around perimeter walls of room.

2. Install cable trays to route cables if conduits cannot be located in these positions.

3. Secure conduits to backboard when entering room from overhead.

4. Extend conduits 3 inches (76 mm above finished floor.

5. Install metal conduits with grounding bushings and connect with grounding conductor to grounding system.

G. Backboards: Install backboards with 96-inch (2440-mm) dimension vertical. Butt adjacent sheets tightly, and form smooth gap-free corners and joints.

3.4 TELECOMMUNICATIONS OUTLET/CONNECTORS

A. Jacks: 100-ohm, balanced, twisted-pair connector; four-pair, eight-position modular. Comply with TIA-568.

B. Workstation Outlets: Two-port-connector assemblies mounted in single faceplate unless otherwise noted.

1. Plastic Faceplate: High-impact plastic. Coordinate color with Division 26.
2. Metal Faceplate: Stainless steel, complying with requirements in Division 26.
3. Faceplates will allow snap-in jacks accommodating any combination of UTP, optical fiber, and coaxial work area cords.
4. Labeling: Machine printed, in the field, using adhesive-tape label or snap-in, clear-label covers and machine-printed paper inserts.

3.5 CABLE MANAGEMENT SYSTEM

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

1. Panduit
2. iTRACS Corporation.
3. Telsoft Solutions.
4. Or approved equal.

C. Description: Computer-based cable management system, with integrated database and graphic capabilities.

D. Document physical characteristics by recording the network, TIA details, and connections between equipment and cable.

E. Information shall be presented in database view, schematic plans, and technical drawings.

1. AutoCAD drawing software shall be used as drawing and schematic plans software.

F. System shall interface with the following testing and recording devices:

1. Direct upload tests from circuit testing instrument into the personal computer.
2. Direct download circuit labeling into labeling printer.

3.6 SOURCE QUALITY CONTROL

A. Factory test UTP and optical fiber cables on reels according to TIA-568.

B. Factory test UTP cables according to TIA-568.

C. Factory test multimode optical fiber cables according to TIA-526 and TIA-568.

D. Cable will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

3.7 INSTALLATION OF CABLES

A. Comply with NECA 1.

B. General Requirements for Cabling:

1. Comply with TIA-568.
2. Comply with BICSI ITSIM, Ch. 6, "Cable Termination Practices."
3. Install 110-style IDC termination hardware unless otherwise indicated.
4. Terminate conductors; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, cross-connects, and patch panels.
5. Cables may not be spliced. Secure and support cables at intervals not exceeding 30 inches (760 mm) and not more than 6 inches (150 mm) from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
6. Install lacing bars to restrain cables, to prevent straining connections, and to prevent bending cables to smaller radii than minimums recommended by manufacturer.
7. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIM, "Cabling Termination Practices" Chapter. Install lacing bars and distribution spools.
8. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.
9. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used for heating.
10. In the communications equipment room, install a 10-foot- (3-m-) long service loop on each end of cable.
11. Pulling Cable: Comply with BICSI ITSIM, Ch. 4, "Pulling Cable." Monitor cable pull tensions.

C. UTP Cable Installation:

1. Comply with TIA-568.
2. Do not untwist UTP cables more than 1/2 inch (12 mm) from the point of termination to maintain cable geometry.

D. Optical Fiber Cable Installation:

1. Comply with TIA-568.
2. Cable may be terminated on connecting hardware that is rack or cabinet mounted.

E. Open-Cable Installation:

1. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.

2. Suspend UTP cable not in a wireway or pathway a minimum of 8 inches (200 mm) above ceilings by cable supports not more than 60 inches (1524 mm) apart.

3. Cable shall not be run through structural members or in contact with pipes, ducts, or other potentially damaging items.

F. Installation of Wireless (Wi-Fi) Access Point (AP) Cabling:

1. Direct Mounting to the Ceiling Grid: In an area where there is a drop ceiling, the cabling for the AP shall be terminated above the ceiling but not higher than 10 ft. above the floor. Mark the location with a green dot sticker on the ceiling directly under the terminated jacks.

2. Right Angle Bracket Mounting (Access Point mounting on a wall): In an area where the AP is scheduled to be mounted on the wall, terminate AP cabling on a standard 2-port faceplate on the wall. Coordinate exact height in the field.

3. Open Ceiling Mounting: In an area where the AP is scheduled to be mounted in open ceiling location, the cabling for the AP shall be terminated on a standard 2-port faceplate which shall be located in a 4” square junction box. This junction box shall be mounted to a rigid steel 1” conduit that is secured to another 4” square junction box mounted to the building structure above. The patch cord shall then be run through the 1” rigid steel conduit to second 4” square junction box with cover. The Contractor will need to punch a hole through the second box cover allowing the AP cables to pass through.

G. Installation of Cable Routed Exposed under Raised Floors:

1. Install plenum-rated cable only.

2. Install cabling after the flooring system has been installed in raised floor areas.

3. Coil cable 6 feet (1800 mm) long not less than 12 inches (300 mm) in diameter below each feed point.

4. Group connecting hardware for cables into separate logical fields.

H. Separation from EMI Sources:

1. Comply with BICSI TDMM and TIA-569 for separating unshielded copper voice and data communication cable from potential EMI sources, including electrical power lines and equipment.

2. Separation between open communications cables or cables in nonmetallic raceways and unshielded power conductors and electrical equipment shall be as follows:

a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 5 inches (127 mm).

b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 12 inches (300 mm).

c. Electrical Equipment Rating More Than 5 kVA: A minimum of 24 inches (610 mm).

3. Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:

a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 2-1/2 inches (64 mm).

b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 6 inches (150 mm).

c. Electrical Equipment Rating More Than 5 kVA: A minimum of 12 inches (300 mm).

4. Separation between communications cables in grounded metallic raceways and power lines and electrical equipment located in grounded metallic conduits or enclosures shall be as follows:

a. Electrical Equipment Rating Less Than 2 kVA: No requirement.

b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 3 inches (76 mm).

c. Electrical Equipment Rating More Than 5 kVA: A minimum of 6 inches (150 mm).

5. Separation between Communications Cables and Electrical Motors and Transformers, 5 kVA or HP and Larger: A minimum of 48 inches (1200 mm).

6. Separation between Communications Cables and Fluorescent Fixtures: A minimum of 5 inches (127 mm).

3.8 FIRESTOPPING

A. Installed by Electrical Subcontractor, refer to 07 84 00 for products and installation requirements

B. Comply with TIA-569, Annex A, "Firestopping."

C. Comply with BICSI TDMM, "Firestopping Systems" Article.

3.9 GROUNDING

A. Install grounding according to BICSI TDMM, "Grounding, Bonding, and Electrical Protection" Chapter.

B. Comply with ANSI-J-STD-607-A.

C. Locate grounding bus bar to minimize the length of bonding conductors. Fasten to wall allowing at least 2-inch (50-mm) clearance behind the grounding bus bar. Connect grounding bus bar with a minimum No. 4 AWG grounding electrode conductor from grounding bus bar to suitable electrical building ground.

D. Bond metallic equipment to the grounding bus bar, using not smaller than No. 6 AWG equipment grounding conductor.

3.10 IDENTIFICATION

A. Identify system components, wiring, and cabling complying with TIA-606. Comply with requirements for identification specified in Division 26.

1. Administration Class: 4.

2. Color-code cross-connect fields. Apply colors to voice and data service backboards, connections, covers, and labels.

B. Using cable management system software specified in Part 2, develop Cabling Administration Drawings for system identification, testing, and management. Use unique, alphanumeric designation for each cable and label cable, jacks, connectors, and terminals to which it connects with same designation. At completion, cable and asset management software shall reflect as-built conditions.

C. Comply with requirements in Division 09 for painting backboards. For fire-resistant plywood, do not paint over manufacturer's label.

D. Paint and label colors for equipment identification shall comply with TIA-606 for Class 4 level of administration.

E. Cable Schedule: Post in prominent location in each equipment room and wiring closet. List incoming and outgoing cables and their designations, origins, and destinations. Protect with rigid frame and clear plastic cover. Furnish an electronic copy of final comprehensive schedules for Project.

F. Cabling Administration Drawings: Show building floor plans with cabling administration-point labeling. Identify labeling convention and show labels for telecommunications closets, backbone pathways and cables, entrance pathways and cables, terminal hardware and positions, horizontal cables, work areas and workstation terminal positions, grounding buses and pathways, and equipment grounding conductors. Follow convention of TIA-606. Furnish electronic record of all drawings, in software and format selected by Owner.

G. Cable and Wire Identification:

1. Label each cable within 4 inches (100 mm) of each termination and tap, where it is accessible in a cabinet or junction or outlet box, and elsewhere as indicated.

2. Each wire connected to building-mounted devices is not required to be numbered at device if color of wire is consistent with associated wire connected and numbered within panel or cabinet.

3. Exposed Cables and Cables in Cable Trays and Wire Troughs: Label each cable at intervals not exceeding 15 feet (4.5 m).

4. Label each terminal strip and screw terminal in each cabinet, rack, or panel.

   a. Individually number wiring conductors connected to terminal strips, and identify each cable or wiring group being extended from a panel or cabinet to a building-mounted device shall be identified with name and number of particular device as shown.

   b. Label each unit and field within distribution racks and frames.

5. Identification within Connector Fields in Equipment Rooms and Wiring Closets: Label each connector and each discrete unit of cable-terminating and connecting hardware. Where similar jacks and plugs are used for both voice and data communication cabling, use a different color for jacks and plugs of each service.

H. Labels shall be preprinted or computer-printed type with printing area and font color that contrasts with cable jacket color but still complies with requirements in TIA-606.

1. Cables use flexible vinyl or polyester that flex as cables are bent.

3.11 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Visually inspect UTP and optical fiber cable jacket materials for NRTL certification markings. Inspect cabling terminations in communications equipment rooms for compliance with color-coding for pin assignments, and inspect cabling connections for compliance with TIA-568.

2. Visually confirm Category 6 marking of outlets, cover plates, outlet/connectors, and patch panels.

3. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.

4. Test UTP backbone copper cabling for DC loop resistance, shorts, opens, intermittent faults, and polarity between conductors. Test operation of shorting bars in connection blocks. Test cables after termination but not cross-connection.

a. Test instruments shall meet or exceed applicable requirements in TIA-568. Perform tests with a tester that complies with performance requirements in "Test Instruments (Normative)" Annex, complying with measurement accuracy specified in "Measurement Accuracy (Informative)" Annex. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.

5. Optical Fiber Cable Tests:

a. Test instruments shall meet or exceed applicable requirements in TIA-568. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.

b. Link End-to-End Attenuation Tests:

1) Horizontal and multimode backbone link measurements: Test at 850 or 1300 nm in 1 direction according to TIA-526, Method B, One Reference Jumper.

2) Attenuation test results for backbone links shall be less than 2.0 dB. Attenuation test results shall be less than that calculated according to equation in TIA-568.

6. UTP Performance Tests:

a. Test for each outlet and MUTOA. Perform the following tests according to TIA-568 and TIA-568:

1) Wire map.

2) Length (physical vs. electrical, and length requirements).

3) Insertion loss.

4) Near-end crosstalk (NEXT) loss.

5) Power sum near-end crosstalk (PSNEXT) loss.

6) Equal-level far-end crosstalk (ELFEXT).

7) Power sum equal-level far-end crosstalk (PSELFEXT).

8) Return loss.

9) Propagation delay.

10) Delay skew.

7. Optical Fiber Cable Performance Tests: Perform optical fiber end-to-end link tests according to TIA-568 and TIA-568.

8. Final Verification Tests: Perform verification tests for UTP and optical fiber systems after the complete communications cabling and workstation outlet/connectors are installed.

a. Voice Tests: These tests assume that dial tone service has been installed. Connect to the network interface device at the demarcation point. Go off-hook and listen and receive a dial tone. If a test number is available, make and receive a local, long distance, and digital subscription line telephone call.

b. Data Tests: These tests assume the Information Technology Staff has a network installed and is available to assist with testing. Connect to the network interface device at the demarcation point. Log onto the network to ensure proper connection to the network.

B. Document data for each measurement. Data for submittals shall be printed in a summary report that is formatted similar to Table 10.1 in BICSI TDMM, or transferred from the instrument to the computer, saved as text files, and printed and submitted.

C. End-to-end cabling will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.12 COMMISSIONING

A. Comply with requirements specified in Division 1.

B. Engage a factory-authorized service representative to supervise and assist with startup service. Complete installation and startup checks according to the approved manufacturer's written instructions.

3.13 TRAINING AND SERVICE

A. Comply with Section 26 00 01.

B. Conduct two 4-hour training sessions. Train the Owner’s maintenance personnel on procedures and schedules related to start up and shutdown, troubleshooting, servicing, and preventive maintenance.

End of Section

Section 27 17 10

TESTING OF FIBER INFRASTRUCTURE

(TRADE CONTRACT REQUIRED AS PART OF SECTION 26 00 01)

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. PUBLICLY BID TRADE CONTRACT REQUIREMENTS: As provided under Section 26 00 01 - ELECTRICAL and supplemented under the Bidding Requirements, Contract Forms, and Conditions of the Contract, and applicable parts of Division 1 - GENERAL REQUIREMENTS.

1. Work of this Trade Contract includes all individual specification sections listed in Section 26 00 01.

1.2 RELATED DOCUMENTS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications

1.3 WORK INCLUDED

A. Provide all labor, materials, tools, field-test instruments and equipment required for the complete testing, identification and administration of the work called for in the Contract Documents.

B. In order to conform to the overall project event schedule, the Cabling Trade Contractor shall survey the work areas and coordinate cabling testing with other applicable trades.

C. In addition to the tests detailed in this document, the Contractor shall notify the Owner or the Owner’s representative of any additional tests that are deemed necessary to guarantee a fully functional system. The Contractor shall carry out and record any additional measurement results at no additional charge.

D. This Section includes the minimum requirements for the test certification, identification and administration of backbone and horizontal optical fiber cabling.

E. This Section includes minimum requirements for:

1. Fiber optic test instruments
2. Fiber optic testing
3. Identification
    a. Labels and labeling
4. Administration
    a. Test results documentation
    b. As-built drawings

F. Testing shall be carried out in accordance with this document. This includes testing the attenuation and polarity of the installed cable plant with an optical loss test set (OLTS) and

the installed condition of the cabling system and its components with an optical time domain reflectometer (OTDR). The condition of the fiber end faces shall also be verified.

G. Testing shall be performed on each cabling link (connector to connector).

H. Testing shall be performed on each cabling channel (equipment to equipment) that is identified by the owner.

1. Testing shall not include any active devices or passive devices within the link or channel other than cable, connectors, and splices, i.e. link attenuation does not include such devices as optical bypass switches, couplers, repeaters, or optical amplifiers.

I. All tests shall be documented including OLTS dual wavelength attenuation measurements for multimode and single mode links and channels and OTDR traces and event tables for multimode and single mode links and channels.

1.4 QUALITY ASSURANCE

A. All testing procedures and field-test instruments shall comply with applicable requirements of:

1. ANSI Z136.2, ANS For Safe Use Of Optical Fiber Communication Systems Utilizing Laser Diode And LED Sources
2. ANSI/EIA/TIA-455-50B, Light Launch Conditions For Long-Length Graded-Index Optical Fiber Spectral Attenuation Measurements
3. ANSI/TIA/EIA-455-59A, Measurement of Fiber Point Discontinuities Using an OTDR
4. ANSI/TIA/EIA-455-60A, Measurement of Fiber or Cable Length Using an OTDR
5. ANSI/TIA/EIA-455-61A, Measurement of Fiber or Cable Attenuation Using an OTDR
6. ANSI/TIA/EIA-526-7, Optical Power Loss Measurements of Installed Singlemode Fiber Cable Plant
7. ANSI/TIA-526-14-B, Optical Power Loss Measurements of Installed Multimode Fiber Cable Plant; IEC 61280-4-1 edition 2, Fibre-Optic Communications Subsystem Test Procedure- Part 4-1: Installed cable plant- Multimode attenuation measurement
8. ANSI/TIA-568-C.0, Generic Telecommunications Cabling for Customer Premises
9. ANSI/TIA-568-C.3, Optical Fiber Cabling Components Standard
10. ANSI/TIA-606-B, Administration Standard for Commercial Telecommunications Infrastructure, including the requirements specified by the customer, unless the customer specifies their own labeling requirements

B. Trained technicians who have successfully attended an appropriate training program, which includes testing with an OLTS and an OTDR and have obtained a certificate as proof thereof shall execute the tests. These certificates may have been issued by any of the following organizations or an equivalent organization:

1. Manufacturer of the fiber optic cable and/or the fiber optic connectors.
2. Manufacturer of the test equipment used for the field certification or representative.
3. Training organization e.g. BICSI

C. The Owner or the Owner’s representative shall be invited to witness and/or review field-testing.

1. The Owner or the Owner's representative shall be notified of the start date of the testing phase five (5) business days before testing commences.
2. The Owner or the Owner's representative will select a random sample of 5% of the installed links. The Owner or the Owner's representative shall test these randomly selected links and the results are to be stored in accordance with Part 3 of this document. The results obtained shall be compared to the data provided by the installation Trade Contractor. If more than 2% of the sample results differ in terms of the pass/fail determination, the installation Trade Contractor under supervision of the representative shall repeat 100% testing at no cost to the Owner.

1.5 SUBMITTALS

A. Manufacturers catalog sheets and specifications for fiber optic field-test instruments including optical loss test sets (OLTS; power meter and source), optical time domain reflectometer (OTDR) and video microscope.

B. A schedule (list) of all optical fibers to be tested.

C. Sample test reports.

1.6 ACCEPTANCE OF TEST RESULTS

A. Unless otherwise specified by the Owner or the Owners representative, each cabling link shall be in compliance with the following test limits:

1. Optical loss testing

a. Multimode and Single mode links

1) The link attenuation shall be calculated by the following formulas as specified in ANSI/TIA-568-C.0.

a) Link Attenuation (dB) = Cable_Attn (dB) + Connector_Attn (dB) + Splice_Attn (dB)

b) Cable_Attn (dB) = Attenuation_Coefficient (dB/km) * Length (Km)

c) Connector_Attn (dB) = number_of_connector_pairs * connector_loss (dB)

d) Maximum allowable connector_loss = 0.75 dB

e) Splice_Attn (dB) = number_of_splices * splice_loss (dB)

f) Maximum allowable splice_loss = 0.3 dB

g) The values for the Attenuation_Coefficient (dB/km) are listed in the table below:

Type of Optical Fiber	Wavelength (nm)	Attenuation Coefficient (dB/km)	Wavelength (nm)	Attenuation Coefficient (dB/km)
Multimode 62.5/125 µm	850	3.5	1300	1.5
Multimode 50/125 µm	850	3.5	1300	1.5

Single-mode (Inside plant)	1310	1.0	1550	1.0
Single-mode (Outside plant)	1310	0.5	1550	0.5

2. OTDR testing
   a. Reflective events (connections) shall not exceed 0.75 dB
   b. Non-reflective events (splices) shall not exceed 0.3 dB.

3. Magnified end face inspection
   a. Fiber connections shall be visually inspected for end face quality.
   b. Scratched, pitted or dirty connectors shall be diagnosed and corrected.

B. All installed cabling links and channels shall be field-tested and pass the test requirements and analysis as described in Part 3. Any link or channel that fails these requirements shall be diagnosed and corrected. Any corrective action that must take place shall be documented and followed with a new test to prove that the corrected link or channel meets performance requirements. The final and passing result of the tests for all links and channels shall be provided in the test results documentation in accordance with Part 3.

C. Acceptance of the test results shall be given in writing after the project is fully completed and tested in accordance with Contract Documents and to the satisfaction of the Owner.

D. Note: High Bandwidth applications such as 1000BASE-SX, 10GBASE-SR, and FC1200 impose stringent channel loss limits. Where practical, certification should consider loss length limits that meet maximum channel (transmitter to receiver) loss. 0.75 dB per connector pair loss may not support the intended application.

E. Performance specification for multimode fiber links at 850 nm:

Fiber Type		Bandwidth	1000BASE-SX		10GBASE-SR		FibreChannel 1200-MX-SN-I	
	µm	(MHz• Km)	Length (m)	Loss (dB)	Length (m)	Loss (dB)	Length (m)	Loss (dB)
OM1	62.5	200	275	2.38	33	2.5	33	2.4
OM2	50	500	550	3.56	82	2.3	82	2.2
OM3	50	2000	N/A	N/A	300	2.6	300	2.6
OM4	50	47000	N/A	N/A	400	2.9	N/A	N/A

PART 2 - PRODUCTS

2.1 OPTICAL FIBER CABLE TESTERS

A. The field-test instrument shall be within the calibration period recommended by the manufacturer and a copy of the calibration certificate made available.

B. Optical loss test set (OLTS)

1. Multimode optical fiber light source

a. Provide dual LED light sources with central wavelengths of 850 nm (±30 nm) and 1300 nm (±20 nm).

b. Output power of –20 dBm minimum.

c. The launch shall meet the Encircled Flux launch requirements of ANSI/TIA-526-14-B.

2. Single mode optical fiber light source

a. Provide dual laser light sources with central wavelengths of 1310 nm (±20 nm) and 1550 nm (±20 nm).

b. Output power of –10 dBm minimum.

3. Power Meter

a. Provide 850 nm, 1300 nm, 1310 nm, and 1550 nm wavelength test capability.

b. Power measurement uncertainty of ± 0.25 dB.

c. Store reference power measurements.

d. Save at least 10,000 results to internal memory.

e. PC interface (USB).

C. Optical Time Domain Reflectometer (OTDR)

1. Shall have a bright, color LCD display with backlight.

2. Shall have rechargeable Li-Ion battery for 8 hours of normal operation.

3. Weight with battery and module of not more than 4.5 lb and volume of not more 200 in^3.

4. Internal non-volatile memory with capacity for storing at least 2,000 OTDR bi-directionally tested fiber links.

5. USB port to transfer data to a PC or thumb drive/memory stick.

6. Multimode OTDR

a. Wavelengths of 850 nm (± 10 nm) and 1300 nm (+ 35 nm / - 15 nm).

b. Event dead zones not to exceed 0.7 m at 850 nm and 1300 nm.

c. Attenuation dead zones not to exceed 2.5 m at 850 nm and 4.5 m at 1300 nm.

d. Distance range not less than 9,000 m.

e. Dynamic range at least 28 dB for 850 nm and 30 dB at 1300 nm.

7. Single mode OTDR

a. Wavelengths of 1310 nm (± 25 nm) and 1550 nm (± 30 nm).

b. Event dead zones not to exceed 0.6 m at 1310 nm and 1550 nm.

c. Attenuation dead zones not to exceed 3.7 m at 1310 nm and 1550 nm.

d. Distance range not less than 80 km at 1310 nm and 130 km at 1550 nm.

e. Dynamic range at least 32 dB for 1310 nm and 30 dB at 1550 nm.

D. Fiber Microscope

1. Magnification of 200X or 400X for end face inspection

E. Integrated OLTS, OTDR and fiber microscope

1. Test equipment that combines into one instrument an OLTS, an OTDR and a fiber microscope may be used.

2.2 IDENTIFICATION

A. Labels

1. Shall meet the legibility, defacement, exposure and adhesion requirements of UL 969.

2. Shall be preprinted using a mechanical means of printing (e.g., laser printer).

3. Where used for cable marking, provide vinyl substrate with a white printing area and a clear “tail” that self laminates the printed area when wrapped around the cable. If cable jacket is white, provide cable label with printing area that is any other color than white, preferably orange or yellow – so that the labels are easily distinguishable.

4. Where insert type labels are used provide clear plastic cover over label.

5. Provide plastic warning tape 6 inches wide continuously printed and bright colored 18” above all direct buried services, underground conduits and duct-banks.

6. Acceptable Manufacturers:

a. Panduit

b. Silver Fox

c. W.H. Brady

d. Or approved equal.

2.3 ADMINISTRATION

A. Administration of the documentation shall include test results of each fiber link and channel.

B. The test result information for each link shall be recorded in the memory of the field-test instrument upon completion of the test.

C. The test result records saved within the field-test instrument shall be transferred into a Windows™-based database utility that allows for the maintenance, inspection and archiving of these test records.

PART 3 - EXECUTION

3.1 GENERAL

A. All tests performed on optical fiber cabling that use a laser or LED in a test set shall be carried out with safety precautions in accordance with ANSI Z136.2.

B. All outlets, cables, patch panels and associated components shall be fully assembled and labeled prior to field-testing. Any testing performed on incomplete systems shall be redone on completion of the work.

3.2 OPTICAL FIBER CABLE TESTING

A. Field-test instruments shall have the latest software and firmware installed.

B. Link and channel test results from the OLTS and OTDR shall be recorded in the test instrument upon completion of each test for subsequent uploading to a PC in which the administrative documentation (reports) may be generated.

C. Fiber end faces shall be inspected at 200X or 400X magnification. 200X magnification is suitable for inspecting multimode and single mode fibers. 400X magnification may be used for detailed examination of single mode fibers. Scratched, pitted or dirty connectors shall be diagnosed and corrected.

1. It is preferable that the end face images be recorded in the memory of the test instrument for subsequent uploading to a PC and reporting.

D. Testing shall be performed on each cabling segment (connector to connector).

E. Testing shall be performed on each cabling channel (equipment to equipment) that is planned for use per the owner's instructions.

F. Testing of the cabling shall be performed using high-quality test cords of the same fiber type as the cabling under test. The test cords for OLTS testing shall be between 1 m and 5 m in length. The test cords for OTDR testing shall be approximately 100 m for the launch cable and at least 25 m for the receive cable.

G. Optical loss testing

1. Horizontal/Backbone link

a. Multimode links shall be tested at 850 nm and 1300 nm in accordance with ANSI/TIA-526-14-B, one-cord reference method.

b. Single mode backbone links shall be tested at 1310 nm and 1550 nm in accordance with ANSI/TIA/EIA-526-7, Method A.1, One Reference Jumper equivalent method.

c. Link attenuation does not include any active devices or passive devices other than cable, connectors, and splices, i.e. link attenuation does not include such devices as optical bypass switches, couplers, repeaters, or optical amplifiers.

H. OTDR Testing

1. Fiber links shall be tested at these wavelengths for anomalies and to ensure uniformity of cable attenuation, connector insertion loss and reflectance.

a. Multimode: 850 nm and 1300 nm.

b. Single mode: 1310 nm and 1550 nm.

2. Each fiber link and channel shall be tested in both directions.

3. A launch cable shall be installed between the OTDR and the first link connection.

4. A tail cable shall be installed after the last link connection.

I. Magnified End face Inspection

1. Fibers shall be inspected at 250X or 400X magnification. 250X magnification is suitable for inspecting multimode and single mode fibers. 400X magnification may be used for detailed examination of single mode fibers.

J. Length Measurement

1. The length of each fiber shall be recorded.

2. It is preferable that the optical length be measured using an OLTS or OTDR.

K. Polarity Testing

1. Paired duplex fibers in multi-fiber cables shall be tested to verify polarity in accordance with Clause E.5.3 of ANSI/TIA-568-C.0. The polarity of the paired duplex fibers shall be verified using an OLTS.

3.3 IDENTIFICATION

A. Labeling

1. Labeling shall conform to the requirements specified within ANSI/TIA-606-B or to the requirements specified by the Owner or the Owner's representative.

3.4 ADMINISTRATION

A. Test results documentation

1. Test results saved within the field-test instrument shall be transferred into a Windows™-based database utility that allows for the maintenance, inspection and archiving of the test records. These test records shall be uploaded to the PC unaltered, i.e., "as saved in the field-test instrument". The following formats do not provide adequate protection of these records and shall not be used.

2. The test results documentation shall be available for inspection by the Owner or the Owner's representative during the installation period and shall be passed to the Owner's representative within 5 working days of completion of tests on cabling served by a telecommunications room or of backbone cabling. The installer shall retain a copy to aid preparation of as-built information.

3. The database for the complete project, including twisted-pair copper cabling links, if applicable, shall be stored and delivered on CD/DVD prior to Owner acceptance of the building in the original format used by the cabling vendors' software.

4. Circuit IDs reported by the test instrument should match the specified label ID (see 3.3 of this Section).

5. The detailed test results documentation data is to be provided in an electronic database for each tested optical fiber and shall contain the following information

a. The identification of the customer site as specified by the end-user.

b. The name of the test limit selected to execute the stored test results.

c. The name of the personnel performing the test.

d. The date and time the test results were saved in the memory of the tester.

e. The manufacturer, model and serial number of the field-test instrument.

f. The version of the test software and the version of the test limit database held within the test instrument.

g. The fiber identification number.

h. The length for each optical fiber.

i. The index of refraction used for length calculation when using length capable OLTS.

j. The backscatter coefficient of the fiber under test when using an OTDR.

k. Test results to include OLTS attenuation link and channel measurements at the appropriate wavelength(s) and the margin (difference between the measured attenuation and the test limit value).

l. Test results to include OTDR link and channel traces, event tables at the appropriate wavelength(s) and a map of the link tested.

m. The length for each optical fiber as calculated by the OTDR.

n. The overall Pass/Fail evaluation of the link-under-test for OLTS and OTDR measurements

B. Record copy and as-built drawings

1. Provide record copy drawings periodically throughout the project as requested by the Construction Manager or Owner, and at end of the project on CD/DVD. Record copy drawings at the end of the project shall be in CAD format and include notations reflecting the as built conditions of any additions to or variation from the drawings provided such as, but not limited to cable paths and termination point. CAD drawings are to incorporate test data imported from the test instruments.

2. The as-built drawings shall include, but are not limited to block diagrams, frame and cable labeling, cable termination points, equipment room layouts and frame installation details. The as-built shall include all field changes made up to construction completion:

a. Field directed changes to pull schedule.

b. Field directed changes to cross connect and patching schedule.

c. Horizontal cable routing changes.

d. Backbone cable routing or location changes.

e. Associated detail drawings.

End of Section

DO NOT REMOVE
THIS PAGE INTENTIONALLY LEFT BLANK

Section 27 17 20

TESTING CATEGORY 6A TWIST PAIR INFRASTRUCTURE

(TRADE CONTRACT REQUIRED AS PART OF SECTION 26 00 01)

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. PUBLICLY BID TRADE CONTRACT REQUIREMENTS: As provided under Section 26 00 01 - ELECTRICAL and supplemented under the Bidding Requirements, Contract Forms, and Conditions of the Contract, and applicable parts of Division 1 - GENERAL REQUIREMENTS.

1. Work of this Trade Contract includes all individual specification sections listed in Section 26 00 01.

1.2 RELATED DOCUMENTS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications

1.3 WORK INCLUDED

A. Provide all labor, materials, tools, field-test instruments and equipment required for the complete testing, identification and administration of the work called for in the Contract Documents.

B. In order to conform to the overall project event schedule, the cabling contractor shall survey the work areas and coordinate cabling testing with other applicable trades.

C. In addition to the tests detailed in this document, the contractor shall notify the Owner or the Owner’s representative of any additional tests that are deemed necessary to guarantee a fully functional system. The contractor shall carry out and record any additional measurement results at no additional charge.

1.4 SCOPE

A. This Section includes the minimum requirements for the test certification, identification and administration of horizontal balanced twisted pair cabling.

B. This Section includes minimum requirements for:

1. Copper cabling test instruments
2. Copper cabling testing
3. Identification
    a. Labels and labeling
4. Administration
    a. Test results documentation
    b. As-built drawings

C. Testing shall be carried out in accordance with this document.

D. Testing shall be performed on each cabling link. (100% testing)

E. All tests shall be documented.

1.5 QUALITY ASSURANCE

A. All testing procedures and field-test instruments shall comply with applicable requirements of:

1. ANSI/TIA-1152, Requirements for Field Test Instruments and Measurements for Balanced Twisted-Pair Cabling
2. ANSI/TIA-568-C.0, Generic Telecommunications Cabling for Customer Premises.
3. ANSI/TIA-568-C.1, Commercial Building Telecommunications Cabling Standard
4. ANSI/TIA 568 C.2, Balanced Twisted-Pair Telecommunications Cabling and Components Standards.
5. ANSI/TIA-606-B, Administration Standard for Commercial Telecommunications Infrastructure, including the requirements specified by the customer, unless the customer specifies their own labeling requirements.

B. Trained technicians who have successfully attended an appropriate training program and have obtained a certificate as proof thereof shall execute the tests. These certificates may have been issued by any of the following organizations or an equivalent organization:

1. Manufacturer of the connectors or cable.
2. Manufacturer of the test equipment used for the field certification.
3. Training organizations (e.g., BICSI, A Telecommunications Association headquarters in Tampa, Florida; ACP [Association of Cabling Professionals™] Cabling Business Institute located in Dallas, Texas)

C. The Owner or the Owner’s representative shall be invited to witness and/or review field-testing.

1. The Owner or the Owner’s representative shall be notified of the start date of the testing phase five (5) business days before testing commences.
2. The Owner or the Owner’s representative will select a random sample of 5% of the installed links. The Owner or the Owner’s representative shall test these randomly selected links and the results are to be stored in accordance with Part 3 of this document. The results obtained shall be compared to the data provided by the installation contractor. If more than 2% of the sample results differ in terms of the pass/fail determination, the installation contractor under supervision of the representative shall repeat 100% testing at no cost to the Owner.

1.6 SUBMITTALS

A. Manufacturers catalog sheets and specifications for the test equipment.

B. A schedule (list) of all balanced twisted-pair copper links to be tested.

C. Sample test reports.

1.7 ACCEPTANCE OF TEST RESULTS

A. Unless otherwise specified by the Owner or the Owners representative, each cabling link shall be in tested for:

1. Wire Map
2. Length
3. Propagation Delay
4. Delay Skew
5. DC Loop Resistance – recorded for information only
6. DC Resistance Unbalance – recorded for information only
7. Insertion Loss
8. NEXT (Near-End Crosstalk)
9. PS NEXT (Power Sum Near-End Crosstalk)
10. ACR-N (Attenuation to Crosstalk Ratio Near-End) – recorded for information only
11. PS ACR-N (Power Sum Attenuation to Crosstalk Ratio Near-End) – recorded for information only
12. ACR-F (Attenuation to Crosstalk Ratio Far-End)
13. PS ACR-F (Power Sum Attenuation to Crosstalk Ratio Far-End)
14. Return Loss
15. TCL (Transverse Conversion Loss) – recorded for information only
16. ELTCTL (Equal Level Transverse Conversion Transfer Loss) – recorded for information only
17. PS ANEXT (Power Sum Alien Near-End Crosstalk) – sampled per section 3.2
18. Average PS ANEXT (Average Power Sum Alien Near-End Crosstalk) – sampled per section 3.2
19. PS AACR-F (Power Sum Alien Attenuation to Crosstalk Ratio Far-End) – sampled per section 3.2
20. Average PS AACR-F (Average Power Sum Alien Attenuation to Crosstalk Ratio Far-End) – sampled per section 3.2

B. All installed cabling Permanent Links shall be field-tested and pass the test requirements and analysis as described in Part 3. Any Permanent Link that fails these requirements shall be diagnosed and corrected. Any corrective action that must take place shall be documented and followed with a new test to prove that the corrected Permanent Link meets performance requirements. The final and passing result of the tests for all Permanent Links shall be provided in the test results documentation in accordance with Part 3.

C. Acceptance of the test results shall be given in writing after the project is fully completed and tested in accordance with Contract Documents and to the satisfaction of the Owner.

PART 2 - PRODUCTS

2.1 BALANCED TWISTED-PAIR CABLE TESTERS

A. The field-test instrument shall be within the calibration period recommended by the manufacturer, typically 12 months.

B. Certification tester

1. Accuracy
    a. Level IIIe accuracy in accordance with ANSI/TIA-1152
    b. Independent verification of accuracy
2. Permanent Link Adapters
    a. RJ45 plug must meet the requirements for NEXT, FEXT and Return Loss in accordance with ANSI/TIA-568-C.2 Annex C
    b. Twisted pair Category 5e, 6, 6A, 7 or 7A cords are not permitted as their performance degrades with use and can cause false Return Loss failures
3. Results Storage
    a. Must be capable of storing > 10,000 results for all measurements found in 2.1.B.4 below
4. Measurement capabilities
    a. Wire Map
    b. Length
    c. Propagation Delay
    d. Delay Skew
    e. DC Loop Resistance
    f. DC Resistance Unbalance
    g. Insertion Loss
    h. NEXT (Near-End Crosstalk)
    i. PS NEXT (Power Sum Near-End Crosstalk)
    j. ACR-N (Attenuation to Crosstalk Ratio Near-End)
    k. PS ACR-N (Power Sum Attenuation to Crosstalk Ratio Near-End)
    l. ACR-F (Attenuation to Crosstalk Ratio Far-End)
    m. PS ACR-F (Power Sum Attenuation to Crosstalk Ratio Far-End)
    n. Return Loss
    o. TCL (Transverse Conversion Loss)
    p. ELTCTL (Equal Level Transverse Conversion Transfer Loss)
    q. Time Domain Reflectometer
    r. Time Domain Xtalk Analyzer
    s. PS ANEXT (Power Sum Alien Near-End Crosstalk)
    t. Average PS ANEXT (Average Power Sum Alien Near-End Crosstalk)
    u. PS AACR-F (Power Sum Alien Attenuation to Crosstalk Ratio Far-End)
    v. Average PS AACR-F (Average Power Sum Alien Attenuation to Crosstalk Ratio Far-End)
5. PC Software
    a. Windows® based.
    b. Must show when 3 dB and 4 dB rules are applied

c. Re-certification capability, where results must have their Cable IDs suffixed with (RC).

d. Built in PDF export – no additional third party software permitted.

e. Built-in statistical analysis.

2.2 IDENTIFICATION

A. Labels

1. Shall meet the legibility, defacement, exposure and adhesion requirements of UL 969.

2. Shall be preprinted using a mechanical means of printing (e.g., laser printer).

3. Where used for cable marking, provide vinyl substrate with a white printing area and a clear “tail” that self laminates the printed area when wrapped around the cable. If cable jacket is white, provide cable label with printing area that is any other color than white, preferably orange or yellow – so that the labels are easily distinguishable.

4. Where insert type labels are used provide clear plastic cover over label.

5. Provide plastic warning tape 6 inches wide continuously printed and bright colored 18” above all direct buried services, underground conduits and duct-banks.

6. Acceptable Manufacturers:

a. Brady Corporation

b. Silver Fox

c. Brothers

d. Or approved equal

2.3 ADMINISTRATION

A. Administration of the documentation shall include test results of each Permanent Link.

B. The test result information for each link shall be recorded in the memory of the field-test instrument upon completion of the test.

C. The test result records saved within the field-test instrument shall be transferred into a Windows® -based database utility that allows for the maintenance, inspection and archiving of these test records.

D. Alien Crosstalk measurements shall be stored to a PC upon completion of the test.

PART 3 - EXECUTION

3.1 GENERAL

A. All outlets, cables, patch panels and associated components shall be fully assembled and labeled prior to field-testing. Any testing performed on incomplete systems shall be redone on completion of the work.

3.2 BALANCED TWISTED PAIR CABLE TESTING

A. Field-test instruments shall have the latest software and firmware installed.

B. Permanent Link test results including the individual frequency measurements from the tester shall be recorded in the test instrument upon completion of each test for subsequent uploading to a PC in which the administrative documentation (reports) may be generated.

C. Permanent Link testing shall be performed on each cabling segment (connector to connector). Sampling is not acceptable.

D. Alien Crosstalk testing shall be performed using a sampling plan. An acceptance quality level (AQL) of 0,4 %, normal inspection, general inspection level I as defined in ISO 2859-1 for populations of up to 500,000 links shall be used. The following table represents this sampling level. Disturbed (Victim) links chosen for Alien Crosstalk testing shall be an equal combination of short, medium and long links.

Installation size (No. of total links)	**Sample size (No. of links to test)**
3 – 33	100%
34 – 3,200	33
3,201 – 35,000	126
35,001 – 150,000	201
150,001 – 500,000	315

E. Permanent Link adapters made from twisted pair Category 5e, 6, 6A, 7 or 7A cords are not permitted as their performance degrades with use and can cause false Return Loss failures.

F. The installer shall build a reference link. All components shall be anchored so it is not possible to disturb them. The technician is to conduct a Category 6A Permanent Link test each day to ensure no degradation of the tester or its Permanent Link adapters.

G. Wire Map Measurement

1. The wire map test is intended to verify pin-to-pin termination at each end and check for installation connectivity errors. For each of the 8 conductors in the cabling, the wire map indicates:
    a. Continuity to the remote end
    b. Shorts between any two or more conductors
    c. Reversed pairs
    d. Split pairs
    e. Transposed pairs
    f. Distance to open on shield
    g. Any other miss-wiring

2. The correct connectivity of telecommunications outlets/connectors is defined in ANSI/TIA-568-C.2. Two color schemes are permitted. The user shall define which scheme is to be used. The field tester shall document which color scheme was used.

H. Length Measurement

1. The length of each balanced twisted pair shall be recorded.
2. Since physical length is determined from electrical length, the physical length of the link calculated using the pair with the shortest electrical delay shall be reported and used for making the pass or fail determination.
3. The pass or fail criteria is based on the maximum length allowed for the Permanent Link as specified in ANSI/TIA-568-C.2 plus the nominal velocity of propagation (NVP) uncertainty of 10%. For a Permanent Link, the length measurement can be 325 ft. (99 m) before a fail is reported.

I. Propagation Delay measurement

1. Is the time it takes for a signal to reach the end of the link.
2. The measurement shall be made at 10 MHz per ANSI/TIA-1152.
3. The propagation delay of each balanced twisted pair shall be recorded.
4. Is not to exceed 498 ns per ANSI/TIA-568-C.2 Section 6.3.18.

J. Delay Skew measurement

1. Is the difference in propagation delay @ 10 MHz between the shortest delay and the delays of the other wire pairs.
2. The delay skew of each balanced twisted pair shall be recorded.
3. Is not to exceed 44 ns per ANSI/TIA-568-C.2 Section 6.3.19.

K. DC Resistance

1. Often reported as Resistance, is the loop resistance of both conductors in the pair.
2. Is not specified in ANSI/TIA-1152 but shall be recorded for all four pairs.

L. DC Resistance Unbalance

1. Often reported as Resistance Unbalance, is the difference in resistance of the two wires within the pair.
2. Is not specified in ANSI/TIA-1152 for a Permanent Link but shall be recorded for all four pairs.

M. Insertion Loss

1. Is the loss of signal strength over the cabling (in dB).
2. The frequency resolution shall be:
   a. 1 – 31.25 MHz: 150 kHz
   b. 31.25 – 100 MHz: 250 kHz
   c. 100 – 250 MHz: 500 kHz
   d. 250 – 500 MHz: 1000 kHz
3. Worst case shall be reported for all four pairs in one direction only.

4. Reported margins found to be within the accuracy of the field tester shall be marked with an asterisk (*).
5. Is not to exceed the Category 6A Permanent Link limits found in ANSI/TIA-568-C.2 Section 6.3.7.

N. NEXT (Near-End Crosstalk)

1. Is the difference in amplitude (in dB) between a transmitted signal and the crosstalk received on other wire pairs at the same end of the cabling.
2. The frequency resolution shall be:
   a. 1 – 31.25 MHz: 150 kHz
   b. 31.25 – 100 MHz: 250 kHz
   c. 100 – 250 MHz: 500 kHz
   d. 250 – 500 MHz: 1000 kHz
3. Shall be measured in both directions. (12 pair to pair possible combinations)
4. Both worst case and worst margins shall be reported.
5. Is not to exceed the Category 6A Permanent Link limits found in ANSI/TIA-568-C.2 Section 6.3.8.
6. Reported margins found to be within the accuracy of the field tester shall be marked with an asterisk (*).
7. The Time Domain Xtalk data shall be stored for any marginal or failing NEXT results.

O. PS NEXT (Power Sum Near-End Crosstalk)

1. Is the difference (in dB) between the test signal and the crosstalk from the other pairs received at the same end of the cabling.
2. The frequency resolution shall be:
   a. 1 – 31.25 MHz: 150 kHz
   b. 31.25 – 100 MHz: 250 kHz
   c. 100 – 250 MHz: 500 kHz
   d. 250 – 500 MHz: 1000 kHz
3. Shall be measured in both directions. (8 pair possible combinations)
4. Both worst case and worst margins shall be reported.
5. Is not to exceed the Category 6A Permanent Link limits found in ANSI/TIA-568-C.2 Section 6.3.9.
6. Reported margins found to be within the accuracy of the field tester shall be marked with an asterisk (*).
7. The Time Domain Xtalk data shall be stored for any marginal or failing PS NEXT results.

P. ACR-N (Attenuation Crosstalk Ratio Near-End)

1. Is a calculation of NEXT minus Insertion Loss of the disturbed pair in dB.
2. The frequency resolution shall be:
   a. 1 – 31.25 MHz: 150 kHz

b. 31.25 – 100 MHz: 250 kHz

c. 100 – 250 MHz: 500 kHz

d. 250 – 500 MHz: 1000 kHz

3. Shall be calculated in both directions.

4. Is not specified in ANSI/TIA-1152, but shall be recorded for all 12 possible combinations.

Q. PS ACR-N (Power Sum Attenuation Crosstalk Ratio Near-End)

1. Is a calculation of PS NEXT minus Insertion Loss of the disturbed pair in dB.

2. The frequency resolution shall be:

a. 1 – 31.25 MHz: 150 kHz

b. 31.25 – 100 MHz: 250 kHz

c. 100 – 250 MHz: 500 kHz

d. 250 – 500 MHz: 1000 kHz

3. Shall be calculated in both directions.

4. Is not specified in ANSI/TIA-1152, but shall be recorded for all 8 possible combinations.

R. ACR-F (Attenuation Crosstalk Ratio Far-End)

1. Is a calculation of FEXT minus Insertion Loss of the disturbed pair in dB.

2. The frequency resolution shall be:

a. 1 – 31.25 MHz: 150 kHz

b. 31.25 – 100 MHz: 250 kHz

c. 100 – 250 MHz: 500 kHz

d. 250 – 500 MHz: 1000 kHz

3. Shall be measured in both directions. (24 pair to pair possible combinations)

4. Both worst case and worst margins shall be reported.

5. Is not to exceed the Category 6A Permanent Link limits found in ANSI/TIA-568-C.2 Section 6.3.11.

6. Reported margins found to be within the accuracy of the field tester shall be marked with an asterisk (*).

S. PS ACR-F (Power Sum Attenuation to Crosstalk Ratio Far-End)

1. Is a calculation of PS FEXT minus Insertion Loss of the disturbed pair in dB.

2. The frequency resolution shall be:

a. 1 – 31.25 MHz: 150 kHz

b. 31.25 – 100 MHz: 250 kHz

c. 100 – 250 MHz: 500 kHz

d. 250 – 500 MHz: 1000 kHz

3. Shall be measured in both directions. (8 pair possible combinations)

4. Both worst case and worst margins shall be reported.
5. Is not to exceed the Category 6A Permanent Link limits found in ANSI/TIA-568-C.2 Section 6.3.13.
6. Reported margins found to be within the accuracy of the field tester shall be marked with an asterisk (*).

T. Return Loss

1. Is the difference (in dB) between the power of a transmitted signal and the power of the signals reflected back.
2. The frequency resolution shall be:
   a. 1 – 31.25 MHz: 150 kHz
   b. 31.25 – 100 MHz: 250 kHz
   c. 100 – 250 MHz: 500 kHz
   d. 250 – 500 MHz: 1000 kHz
3. Shall be measured in both directions. (8 pair possible combinations)
4. Both worst case and worst margins shall be reported.
5. Shall be ignored at all frequencies where the Insertion Loss is less than 3 dB for that pair.
6. Is not to exceed the Category 6A Permanent Link limits found in ANSI/TIA-568-C.2 Section 6.3.6.
7. Reported margins found to be within the accuracy of the field tester shall be marked with an asterisk (*).
8. The Time Domain Reflectometer data shall be stored for any marginal or failing Return Loss results.

U. TCL (Transverse Conversion Loss)

1. Is the ratio (in dB) between a differential mode signal inject at the near-end and the common-mode signal measured at the near-end on the same wire pair.
2. The frequency resolution shall be:
   a. 1 – 31.25 MHz: 150 kHz
   b. 31.25 – 100 MHz: 250 kHz
   c. 100 – 250 MHz: 500 kHz
   d. 250 – 500 MHz: 1000 kHz
3. Shall be measured in both directions.
4. Is not specified in ANSI/TIA-1152 for a Permanent Link, but shall be recorded for all 8 possible combinations.

V. ELTCTL (Equal Level Transverse Conversion Transfer Loss)

1. Is the ratio (in dB) between a differential mode signal inject at the near-end and the common-mode signal measured at the far end on the same wire pair minus the Insertion Loss of that pair.
2. The frequency resolution shall be:

a. 1 – 31.25 MHz: 150 kHz

b. 31.25 – 100 MHz: 250 kHz

c. 100 – 250 MHz: 500 kHz

d. 250 – 500 MHz: 1000 kHz

3. Shall be measured in both directions.

4. Is not specified in ANSI/TIA-1152 for a Permanent Link, but shall be recorded for all 8 possible combinations.

W. PS ANEXT (Power Sum Alien Near-End Crosstalk)

1. Takes into account the combined alien crosstalk (statistical) on a receive pair from all external near-end disturbers operating simultaneously.

2. The frequency resolution shall be:

a. 1 – 31.25 MHz: 150 kHz

b. 31.25 – 100 MHz: 250 kHz

c. 100 – 250 MHz: 500 kHz

d. 250 – 500 MHz: 1000 kHz

3. The disturbed (victim) link shall have links to the left and right of it and if present, links above and below it.

4. Disturber cables shall include all links within the same bundle as the disturbed (victim) link and adjacent links

5. Should be measured in both directions if the link is patch panel to patch panel. If the link is patch panel to telecommunications outlet, then it shall be measured from the patch panel end only.

6. Is not to exceed the Category 6A Permanent Link limits found in ANSI/TIA-568-C.2 Section 6.3.21.

X. Average PS ANEXT (Power Sum Alien Near-End Crosstalk)

1. Is calculated by averaging the individual PSANEXT loss values, in dB, for all four pairs in the disturbed (victim) link.

2. The frequency resolution shall be:

a. 1 – 31.25 MHz: 150 kHz

b. 31.25 – 100 MHz: 250 kHz

c. 100 – 250 MHz: 500 kHz

d. 250 – 500 MHz: 1000 kHz

3. Is not to exceed the Category 6A Permanent Link limits found in ANSI/TIA-568-C.2 Section 6.3.22.

Y. PS AACR-F (Power Sum Alien Attenuation to Crosstalk Ratio Far-End)

1. AFEXT loss is the coupling of crosstalk at the far-end from external link pairs into a disturbed (victim) pair of the 4-pair link under test. PS AACR-F is the calculated power sum from all external pairs into the disturbed (victim) pair.

2. The frequency resolution shall be:

a. 1 – 31.25 MHz: 150 kHz

b. 31.25 – 100 MHz: 250 kHz

c. 100 – 250 MHz: 500 kHz

d. 250 – 500 MHz: 1000 kHz

3. The disturbed (victim) link shall have links to the left and right of it and if present, links above and below it.

4. Disturber cables shall include all links within the same bundle as the disturbed (victim) link and adjacent links

5. Should be measured in both directions if the link is patch panel to patch panel. If the link is patch panel to telecommunications outlet, then it shall be measured from the patch panel end only.

6. Is not to exceed the Category 6A Permanent Link limits found in ANSI/TIA-568-C.2 Section 6.3.25.

Z. Average PS AACR-F (Power Sum Alien Attenuation to Crosstalk Ratio Far-End)

1. Is calculated by averaging the individual PS AACR-F values, in dB, for all four pairs in the disturbed (victim) link.

2. The frequency resolution shall be:

a. 1 – 31.25 MHz: 150 kHz

b. 31.25 – 100 MHz: 250 kHz

c. 100 – 250 MHz: 500 kHz

d. 250 – 500 MHz: 1000 kHz

3. The disturbed (victim) link shall have links to the left and right of it and if present, links above and below it.

4. Disturber cables shall include all links within the same bundle as the disturbed (victim) link and adjacent links

5. Should be measured in both directions if the link is patch panel to patch panel. If the link is patch panel to telecommunications outlet, then it shall be measured from the patch panel end only.

6. Is not to exceed the Category 6A Permanent Link limits found in ANSI/TIA-568-C.2 Section 6.3.26.

3.3 ADMINISTRATION

A. Test results documentation

1. Test results saved within the field-test instrument shall be transferred into a Windows™-based database utility that allows for the maintenance, inspection and archiving of the test records. These test records shall be uploaded to the PC unaltered, i.e., “as saved in the field-test instrument”. The file format, CSV (comma separated value), does not provide adequate protection of these records and shall not be used.

2. The test results documentation shall be available for inspection by the Owner or the Owner’s representative during the installation period and shall be passed to the Owner's representative within 5 working days of completion of tests on cabling

served by a telecommunications room or of backbone cabling. The installer shall retain a copy to aid preparation of as built information.

3. The database for the complete project, including twisted-pair copper cabling links, if applicable, shall be stored and delivered on CD or DVD prior to Owner acceptance of the building. This CD or DVD shall include the software tools required to view, inspect, and print any selection of the test reports.

4. Circuit IDs reported by the test instrument should match the specified label ID (see 3.3 of this Section).

5. For Permanent Link testing, the detailed test results documentation data is to be provided in an electronic database for each tested balance twisted-pair and shall contain the following information

   a. The overall Pass/Fail evaluation of the link-under-test

   b. The date and time the test results were saved in the memory of the tester

   c. The identification of the customer site as specified by the end-user

   d. The name of the test limit selected to execute the stored test results

   e. The name of the personnel performing the test

   f. The version of the test software and the version of the test limit database held within the test instrument

   g. The manufacturer, model and serial number of the field-test instrument

   h. The adapters used

   i. The factory calibration date

   j. Wire Map

   k. Propagation Delay values, for all four pairs

   l. Delay Skew values, for all four pairs

   m. DC Resistance values, for all four pairs

   n. DC Resistance Unbalance, values for all four pairs

   o. Insertion Loss, worst case values for all four pairs

   p. NEXT, worst case margin and worst case values, both directions

   q. PS NEXT, worst case margin and worst case values, both directions

   r. ACR-F, worst case margin and worst case values, both directions

   s. PS ACR-F, worst case margin and worst case values, both directions

   t. Return Loss, worst case margin and worst case values, both directions

   u. TCL, worst case values both directions

   v. ELTCTL, worst case values, both directions.

   w. Time Domain Crosstalk data if the link is marginal or fails

   x. Time Domain Reflectometer data if the link is marginal or fails

6. For Alien Crosstalk testing, the detailed test results documentation data is to be provided in an electronic database for each tested balance twisted-pair and shall contain the following information

   a. The overall Pass/Fail evaluation of the link-under-test

b. The date and time the measurements were made

c. The identification of the customer site as specified by the end-user

d. The name of the test limit selected to execute the stored test results

e. The name of the personnel performing the test

f. The version of the test software

g. PS ANEXT, worst case margin for all four pairs

h. Average PS ANEXT, worst case margin

i. PS AACR-F, worst case margin for all four pairs

j. Average PS AACR-F, worst case margin

B. Record copy and as-built drawings

1. Provide record copy drawings periodically throughout the project as requested by the Construction Manager or Owner, and at end of the project on a CD or DVD. Record copy drawings at the end of the project shall be in CAD format and include notations reflecting the as built conditions of any additions to or variation from the drawings provided such as, but not limited to cable paths and termination point. The as built drawings shall include, but are not limited to block diagrams, frame and cable labeling, cable termination points, equipment room layouts and frame installation details. The as-builts shall include all field changes made up to construction completion:

a. Field directed changes to pull schedule.

b. Horizontal cable routing changes.

c. Associated detail drawings.

End of Section

Section 27 21 00

DATA COMMUNICATIONS NETWORK EQUIPMENT

(TRADE CONTRACT REQUIRED AS PART OF SECTION 26 00 01)

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. PUBLICLY BID TRADE CONTRACT REQUIREMENTS: As provided under Section 26 00 01 - ELECTRICAL and supplemented under the Bidding Requirements, Contract Forms, and Conditions of the Contract, and applicable parts of Division 1 - GENERAL REQUIREMENTS.

1. Work of this Trade Contract includes all individual specification sections listed in Section 26 00 01.

1.2 RELATED DOCUMENTS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications

1.3 SCOPE

A. It is the intent of these specifications that the Vendor, Manufacturer and/or its Authorized System Integrator expeditiously furnishes and installs a system complete in every respect and ready to operate. All miscellaneous items and accessories required for such installation, whether or not each such item or accessory is shown on the plans or mentioned in these specifications, shall be furnished and installed.

B. The data network communications equipment shall be installed as shown on the drawings and as specified herein. The work covered by this section of the specifications includes the furnishing of all labor, equipment, materials and performance of all operations associated with the data network communications equipment for a fully functional system.

C. The school district has standardized on Hewlett Packard (HP) wired LAN equipment and on Cisco wireless LAN equipment. This Contractor shall provide HP 5400 series chassis switches and Cisco Meraki MR 53 Wi-Fi access points as specified herein.

1.4 PROGRAMMING

A. Coordinate and obtain a written approval of system functionality from the Owner prior to programming.

B. Perform a walk-through with the Owner and demonstrate the system functionality.

C. Make any adjustments to system functionality after initial programming if necessary to achieve the desired functionality requested by the Owner.

D. Obtain a written final letter of acceptance from the Owner upon completion of system functionality programming and demonstration.

1.5 SUMMARY

A. General: This section describes the data communications network infrastructure including electronics and software needed to support Local Area Networks and network management.

B. Related Work

1. Related Documents: Drawings and Specifications, including General and Supplementary Conditions and Cabling specifications apply to the Work in this Section.

2. Products Installed but not Furnished Under this Section:

a. Manholes, hand-holes, conduits, electrical work, pull-strings, sleeves, cores, raceways, cable tray, plywood and associated supporting hardware.

b. The provisioning of telephone equipment, its mainframe cross-connects and placement of telephone instruments.

c. Cabling systems including station copper cabling and backbone fiber optic multimode cabling.

C. Products Installed Under this Section: Only new equipment and material, produced by manufacturers that are recognized nationally by the telecommunications industry and approved by Underwriters Laboratory shall be used as specified in this Section or on the Drawings.

1. All mounting hardware.

2. All mounting brackets.

1.6 QUALITY ASSURANCE:

A. Vendors providing equipment installation services shall use adequate numbers of skilled workmen who are certified by the component manufacturer, thoroughly trained and experienced with the necessary technology and systems, and completely familiar with the specified requirements and methods needed for proper performance of work. The system head-end installation, start-up and commissioning shall be by the manufacturer certified vendor.

B. Each vendor is required to provide a certification from the manufacturer indicating that they hold a current certification for the specified system.

C. Use adequate numbers of skilled workers thoroughly trained and experienced on the necessary crafts and completely familiar with the specified requirements and methods needed for the proper performance of the work of this Section.

D. The vendor must provide a project manager who has demonstrated the ability to supervise a project of this magnitude. The Project Manager must be available to attend meetings as required.

1.7 SUBMITTALS

A. Comply with requirements specified in Division 01 and the following:

1. The vendor shall submit certification letter from the manufacturer of submitted equipment certifying that the installer is an authorized and certified installer of the submitted equipment.

2. The vendor shall make all connections at all field devices and at the head-end; and shall make all necessary field adjustments for a fully functional system.

B. Shop Drawings

1. Prior to assembling or installing the system, the Contractor shall provide complete shop drawings which include the following:

   a. List the name of the manufacturer's local representative and his/her phone number.

   b. Table of contents.

   c. Manufacturer's parts lists

   d. Product serial numbers

   e. Catalog cut sheets

   f. Installation instructions

   g. Typical wiring diagrams

   h. Drawings showing equipment locations

   i. Manufacturer's warranty documents

2. All drawings shall be fully dimensioned.

3. Operating License: Submit evidence of application for FCC Radio Station Authorization prior to installing equipment when required for operation of the equipment.

C. As-Built Drawings

1. At the conclusion of the project, the Vendor shall provide "as built" drawings. The "as built" drawings shall be a continuation of the Contractors shop drawings as modified, augmented, and reviewed during the installation, check out and acceptance phases of the project. All drawings shall be fully dimensioned and prepared in DWG format using the latest version of AutoCAD.

2. The as-built drawings shall incorporate all updated system riser diagrams prepared in DWG format using the latest version of AutoCAD.

D. Manuals

1. At the conclusion of the project, the Vendor shall provide copies of the manuals as described herein. Each manual's contents shall be identified on the cover. The manual shall include names, addresses, and telephone numbers of each system integrator installing equipment and systems and the nearest service representatives for each item of equipment for each system. The manuals shall have a table of contents and labeled sections. The manuals shall include all modifications made during installation, checkout, and acceptance. The manuals shall contain the following:

   a. Hardware Manual

      1) The hardware manual shall describe all equipment furnished including:

      2) General description and specifications

      3) Installation and check out procedures

      4) Equipment layout and electrical schematics to the component level

5) System layout drawings and schematics

6) Alignment and calibration procedures

7) Manufacturers repair parts list indicating sources of supply

b. Software Manual

1) The software manual shall describe the functions of all software and shall include all other information necessary to enable proper loading, testing, and operation. The manual shall include:

2) Definition of terms and functions

a) Use of system and applications software

b) Initialization, start up, and shut down

c) Alarm reports

d) Reports generation

e) Data base format and data entry requirements

f) Directory of all disk files

2. Operators Manual

a. The operator’s manual shall fully explain all procedures and instructions for the operation of the system including:

1) Computers and peripherals

2) System start up and shut down procedures

3) Use of system, command, and applications software

4) Recovery and restart procedures

5) Use of report generator and generation of reports

6) Data entry

7) Operator commands

8) Alarm messages and reprinting formats

9) System access requirements

3. Maintenance Manual

a. The maintenance manual shall include descriptions of maintenance for all equipment including inspection, periodic preventive maintenance, fault diagnosis, and repair or replacement of defective components.

1.8 DELIVERY, STORAGE AND HANDLING

A. Delivery of Materials: Deliver materials (except bulk materials) in manufacturer's unopened containers fully identified with manufacturer's name, trade name, type, class, grade, size and color.

B. Storage of Materials: Store materials in unopened containers. Store off ground and under cover, protected from damage.

1.9 WARRANTY

A. Comply with Section 260001.

B. The Electrical Trade Contractor shall warranty that all materials furnished shall be free from defects of material for a period of one year from the date of Substantial Completion.

C. Manufacturer's Warranty:

1. Lifetime warranty on LAN electronics.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Wired LAN Equipment

1. Hewlett Packard, Aruba Enterprise Company

B. Wireless LAN Equipment

1. Cisco Meraki

2.2 WIRED LAN EQUIPMENT

A. Furnish and install the following wired LAN equipment in the rooms noted.

B. Room A213

1. Server: Furnish, install and configure one (1) server with the following specifications:

a. PowerEdge R630: PowerEdge R630 Server

b. Trusted Platform Module (TPM): No Trusted Platform Module

c. Chassis Configuration: Chassis with up to 8, 2.5" Hard Drives, 3 PCIe Slots

d. Shipping: PowerEdge R630 Shipping- 8 Drive Chassis

e. Processor: Intel® Xeon® E5-2609 v4 1.7GHz,20M Cache,6.4GT/s QPI,8C/8T (85W) Max Mem 1866MHz

f. Additional Processor: Intel® Xeon® E5-2609 v4 1.7GHz,20M Cache,6.4GT/s QPI,8C/8T (85W) Max Mem 1866MHz

g. Processor Thermal Configuration: 2 CPU up to 120W

h. Memory DIMM Type and Speed: 2666MT/s RDIMMs

i. Memory Configuration Type: Performance Optimized

j. Memory Capacity: (4) 16GB RDIMM, 2666MT/s, Dual Rank

k. RAID Configuration: RAID 1+RAID 1 for H330/H730/H730P (2 + 2 HDDs or SSDs)

l. RAID Controller: PERC H730 RAID Controller, 1GB NV Cache

m. Hard Drives: (2) 1.6TB Solid State Drive SATA Mix Use MLC 6Gbps 512n 2.5in Hot-plug Drive, Hawk-M4E; (2) 240GB Solid State Drive SATA Mix Use TLC 6Gbps 512e 2.5in Hot-plug Drive, S4600

n. Additional Network Cards: Intel XL710 Dual Port 40G, QSFP+, Low Profile with SR Optics

o. Embedded Systems Management: iDRAC8 Enterprise, integrated Dell Remote Access Controller, Enterprise

p. Internal Optical Drive: No Internal Optical Drive for 8 HDD Chassis

q. Rack Rails: No Rack Rails or Cable Management Arm

r. Bezel: No Bezel

s. Power Management BIOS Settings: Power Saving Dell Active Power Controller

t. Power Cords: (2) NEMA 5-15P to C13 Wall Plug, 125 Volt, 15 AMP, 10 Feet (3m), Power Cord, North America

u. Power Supply: Dual, Hot-plug, Redundant Power Supply (1+1), 1100W

v. System Documentation: No Systems Documentation, No OpenManage DVD Kit

w. Operating System: No Operating System

x. OS Media Kits: No Media Required

y. Shipping Information: US No

z. Network Daughter Card: Broadcom 5720 QP 1Gb Network Daughter Card

aa. Service: 3 Year Basic Hardware Warranty Repair, 5X10 HW-Only, 5x10 NBD On-site

bb. Deployment Services: No Installation

cc. Remote Consulting Services: Declined Remote Consulting Service

2. Fiber Aggregation - Base Network

DESCRIPTION	PART NO.	QTY
HPE X142 40G QSFP+ LC LR4 SM Transceiver	JH232A	2
HPE X142 40G QSFP+ LC LR4 SM Transceiver	JH232A	12
ARUBA 8325-32C 32-PORT 100G QSFP+/QSFP28 FRONT-TO-BACK 6 FANS AND 2 PSU BUNDLE	JL626A	1

3. Fiber Aggregation - Security Network

DESCRIPTION	PART NO.	QTY
Aruba 100G QSFP28-QSFP28 3m Direct Attach Copper Cable	JL307A	1
HPE X142 40G QSFP+ MPO eSR4 300M XCVR	JH233A	7
ARUBA 8325-32C 32-PORT 100G QSFP+/QSFP28 FRONT-TO-BACK 6 FANS AND 2 PSU BUNDLE	JL626A	1

4. PDU and UPS

DESCRIPTION	PART NO.	QTY
Eaton 5PX UPS	5PX3000RTN	1

5. Base Network

DESCRIPTION	PART NO.	QTY
24 Port Gig-E POE+ v3 Modules (Minus Multi-Gig)	J9986A	25
8 Port Multi-Gig T POE+ v3 Module	J9995A	7
20 Port Gig-E POE+/ 1 Port 40GbE QSFP+ v3 Module	J9992A	3
HPE X142 40G QSFP+ LC LR4 SM Transceiver	JH232A	3
5412R - 12 Slot Chassis	J9822A	3
5400R 2750W POE+ zl2 Power Supply	J9830B	12
Aruba 5400R zl2 Management Module	J9827A	3

6. Security Network

DESCRIPTION	PART NO.	QTY
24 Port Gig-E POE+ v3 Modules (Minus Multi-Gig)	J9986A	4
8 Port Multi-Gig T POE+ v3 Module	J9995A	0
20 Port Gig-E POE+/ 1 Port 40GbE QSFP+ v3 Module	J9992A	1
HPE X142 40G QSFP+ LC LR4 SM Transceiver	JH232A	1
5412R - 6 Slot Chassis	J9821A	1
5400R 2750W POE+ zl2 Power Supply	J9830B	4
Aruba 5400R zl2 Management Module	J9827A	1

7. PDU and UPS

DESCRIPTION	PART NO.	QTY
Eaton Metered Outlet Rack PDU, 0U	EMI117-10	4
Eaton 5PX UPS	5PX3000RTN	4

C. Room A234

1. Base Network

DESCRIPTION	PART NO.	QTY
24 Port Gig-E POE+ v3 Modules (Minus Multi-Gig)	J9986A	21
8 Port Multi-Gig T POE+ v3 Module	J9995A	6
20 Port Gig-E POE+/ 1 Port 40GbE QSFP+ v3 Module	J9992A	2
HPE X142 40G QSFP+ LC LR4 SM Transceiver	JH232A	2
5412R - 12 Slot Chassis	J9822A	2
5400R 2750W POE+ zl2 Power Supply	J9830B	8
Aruba 5400R zl2 Management Module	J9827A	2

2. Security Network

DESCRIPTION	PART NO.	QTY
24 Port Gig-E POE+ v3 Modules (Minus Multi-Gig)	J9986A	2
8 Port Multi-Gig T POE+ v3 Module	J9995A	0
20 Port Gig-E POE+/ 1 Port 40GbE QSFP+ v3 Module	J9992A	1
HPE X142 40G QSFP+ LC LR4 SM Transceiver	JH232A	1
5412R - 6 Slot Chassis	J9821A	1
5400R 2750W POE+ zl2 Power Supply	J9830B	4
Aruba 5400R zl2 Management Module	J9827A	1

3. PDU and UPS

DESCRIPTION	PART NO.	QTY
Eaton Metered Outlet Rack PDU, 0U	EMI117-10	3
Eaton 5PX UPS	5PX3000RTN	3

D. Room A262.1

1. Base Network

DESCRIPTION	PART NO.	QTY
24 Port Gig-E POE+ v3 Modules (Minus Multi-Gig)	J9986A	21
8 Port Multi-Gig T POE+ v3 Module	J9995A	5
20 Port Gig-E POE+/ 1 Port 40GbE QSFP+ v3 Module	J9992A	3
HPE X142 40G QSFP+ LC LR4 SM Transceiver	JH232A	3
5412R - 12 Slot Chassis	J9822A	3
5400R 2750W POE+ zl2 Power Supply	J9830B	12
Aruba 5400R zl2 Management Module	J9827A	3

2. Security Network

DESCRIPTION	PART NO.	QTY
24 Port Gig-E POE+ v3 Modules (Minus Multi-Gig)	J9986A	2
8 Port Multi-Gig T POE+ v3 Module	J9995A	0
20 Port Gig-E POE+/ 1 Port 40GbE QSFP+ v3 Module	J9992A	1
HPE X142 40G QSFP+ LC LR4 SM Transceiver	JH232A	1
5412R - 6 Slot Chassis	J9821A	1
5400R 2750W POE+ zl2 Power Supply	J9830B	4
Aruba 5400R zl2 Management Module	J9827A	1

3. PDU and UPS

DESCRIPTION	PART NO.	QTY
Eaton Metered Outlet Rack PDU, 0U	EMI117-10	4
Eaton 5PX UPS	5PX3000RTN	4

E. Room B003

1. Base Network

DESCRIPTION	PART NO.	QTY
24 Port Gig-E POE+ v3 Modules (Minus Multi-Gig)	J9986A	5
8 Port Multi-Gig T POE+ v3 Module	J9995A	1
20 Port Gig-E POE+/ 1 Port 40GbE QSFP+ v3 Module	J9992A	1
HPE X142 40G QSFP+ LC LR4 SM Transceiver	JH232A	1
5412R - 12 Slot Chassis	J9822A	1
5400R 2750W POE+ zl2 Power Supply	J9830B	4
Aruba 5400R zl2 Management Module	J9827A	1

2. Security Network

DESCRIPTION	PART NO.	QTY
24 Port Gig-E POE+ v3 Modules (Minus Multi-Gig)	J9986A	1
8 Port Multi-Gig T POE+ v3 Module	J9995A	0
20 Port Gig-E POE+/ 1 Port 40GbE QSFP+ v3 Module	J9992A	1
HPE X142 40G QSFP+ LC LR4 SM Transceiver	JH232A	1
5412R - 6 Slot Chassis	J9821A	1
5400R 2750W POE+ zl2 Power Supply	J9830B	4
Aruba 5400R zl2 Management Module	J9827A	1

3. PDU and UPS

DESCRIPTION	PART NO.	QTY
Eaton Metered Outlet Rack PDU, 0U	EMI117-10	2
Eaton 5PX UPS	5PX3000RTN	2

F. Room B040

1. Base Network

DESCRIPTION	PART NO.	QTY
24 Port Gig-E POE+ v3 Modules (Minus Multi-Gig)	J9986A	4
8 Port Multi-Gig T POE+ v3 Module	J9995A	2
20 Port Gig-E POE+/ 1 Port 40GbE QSFP+ v3 Module	J9992A	1
HPE X142 40G QSFP+ LC LR4 SM Transceiver	JH232A	1
5412R - 12 Slot Chassis	J9822A	1
5400R 2750W POE+ zl2 Power Supply	J9830B	4
Aruba 5400R zl2 Management Module	J9827A	1

2. Security Network

DESCRIPTION	PART NO.	QTY
24 Port Gig-E POE+ v3 Modules (Minus Multi-Gig)	J9986A	1
8 Port Multi-Gig T POE+ v3 Module	J9995A	0
20 Port Gig-E POE+/ 1 Port 40GbE QSFP+ v3 Module	J9992A	1
HPE X142 40G QSFP+ LC LR4 SM Transceiver	JH232A	1
5412R - 6 Slot Chassis	J9821A	1
5400R 2750W POE+ zl2 Power Supply	J9830B	4
Aruba 5400R zl2 Management Module	J9827A	1

3. PDU and UPS

DESCRIPTION	PART NO.	QTY
Eaton Metered Outlet Rack PDU, 0U	EMI117-10	2
Eaton 5PX UPS	5PX3000RTN	2

G. Room B133

1. Base Network

DESCRIPTION	PART NO.	QTY
24 Port Gig-E POE+ v3 Modules (Minus Multi-Gig)	J9986A	7
8 Port Multi-Gig T POE+ v3 Module	J9995A	3
20 Port Gig-E POE+/ 1 Port 40GbE QSFP+ v3 Module	J9992A	1
HPE X142 40G QSFP+ LC LR4 SM Transceiver	JH232A	1
5412R - 12 Slot Chassis	J9822A	1
5400R 2750W POE+ zl2 Power Supply	J9830B	4
Aruba 5400R zl2 Management Module	J9827A	1

2. Security Network

DESCRIPTION	PART NO.	QTY
24 Port Gig-E POE+ v3 Modules (Minus Multi-Gig)	J9986A	2
8 Port Multi-Gig T POE+ v3 Module	J9995A	0
20 Port Gig-E POE+/ 1 Port 40GbE QSFP+ v3 Module	J9992A	1
HPE X142 40G QSFP+ LC LR4 SM Transceiver	JH232A	1
5412R - 6 Slot Chassis	J9821A	1
5400R 2750W POE+ zl2 Power Supply	J9830B	4
Aruba 5400R zl2 Management Module	J9827A	1

3. PDU and UPS

DESCRIPTION	PART NO.	QTY
Eaton Metered Outlet Rack PDU, 0U	EMI117-10	2
Eaton 5PX UPS	5PX3000RTN	2

H. Room B177

1. Base Network

DESCRIPTION	PART NO.	QTY
24 Port Gig-E POE+ v3 Modules (Minus Multi-Gig)	J9986A	9
8 Port Multi-Gig T POE+ v3 Module	J9995A	4
20 Port Gig-E POE+/ 1 Port 40GbE QSFP+ v3 Module	J9992A	1
HPE X142 40G QSFP+ LC LR4 SM Transceiver	JH232A	1
5412R - 12 Slot Chassis	J9822A	1
5400R 2750W POE+ zl2 Power Supply	J9830B	4
Aruba 5400R zl2 Management Module	J9827A	1

2. Security Network

DESCRIPTION	PART NO.	QTY
24 Port Gig-E POE+ v3 Modules (Minus Multi-Gig)	J9986A	1
8 Port Multi-Gig T POE+ v3 Module	J9995A	0
20 Port Gig-E POE+/ 1 Port 40GbE QSFP+ v3 Module	J9992A	1
HPE X142 40G QSFP+ LC LR4 SM Transceiver	JH232A	1
5412R - 6 Slot Chassis	J9821A	1
5400R 2750W POE+ zl2 Power Supply	J9830B	4
Aruba 5400R zl2 Management Module	J9827A	1

3. PDU and UPS

DESCRIPTION	PART NO.	QTY
Eaton Metered Outlet Rack PDU, 0U	EMI117-10	2
Eaton 5PX UPS	5PX3000RTN	2

I. Storage/Toilet Building

1. Base Network

DESCRIPTION	PART NO.	QTY
3810M 40G 8 HPE Smart Rate PoE+ 1-slot Switch	JL076A	1
Aruba X372 54VDC 1050W 110-240VAC Power Supply	JL087A	2
Aruba 3810M 2QSFP+ 40GbE Module	JL079A	1
HPE X142 40G QSFP+ LC LR4 SM Transceiver	JH232A	2

2. Security Network

DESCRIPTION	PART NO.	QTY
3810M 40G 8 HPE Smart Rate PoE+ 1-slot Switch	JL076A	1
Aruba X372 54VDC 1050W 110-240VAC Power Supply	JL087A	2
Aruba 3810M 2QSFP+ 40GbE Module	JL079A	1
HPE X142 40G QSFP+ LC LR4 SM Transceiver	JH232A	2

3. PDU and UPS

DESCRIPTION	PART NO.	QTY
Eaton Metered Input Rack PDU, 1U	EMIT09-10	1
Eaton 5PX UPS	5PX2200RT	1

J. Accessories:

1. All accessories, hardware, and equipment necessary for a complete and functional system.
2. Fiber Optic patch cables – length and quantity as required for closet connections between fiber optic patch panels and equipment;
3. All software as required.
4. Shelves, Hardware and accessories in open two-post 19” equipment racks as required for supporting all equipment.
5. UPS’s shall be installed using manufacturer recommended mounting hardware.

2.3 WIRELESS LAN EQUIPMENT

A. Furnish and install the following wireless LAN equipment where shown on the drawings and as directed by Worcester Public Schools (WPS) IT department.

DESCRIPTION	PART NO.	QTY
Cisco Meraki MR53 High performance 802.11ac Wave 2 wireless Access Point	MR53	210
Management of the MR53 is through the Meraki cloud	-	1

B. All locations will be coordinated with WPS IT department prior to installation.

C. Furnish and install with proper Aerohive ceiling mount brackets for the ceiling it is being installed on with appropriate patch cords.

2.4 CONFIGURATION

A. Un-box and install equipment in the various rooms as identified. Dispose of all refuse from site.

B. Install all switches, access points and UPS equipment. Verity interconnectivity between switches with the Owner.

1. Mount the chassis switch in between the patch panels rather than mounting the switch on the bottom of the rack or in a separate.

C. Connect switches to UPS equipment and configure UPS's to notify network administrator(s) of a power failure; configure switches and access points according to Owner requirements (VLANs, Security, etc.).

D. Install and dress appropriate size fiber and Cat. 6A patch cords (provided by Electrical Trade Contractor) between all active switch ports and patch panel ports serving equipment.

E. Connect all wireless networking equipment as required. Install station side patch cords (provided by Electrical Trade Contractor) for connecting terminal end equipment. Verify Operation. Assign proper IP information and verify connectivity and operation of all switch ports whether in service or not.

F. Configure static IP addresses for video surveillance, access control, intrusion detection, public address, lighting control, voice communications, fire alarm, photovoltaic, media distribution systems and any other systems requiring a static IP address.

G. Provide labeling, documentation, and knowledge transfer.

2.5 UTILITY COMPANY SERVICE

A. Schedule the installation of the data service to the building with the utility company. Coordinate the time frame of the installation with the utility company and the Owner.

B. The Owner shall be responsible for any utility company back charges for installation of the data service to the building.

PART 3 - EXECUTION

3.1 EXAMINATION

A. The Vendor shall coordinate with the construction schedule to ensure that acceptable conditions exist for installation of all equipment and components.

B. Proceed with installation only after unsatisfactory conditions have been corrected. Provide detailed site survey to ensure acceptable conditions exist.

C. Examine all rooms and areas where equipment and components will be installed. Check all elements for compliance with space allocations, installation tolerances, hazards to equipment installation, and other conditions affecting installation.

D. Examine walls, floors, roofs, and roof supports for suitable conditions where equipment is to be installed.

E. Examine all support systems such as air-conditioning, electrical panels, receptacles, UPS, lighting, etc. are installed and functioning correctly.

F. Examine all equipment racks and cabinets installations to ensure acceptable conditions exist for installation of all equipment and components.

G. Ensure that all rooms and any areas where equipment and components are installed are physically secured at all times from theft, vandalism, etc.

H. Report unacceptable installation or unsafe conditions to the Construction Manager.

I. Under no condition shall the vendor install any equipment or component that will void Manufacturer warranty or such conditions that will reduce equipment performance, longevity, and life.

3.2 INSTALLATION

A. General

1. The Vendor shall be knowledgeable of work to be performed by other trades and take necessary steps to integrate and coordinate their work with other trades.

2. The Vendor shall be responsible for furnishing all equipment, components, and cabling as specified herein and as indicated on the drawings.

3. All equipment, components and cabling shall be new.

4. All equipment, components, and cabling shall be installed in a manner neatly and consistent with this type of work.

5. All equipment, components, and cabling shall be installed for optimal performance.

6. All equipment, components, and cabling shall be installed to allow for easy adds, moves, and other changes in the future.

7. Final labeling scheme shall be coordinated with the Owner during the shop drawings process, prior to initiating work. Labeling scheme shall include all equipment, components, and cabling with all appropriate references such as communications rooms, cabinets, racks, cable terminal blocks, patch panels, antennas, outlets, cables, etc.

8. Construction within telecommunications rooms must be substantially complete before the installation of equipment, components, and cabling. This includes, but is

not limited to, the installation of plywood backboard, cable tray or ladder rack, electrical outlets, light fixtures, sprinklers and ductwork. All walls shall also be painted by others before the installation. The telecommunications rooms must be free from dust, dirt, and other foreign materials before the installation of any equipment and components. The door to the communication rooms must be installed and closed during termination.

9. All equipment, components, and cable noted in this Specification and associated drawings shall be provided and completely setup and installed.

10. The Vendor is required to coordinate their efforts with the other trades and Contractors who may be working within the same vicinity to avoid conflict and lost time.

11. The Vendor shall supply all necessary tools, equipment, accessories, safety equipment, protective clothing, etc., as customary for the craft and necessary for the installation.

12. All mis-installed components will be removed and replaced with new at the Vendors expense. No additional cost will be submitted to Owner.

13. All equipment shall be installed in a neat and workmanlike manner, arranged for convenient operation, testing and future maintenance.

B. Implementation

1. The Owner requires the successful vendor to provide a full suite of installation services.

2. The project shall be executed under the direction of the Owner's IT department.

3. Each vendor will be responsible to coordinate activities with other Contractors on site under the overall direction of the project team.

4. The successful vendor will appoint their own project manager who will be responsible for the implementation of the system hardware and software components.

5. The vendor shall provide the name and resume of their project manager in their response to this specification.

6. The successful vendor is expected to have their personnel perform in a professional manner. At the end of each workday, the vendor personnel will clean the work area. This includes removal of all garbage, trash, food and installation debris.

7. The vendor will be responsible for attending coordination meetings (weekly or biweekly as needed) until the system has reached final acceptance.

8. The vendor will be responsible for all phases of the equipment delivery process.

9. The vendor will be responsible for all insurance, security, delivery and staging of equipment.

10. The vendor will be responsible for installation of all equipment and software identified in this specification to insure a functional, attractive and quality installation.

11. The vendor will coordinate installation schedules with the district IT department so as to minimize the impact on day-to-day operation for each campus project.

12. Turnkey installation is defined as having all networking components including cabling, LAN electronics and LAN servers working as individual components as well as a homogenous system.

13. The vendor will be responsible for all mounting kits and brackets for the LAN electronics.

14. The vendor will be responsible for patching ALL fiber and copper data cables into LAN electronics.

C. Cable and Patch Cord Installation relating to Data Communications Network Equipment

1. All cable and patch cords shall be provided and installed per Specifications Sections 271300 and 271500. The vendor will be responsible for patching ALL fiber and copper data cables into LAN electronics.

2. All cables and patch cords routed within communications rooms shall be bundled and combed with Velcro to provide a neat and organized appearance. This includes horizontal and vertical cables routed on cable tray, d-rings, vertical cable managers, equipment rack cable managers, etc. Cables shall be bundled using only manufacturer and industry approved Velcro ties with tensions that do not deform and damage cable resulting in loss of transmission or performance. Any bundles and combing methods used shall not exceed manufacturer or industry standards recommendations for that cable type.

3. Within communications rooms, cables and patch cords shall be snugly wrapped using Velcro reusable cable ties, a minimum of every 3’-0” for cable organization. Velcro ties shall be tightened so as not to deform cable jackets and thus affect cable performance. Plastic cable tie wraps shall not be used and will prevent system acceptance.

4. Cable bends shall not be less than that recommended by the manufacturer of the cable. Do not exceed manufacturer's minimum bending radii and other cable requirements. Provided below are some examples but all requirements shall be verified.

5. Care shall be taken so as not to damage cable and patch cords during the installation process and that the manufacturer’s and industry standard’s pull tension specification is not exceeded.

6. Do not install bruised, kinked, scored, deformed, or abraded cable or patch cords. Remove and discard cable if damaged during installation and replace it with new cable.

7. All cables and patch cords shall be installed in vertical and horizontal cable management within cabinets and racks.

8. Cable and patch cords routed outside of racks and cabinets shall be in cable tray and ladder rack. Fiber optic patch cords shall be routed in fiber trough.

9. Provide independent circuit grounding recommended by manufacturer.

10. Under no circumstances shall the cable or patch cords be painted, treated, or covered with other material unless approved by manufacturer, Owner and Engineer.

D. Acceptance Testing

1. All LAN electronics specified in this document must meet manufacturer’s standard tests. Testing must include the ability to successfully “ping” from one device to another and to and from PC end stations and servers. PC’s must be able to connect to their appropriate servers.

2. The Owner will issue an acceptance certificate upon successful completion of all network tests. Issuance of the certificate will not be unreasonably withheld.

3.3 INSTALLATION OF WIRELESS ACCESS POINTS (AP)

A. There are three different mounting scenarios for indoor APs. They are Direct Mounting to the ceiling grid, Right Angle Mounting to the wall, and Open Ceiling Mounting.

1. Direct Mounting to the Ceiling Grid:

a. In an area where there is a drop ceiling, the cabling for the Access Point shall be terminated above the ceiling. A green dot sticker on the ceiling grid shall mark the location of the terminated cables. The Contractor shall be responsible for patching “Port 1”” into the eth0 port of the AP. Provide access points mounting hardware that directly connects to it to the ceiling grid. The AP must be mounted below the ceiling grid with no obvious obstructions nearby. The standard mounting bracket (enclosed in the AP packaging) shall be used to connect to the ceiling grid.

2. Right Angle Bracket Mounting (Access Point mounting on a wall):

a. When an access point is designed to be mounted adjacent to a wall, a special right angle bracket (Oberon model # 1010-00-Right Angle Bracket) shall be provided by the contractor so proper mounting can be achieved. This right-angle bracket is specially designed for this purpose. The cabling for the Access Point should be terminated on a standard 2-port faceplate. The Contractor shall be responsible for patching ”Port 1” into the eth0 port of the AP. The standard mounting bracket (enclosed in the AP packaging) shall be used to connect to the right-angle bracket in the same manner as a ceiling grid mount.

3. Open Ceiling Mounting:

a. In an open ceiling location, the cabling for the Access Point shall be terminated on a standard 2-port faceplate which shall be located in a 4” square junction box. The patch cord shall then be run through the 1” rigid steel conduit to second 4” square junction box with cover. The Contractor shall be responsible for patching “Port 1”” into the eth0 port of the AP. The standard mounting bracket (enclosed in the AP packaging) shall be used to connect to 4” junction box in the same manner as a ceiling grid mount.

B. All patch cords shall be provided under Section 271500. Any placement questions for cabling or AP mounting must be presented to WPS IT Department.

3.4 PROJECT RECORD DOCUMENTATION

A. Prepare and submit as-builds and logical network diagrams updated to reflect the new work completed for the project (i.e. site plans, cable, pathways, TER/TR cabinet elevations, equipment configuration spreadsheets, etc.). Submit hard copies and electronic files.

B. Documentation Requirements

1. Initial set-up and configuration.

2. Configuration management for adds and changes. (Including emergency board replacement.)

3. Problem solving and resolution procedures.

4. A custom operation manual in support of the day-to-day operations unique to Network.

5. The vendor shall provide all products standard documentation in printed and electronic format. Two copies of the printed documentation are required for all equipment and software products proposed in this section.

3.5 MAINTENANCE

A. The vendor shall provide one-year maintenance on all equipment and software provided during the course of this contract. In addition, the vendor shall provide a limited lifetime hardware and software warranty on all products supplied. The vendor will warrant the system to perform in the intended use as indicated in this section.

B. The system is expected to operate 24 hours/day, 7 days/week. At a minimum, the Owner expects an uptime of 99 percent for any single switch component during the hours of 7:00 a.m. to 7:00 p.m. (and 98 percent uptime when calculated over a 24-hour day).

C. The vendor shall commit that major component failures will be replaced within a four-hour period. A major component shall be considered any hub or switch component that affects fifty or more user devices.

D. Once work has begun on repair of a critical problem, a technician shall remain on-site until the problem has been repaired. The vendor shall be allowed to change technicians at shift changes, however, the first technician shall not leave the site until the second has arrived and has been briefed on the problem.

E. The vendor shall provide a toll-free hotline and support center to assist the Owner in the installation, tuning, maintenance and updating of the systems hardware and software for the term of this contract.

F. The vendor shall maintain an inventory of critical spare parts that shall be available locally, in a location approved by the Owner, so as to ensure the repair response times required in this section.

G. If parts are required to fix a critical problem that are not available locally, they shall be shipped by the fastest possible means at no cost to the Owner.

H. The vendor shall keep on-site detailed maintenance records of all maintenance calls made to the facility.

3.6 COORDINATION AND INTEGRATION WITH OTHER SYSTEMS

A. The Vendor shall work with the Voice Communications Equipment Vendor in enabling security hardening for the VoIP communication system throughout the communication infrastructure.

B. The vendor shall work with the Media Distribution System Vendor to coordinate network requirements including but not limited to MAC and IP addressing, VLAN assignment, bandwidth requirements, multicasting, VPN requirements, etc.

C. The vendor shall co0rdinate and configure static IP addresses the Building Management System, Network Lighting Control System, Fire Alarm System, Public Address System, Photovoltaic System, and any other systems requiring configuration of static IP addresses.

3.7 COMMISSIONING

A. Comply with requirements specified in Division 1.

B. Engage a factory-authorized service representative to supervise and assist with startup service. Complete installation and startup checks according to the approved manufacturer's written instructions.

3.8 TRAINING AND SERVICE

A. Comply with Section 26 00 01.

B. Conduct four 4-hour training sessions. Train the Owner’s maintenance personnel on procedures and schedules related to start up and shutdown, troubleshooting, servicing, and preventive maintenance.

End of Section

DO NOT REMOVE
THIS PAGE INTENTIONALLY LEFT BLANK

Section 27 30 00

AREA OF REFUGE SYSTEM

(TRADE CONTRACT REQUIRED AS PART OF SECTION 26 00 01)

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. PUBLICLY BID TRADE CONTRACT REQUIREMENTS: As provided under Section 26 00 01 - ELECTRICAL and supplemented under the Bidding Requirements, Contract Forms, and Conditions of the Contract, and applicable parts of Division 1 - GENERAL REQUIREMENTS.

1. Work of this Trade Contract includes all individual specification sections listed in Section 26 00 01.

1.2 RELATED DOCUMENTS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.

1.3 WORK INCLUDED

A. Area of refuge system including but not limited to:

1. Command Center
2. Distribution Box
3. Call Boxes
4. Battery Backup
5. Signage
6. Power Supplies
7. 2-hour rated wiring

1.4 REFERENCES

A. Federal Communications Commission (FCC):

1. FCC Part 15 - Radio Frequency Device.
2. FCC Part 68 - Connection of Terminal Equipment to the Telephone Network.
3. FCC Compliance to applicable Regulations and Display a valid FCC ID on the Product and/or have a valid FCC license for operation

B. National Fire Protection Association (NFPA):

1. NFPA70 - National Electrical Code.

C. Underwriters Laboratories (UL):

1. UL294 - Access Control System Units.
2. ITE UL 60950, #E218113

D. U. S. Federal Drug Administration (FDA):

1. FDA Listed under CFR Title 21 Section 890.3725 and produced by an FDA registered manufacturer

1.5 APPLICABLE CODES & STANDARDS

A. The Contractor shall ensure that all Work provided under this section shall meet the minimum requirements of all applicable codes and standards, as determined by the AHJ.

B. Where the requirements of this section exceed the minimum requirements of the AHJ, this section shall govern. Where codes conflict with the Contract Documents, codes shall govern. Where any applicable codes and standards conflict between themselves, the more stringent shall apply.

C. Nothing in this section shall relieve Contractor from the responsibility for compliance with all applicable codes, standards or specifications which are generally recognized to be applicable to the Work specified herein.

D. Contractor shall make application for and obtain any and all permits required by federal, state, county, city or other AHJ over the work. In the event that inspections are required, it shall be the responsibility of Contractor to schedule and ensure the completion of said inspections and to ensure that all necessary certificates are issued, obtained, and delivered to the Owner.

E. Within this Section and the Subsystem Specifications, reference is made to United States-based standards, codes and legislation. For projects outside the United States, the corresponding local codes, standards and legislation shall apply, except where local requirements are less stringent than those proscribed within the referenced United States requirements. In these cases, the referenced United States requirements shall apply.

1.6 SUBMITTALS

A. Comply with Division 01.

B. Shop drawings

1. Shop drawings shall be computer generated in AutoCAD® version 2010, VISIO or similar software and shall be precisely scaled. Free-hand sketches or reproductions of Contract Documents shall not be acceptable.

2. Coordinate with the Owner's Representative to obtain architectural backgrounds in electronic or hardcopy format for use in the shop drawings.

3. Shop drawings shall consist, at a minimum, of the following:

a. Floor plan drawings indicating the location of all devices as well as all wire runs and designations.

b. Plans, elevations and details indicating dimensions, gages, reinforcement, anchorage, and other installation details for each device as required.

c. System point-to-point diagram indicating the inter-relationship of all system peripheral devices, control panels, software / monitoring workstations, and other components as necessary for a complete and operational system.

d. Typical wiring diagrams for each system peripheral device.

e. Specific wiring diagrams for each system control panel, power supply, video recorder, fire system interface, emergency call system interface or other

device or equipment that controls or communicates with multiple peripheral devices.

f. Fabrication shop drawings for all custom equipment.

C. Record Drawings: Contractor shall maintain up-to-date record drawings on site for inspection by the Owner's Representative. Each change to the original approved submittal data and deviation from the Contract Documents shall be indicated on the record drawings. Contractor shall ensure that the record drawings are protected against soiling, tears, or other damage or defacement. At the conclusion of the Project the Contractor shall incorporate all changes on the record drawings into electronic format and shall submit the completed set as as-built documentation as defined in the section titled "Record documentation" herein.

D. Product data

1. All product data for the Project shall be tabulated into a comprehensive list of equipment to be provided for the Project, including quantities, manufacturer names, model numbers, description and any applicable options. The product data submittal shall be of sufficient detail that the Owner's Representative may readily identify the equipment and materials proposed.

2. Provide all product data in electronic format on CD or USB thumb drive.

3. Product data shall consist, at a minimum, of the following:

a. Product data sheets for each piece of equipment included in the project identifying the following:

1) Materials and Fabrication

2) Tolerances

3) Power and environmental / HVAC requirements

4) Special criteria related to particular systems and components.

5) Specifically, and clearly mark items submitted where multiple items and options occur on a sheet.

6) Identify all Parts and Components by name and manufacturer's number.

b. Manufacturers' brochures for each of the system components included. Contractor shall submit original brochures; copies shall not be acceptable. Where information is in color, all copies shall be provided in color.

c. Schedules shall independently identify each piece of equipment, component and device provided for the project including project name/number reference, product name and number, installation location and conductor/cable identifications that devices are connected to.

1) Reference both manufacturer and construction document identification.

2) For information submitted in a schedule, include information independently in an organized and consistent format.

3) Provide programming point information within the schedules.

d. At the request of the Owner's Representative and as identified in Subsystem Specifications, submit color samples for specific pieces of equipment.

e. Where test data is required by the Subsystem Specifications or Project General Conditions, all tests must be specific to products supplied specific for this project.

4. Certificates and Testing Information:

a. Provide a manufacturer's certificate certifying that Products meet or exceed specified requirements.

b. Manufacturer's Instructions: Indicate application conditions and limitations of use stipulated by Product testing agency.

5. The Owner's Representative shall have the right to request additional information as required for a proper review of the submittal information.

E. Operation and Maintenance Data: Submit manufacturer's operation and maintenance data, customized to the system installed. Include system and operator or user manuals.

1.7 QUALITY ASSURANCE

A. The Manufacturer shall be equipped to support the end-user with around-the-clock live support (24/7/365) with direct access to technical support specialists to help accelerate issue resolutions and offer software upgrades as part of a maintenance program offering. The manufacturer shall offer remote technical support capability, including the ability to remotely access system resources and resolve issues.

1.8 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Deliver, store and handle products in accordance with manufacturer's recommendations, so as to minimize the opportunity for damage, deterioration, or loss.

B. The Owner assumes no liability or responsibility for loss by theft, vandalism, burglary of material or equipment stored on site.

C. Deliver all equipment and material to the site in the manufacturer's original sealed packaging. Packaging is to provide factory identification of items contained within the packaging, and protection until the items or materials are installed. Inspect all equipment and material upon delivery to ensure that they are free from damage and in accordance with the Contract Documents.

D. Upon arrival, contractor should observe products for unacceptable conditions and/or damage. Acceptance of the products constitutes the contractor's acknowledgment that products or materials are satisfactory for use.

E. Store products in their original packaging until installation. Protect from soilage, moisture, all weather-related conditions, corrosion, breakage or other damaging elements. Store in conditions that will insure all required manufacturer's environmental criteria are maintained until use of material or products.

1.9 CONTRACTOR QUALIFICATIONS

A. The Contractor shall be in the trade of installing and servicing area of refuge systems for a minimum of 5 years.

1.10 WARRANTY

A. Comply with Section 260001.

B. The Electrical Trade Contractor shall warranty that all materials furnished shall be free from defects of material for a period of one year from the date of Substantial Completion.

C. Provide a 3-year preventive maintenance plan. The plan shall include one site visit per year after the warranty period to verify that the system is working per the specifications and to proactively perform maintenance, repairs, and replacements to prevent failures before they occur.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers

1. Rath
2. Alpha Communications
3. Cornell
4. Or approved equal

2.2 BASIS OF DESIGN

A. Basis of design product shall be by RATH® and represents the performance standard upon which any equivalent solution shall be based.

2.3 SYSTEM REQUIREMENTS

A. The Command Center is to be located at a central control point on the first floor or as determined by local Authority Having Jurisdiction. RATH® Command Center Call Boxes are to be located on all floors above and below the first floor, ideally next to a stairwell emergency exit or elevator landing on each floor.

B. The Command Center must include visual indicators to allow rescue personnel to know which Call Box needs assistance. The Command Center must allow rescue personnel to speak to each Call Box individually. The Command Center must include both a handset and speakerphone to communicate back to the Call Boxes.

C. The emergency communication hardware shall comply with the Americans with Disabilities Act (ADA). The Call Boxes shall have the ability to be programmed with up to 2 emergency phone numbers (either both off-site or Base Station and one off-site). Upon activation of the emergency push button, a call will be automatically placed to the Command Center. If no one answers at the Command Center, the Call Box must dial a secondary location outside the building to activate two-way off-site person to person voice communications via landline.

2.4 CONSTRUCTION

A. The Command Center (2500 series) shall include both the Base Station and Distribution Module. The Base Station must have a powder coated steel housing (surface or flush mount) or be desk mounted, include a black handset with coil cord and be powered from the Distribution Module.

B. Distribution Module must be a surface mount enclosure, include connections for the Call Boxes and power both the Base Station and 2400 series Call Boxes. The Distribution

Module shall be powered from 120vac power with a battery backup that provides power for a minimum of 4 hours (part # RP7701500 for 56-Up Zone).

C. The Call Boxes (2400 series) must be in full compliance with ADA requirements. Call Boxes require a hands-free speakerphone with an LED to indicate status of call.

D. The Call Boxes must allow the programming of a specific location message of the unit. This allows rescue personnel to know the location of the activated Call Box.

E. The Call Boxes are to be located no higher than 48” front reach, or 54” side reach to the center of the button above ground level to ensure conformance with the ADA requirements.

F. The Call Boxes must have a Braille face plate to ensure conformance with the ADA requirements.

G. The Command Center must provide an audible and visual indicator that a Call Box has been activated.

H. The 120vac Power Supply RATH® part # RP7701500 (56-Up Zone) must be capable of supplying power to the Distribution Module.

2.5 MOUNTING

A. The Command Center is to be mounted on a flat wall surface.

B. The Call Boxes are to be wall flush mounted.

2.6 ELECTRICAL REQUIREMENTS

A. The Command Center and Call Boxes (2400 series) are to be powered by the Distribution Module.

B. Distribution Module shall be powered by the RATH® Power Supply. It shall require 120vac power and provide battery backup capable of providing a minimum of 4 hours of electrical backup in case of building power failure.

C. The Base Station shall connect to the Distribution Module with single wire pair (12-16 zone), two wire pairs (28-56 zone) and three wire pairs (76-up zone).

D. Each Call Box shall connect to the Distribution Module with a single wire pair. Wire pairs shall be shielded if near any power runs, otherwise standard pair is acceptable.

1. Cabling for two-way communication system shall meet the applicable requirements for pathway survivability. Cabling installation shall consist of one or more of the following:

a. UL Listed 2-hour fire-rated cable system – type MI cable, 2-hour fire rated circuit integrity (CI) or listed fire-resistive cable.

b. 2-hour fire-rated enclosure or protected area.

E. System shall be in compliance with all state and local Electrical Codes.

F. Provide protective covers RATH® 2400-XXXSSPC2.

G. Monitoring of the system integrity is required per NFPA 72, provide RATH® Supervisor Board 2500-XXSPVSR.

2.7 CALLBOX REQUIREMENTS

A. The Call Boxes (RATH® part # 2400-808NSP) shall be an ADA compliant and vandal resistant speakerphone.

B. The Call Boxes shall be hands-free and be a push-button-once to talk system. Once the button has been pushed, the Call Box will call the Base Station. If no answer at the Base Station, it will automatically call a pre-programmed emergency number. The Call Box must be capable of being programmed with up to 2 emergency numbers (either both off-site or Base Station and one off-site).

C. The Call Box shall have location message capability. Call Box must have a minimum 18 second recordable message capability, programmable to play 1 or 2 times. Call Box shall notify called party of the location of the call upon being received at the emergency dispatch center.

D. The Call Box shall be capable of allowing the called party to replay the location message if necessary, to ensure an understanding of the caller location.

E. If system is not attended to 24 hours a day, the Call Box must dial a secondary location outside the building to activate two-way off-site person to person voice communications.

F. Once a call has been made (button pushed), the call can only be terminated by the called party.

G. The Call Box must have a red LED that will light up upon push of the button. The light shall be a solid color when the Call Box is activated and will flash when call has been answered.

H. The Call Box must be capable of being programmed and re-programmed on-site.

I. Standard Call Box features:

1. Two number programming (either both off-site or Base Station and one off-site).
2. Operating temperature of between -40˚F to +150˚F (-40˚ to + 65˚ C).
3. On-site programmable.
4. EEPROM memory to protect programming.

2.8 SIGNAGE

A. System shall consist of a minimum of one 120/277vac edge light sign (part # 7050 or 7050E), a “location” and “instruction” sign (part # 7049) to clearly indicate location of designated area. A tactile sign (part # 7043/7044 or 7087) with raised letter and Braille shall be located at entrance to area.

2.9 GRAPHICS

A. Command Center must include wording identifying the location of each Call Box and light an LED when a particular Call Box has been activated.

B. The Call Box wording must include “Emergency Phone”, International Phone Symbol and raised Braille lettering.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install all system components in accordance with manufacturer's written instructions, in compliance with all applicable codes and standards and in accordance with recognized industry practices.

3.2 COORDINATION

A. It is intended that all installations will be performed in accordance with the Manufacturer's Installation Instructions and as defined herein and within the Subsystem Specifications. If coordination is required beyond local teams, the Owner's Representative may be contacted by the Owner's Representative for guidance.

B. Coordinate all Work to be performed with the General Contractor as necessary for smooth and expedient completion. Ensure critical path to completion where Work specified herein in dependent upon completion of Work by other trades or by Owner. Coordinate with other trades to avoid conflicts where Work in a certain area requires exclusive use of the area for the duration of the Work.

C. Coordinate arrangement and quantity of related assemblies with ceiling space configuration and with other components occupying ceiling space, including structural members, ductwork, electrical raceways, lighting fixtures and other items.

D. Furnish any inserts required for building into concrete, masonry, and other work, to support and attach work of this section. Furnish in ample time to comply with schedule.

3.3 ACCEPTANCE

A. System Warranty shall not start until Acceptance. Acceptance shall be withheld until the following activities have been successfully completed:

1. Acceptance of all submittals.
2. Delivery of final documentation.
3. Successful final test and inspection.
4. Successful operational demonstration test.

B. Successful training and demonstration, including operation of systems using the manuals.

3.4 COMMISSIONING

A. Comply with requirements specified in Division 1.

B. Engage a factory-authorized service representative to supervise and assist with startup service. Complete installation and startup check according to the approved manufacturer's written instructions.

3.5 TRAINING AND SERVICE

A. Comply with Section 26 00 01.

B. Conduct two 4-hour training sessions. Train the Owner's maintenance personnel on procedures and schedules related to start up and shutdown, troubleshooting, servicing, and preventive maintenance.

End of Section

DO NOT REMOVE
THIS PAGE INTENTIONALLY LEFT BLANK

Section 27 31 00

VOICE COMMUNICATION EQUIPMENT

(TRADE CONTRACT REQUIRED AS PART OF SECTION 26 00 01)

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. PUBLICLY BID TRADE CONTRACT REQUIREMENTS: As provided under Section 26 00 01 - ELECTRICAL and supplemented under the Bidding Requirements, Contract Forms, and Conditions of the Contract, and applicable parts of Division 1 - GENERAL REQUIREMENTS.

1. Work of this Trade Contract includes all individual specification sections listed in Section 26 00 01.

1.2 RELATED DOCUMENTS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications

1.3 SCOPE

A. It is the intent of these specifications that the Vendor, Manufacturer and/or its Authorized System Integrator expeditiously furnishes and installs a system complete in every respect and ready to operate. All miscellaneous items and accessories required for such installation, whether or not each such item or accessory as shown on the plans or mentioned in these specifications, shall be furnished and installed.

B. The voice network communications equipment shall be installed as shown on the drawings and as specified herein. The work covered by this section of the specifications includes the furnishing of all labor, equipment, materials and performance of all operations associated with the voice network communications equipment for a fully functional system.

C. The school district has standardized on the Shoretel/Mitel VOIP phone system. The district already has all the core services setup at the network operation center. This includes the virtualized call management server, PRI, mobility router, and Shoregear switch. The core system is version 14 of the Shoretel system and has a current maintenance agreement and ShoreCare support.

1. This contractor shall employ the services of Harbor Networks for installation and maintenance of the system to maintain the district’s warranty, maintenance and support agreements.

2. Harbor Networks, point of contact is: Jim McCormack, telephone: 508-652-3062, email: jimm@harbornetworks.com.

D. This contractor shall provide Shoretel/Mitel VOIP phone system as specified herein.

E. The Shoregear will have four copper lines for survivability. The system will be managed at the core by the district's Shoretel system.

F. The terms of the support and maintenance contract must include the following:

1. Break/Fix: Vendor will repair hardware (exclusive of the phones) and any Shoretel software. Any significant outages must have a repair tech on site within 6 hours 24x7.
2. Software upgrades: Vendor will obtain and install (at no cost to the district) any software patches and major software updates
3. Remote monitoring: Vendor will provide 24x7 remote monitoring and notify the district of any outages
4. Voice carrier support: Vendor will be the primary contact with the district's voice carrier and handle all communications and fixes directly with the carrier
5. Change/Add/Deletes: After initial deployment plus 3 months, the district will then be responsible for all changes/add/deletes of users and mailboxes.
6. All software maintenance must be conducted after 9PM EST and/or coordinated with district IT Staff.

1.4 CODES AND STANDARDS

A. Complete installation shall meet or exceed the latest edition of following standards:

1. TIA-568: Commercial building telecommunications wiring standard and all current addenda.
2. TIA-569: Commercial building standard for telecommunications pathways and spaces.
3. TIA-606: Administration standard for telecommunications infrastructure of commercial buildings.
4. TIA-607: Commercial building grounding and bonding requirements for telecommunications.
5. ANSI, ASTM, UL, NEMA, IEEE and FCC standards as applicable.
6. BICSI Telecommunications Distribution Methods Manual, current edition.

1.5 PROGRAMMING

A. Coordinate and obtain a written approval of system functionality from the Owner prior to programming.

B. Perform a walk-through with the Owner and demonstrate the system functionality.

C. Make any adjustments to system functionality after initial programming if necessary to achieve the desired functionality requested by the Owner. Coordinate all required reprogramming with the Owner as required as part of this contract.

D. Obtain a written final letter of acceptance from the Owner upon completion of system functionality programming and demonstration.

1.6 SUMMARY

A. This specification describes the equipment provision, installation, integration, configuration, testing, training, documentation, standards, and acceptance criteria of Telephone systems. This specification and provide requirements for product performance, installation, configuration, and testing.

B. This specification identifies the installation of Telecommunications systems. This vendor will provide the Network Design and design documents. In addition, the Vendor will provide all necessary preparation and consumable supplies to implement a fully functioning system.

C. The Vendor will be required to furnish all labor, supervision, tooling, miscellaneous mounting hardware, and consumables for all systems installed. In addition, the Vendor will provide integration services to achieve Telecommunications connectivity for all office work areas, classrooms, computer laboratories, libraries, and other instructional areas, as specified. It is the vendor's responsibility to propose any and all items required for a complete and operational system.

D. Principal items of Work in this Section include but are not limited to:

1. Installing and connecting telecommunications equipment cabinet, attendant consoles, and telephone instruments as indicated on Drawings. Telecommunications system shall include provisions for paging over PA system. The vendor shall provide interface and cabling between the telephone system and the PA system.
2. Furnishing and installing connections to telecommunications main grounding busbar (coordinate provisioning of dedicated power outlet) and power supplies, including backup power.
3. Interfacing and connecting to telecommunications system with public utilities telephone lines at the Entrance Facility (EF).
4. Furnishing and installing wiring, connectors, and power supplies as specified and as required to comply with requirements.
5. Provide coordination, test and acceptance, materials, and components required to provide a completely operable installation.

E. Acronyms:

1.	DSS	Direct Station Selection
2.	DTMF	Dual Tone, Multiple Frequency
3.	DID	Direct Inward Dialing
4.	IC	Intercommunications
5.	IOR	Inspector of Record
6.	IP	Internet Protocol
7.	ISDN	Integrated Services Digital Network
8.	N12	National ISDN 2 Standard
9.	OAR	Owner Authorized Representative
10.	PA	Public Address
11.	PRI	ISDN Primary Rate Interface
12.	VoIP	Voice over Internet Protocol
13.	Q.931	ISDN Signaling and Routing Protocol

1.7 SYSTEM REQUIREMENTS

A. General Telecommunications System:

1. The telecommunications systems shall use digital, microprocessor-controlled switching equipment and shall include station and system features found on a typical high-end voice communications system, including station equipment of analog, digital voice, and Voice over IP capable equipment.
2. The Vendor shall install baseline operating system, programming, and coordinate the requirements for customized templates with the owner. The templates shall be approved by the Owner prior to programming. No deviations from owner approved templates are permitted.
3. System shall provide the following feature sets:
    a. Time of Day Feature
    b. Automatic Route Selection for Trunk Groups
    c. Hold
    d. Transfer
    e. Transfer Upon Hang up
    f. Conference Calling - three way and minimum 6 port user activated
    g. Call Forwarding variations including Fixed, Variable, Busy Line, Don’t Answer, and Busy Line/Don’t Answer
    h. Call Park
    i. Call Coverage
    j. Direct Inward Dialing
    k. 911 calling number identification
    l. Send All Calls
    m. Least Cost Routing for Trunk Groups
    n. Media Gateway supporting Trunk side IP call routing
    o. Night Service
        1) Night station
        2) Trunk group night
        3) Trunk answer from any station
        4) Night console
        5) Hunt group night
    p. Bridged Call Appearance (Single line telephone)
    q. Bridged Call Appearance (Multi-Appearance Telephone)
    r. Privacy (manual exclusion)
    s. Privacy (automatic exclusion)
    t. Call Pickup
    u. Group Call Pickup
    v. Abbreviated Dialing
    w. Last Number Dialed
    x. Numbering Plans for 4 or 5 Digit dialing

y. Telephone Display (multiple languages)

z. Directory

aa. Loudspeaker paging access

bb. Personalized ringing

cc. Ring Options

dd. Crisis alert

ee. Extension Status (attendant)

B. Equipment specifications for the Project site shall be as specified herein.

C. Dialing Requirements: Station instruments furnished in conjunction with this system shall be DTMF.

D. Catalog and model numbers listed are intended to establish type and quality of equipment and system design as well as required operating features. Any deviation from intended functions of system specified will require Designer review.

1.8 SUBMITTALS

A. Comply with requirements specified in Division 01 and the following:

1. The vendor shall submit certification letter from the manufacturer of submitted equipment certifying that the installer is an authorized and certified installer of the submitted equipment.

2. The vendor shall make all connections at all field devices and at the head-end; and shall make all necessary field adjustments for a fully functional system.

B. Shop Drawings

1. Prior to assembling or installing the system, the Contractor shall provide complete shop drawings which include the following:

a. List the name of the manufacturer’s local representative and his/her phone number.

b. Table of contents.

c. Manufacturer’s parts lists

d. Product serial numbers

e. Catalog cut sheets

f. Installation instructions

g. Typical wiring diagrams

h. Drawings showing equipment locations

i. Manufacturer’s warranty documents

2. All drawings shall be fully dimensioned.

3. Operating License: Submit evidence of application for FCC Radio Station Authorization prior to installing equipment when required for operation of the equipment.

C. As-Built Drawings

1. At the conclusion of the project, the Vendor shall provide “as built” drawings. The “as built” drawings shall be a continuation of the Contractors shop drawings as modified, augmented, and reviewed during the installation, check out and acceptance phases of the project. All drawings shall be fully dimensioned and prepared in DWG format using the latest version of AutoCAD.
2. The as-built drawings shall incorporate all updated system riser diagrams prepared in DWG format using the latest version of AutoCAD.

D. Manuals

1. At the conclusion of the project, the Vendor shall provide copies of the manuals as described herein. Each manual’s contents shall be identified on the cover. The manual shall include names, addresses, and telephone numbers of each system integrator installing equipment and systems and the nearest service representatives for each item of equipment for each system. The manuals shall have a table of contents and labeled sections. The manuals shall include all modifications made during installation, checkout, and acceptance. The manuals shall contain the following:
    a. Hardware Manual
        1) The hardware manual shall describe all equipment furnished including:
        2) General description and specifications
        3) Installation and check out procedures
        4) Equipment layout and electrical schematics to the component level
        5) System layout drawings and schematics
        6) Alignment and calibration procedures
        7) Manufacturers repair parts list indicating sources of supply
    b. Software Manual
        1) The software manual shall describe the functions of all software and shall include all other information necessary to enable proper loading, testing, and operation. The manual shall include:
        2) Definition of terms and functions
            a) Use of system and applications software
            b) Initialization, start up, and shut down
            c) Alarm reports
            d) Reports generation
            e) Data base format and data entry requirements
            f) Directory of all disk files
2. Operators Manual
    a. The operator’s manual shall fully explain all procedures and instructions for the operation of the system including:
        1) Computers and peripherals
        2) System start up and shut down procedures
        3) Use of system, command, and applications software

4) Recovery and restart procedures

5) Use of report generator and generation of reports

6) Data entry

7) Operator commands

8) Alarm messages and reprinting formats

9) System access requirements

3. Maintenance Manual

a. The maintenance manual shall include descriptions of maintenance for all equipment including inspection, periodic preventive maintenance, fault diagnosis, and repair or replacement of defective components.

1.9 CODES AND STANDARDS

A. Complete installation shall meet or exceed the latest edition of following standards:

1. TIA-568: Commercial building telecommunications wiring standard

2. TIA-569: Commercial building standard for telecommunications pathways and spaces

3. TIA-606: Administration standard for telecommunications infrastructure of commercial buildings

4. TIA-607: Commercial building grounding and bonding requirements for telecommunications

5. Massachusetts Building Code

6. Massachusetts Electrical Code

7. ANSI, ASTM, UL, NEMA, IEEE and FCC standards as applicable

8. BICSI Telecommunications Distribution Methods Manual, current edition

1.10 QUALITY ASSURANCE

A. Only a qualified Vendor holding licenses required by legally constituted authorities having jurisdiction over the work, shall do the work.

B. Installed telecommunications system shall be acceptable to local operating access provider, and shall be registered by the FCC for direct connection to public telephone network.

C. Prior to the start of work, verify public utility serving location or access splice location. Determine work required, equipment, and material to be furnished for a complete installation.

D. Vendors providing equipment installation services shall use adequate numbers of skilled workmen who are certified by the component manufacturer, thoroughly trained and experienced with the necessary technology and systems, and completely familiar with the specified requirements and methods needed for proper performance of work. The system head-end installation, start-up and commissioning shall be by the manufacturer certified vendor.

E. Each vendor is required to provide a certificate from the manufacturer indicating that they hold a current certification for the specified system.

F. Use adequate numbers of skilled workers thoroughly trained and experienced on the necessary crafts and completely familiar with the specified requirements and methods needed for the proper performance of the work of this Section.

G. The Vendor must provide a project manager who has demonstrated the ability to supervise a project of this magnitude. The Project Manager must be available to attend meetings as required.

H. Vendor shall assure their ability to service the warranty on all Work executed and materials furnished to be free from defects of material and workmanship.

I. Material or Work damaged during the planning, installation, testing, and clean-up of this project must be replaced or repaired by the Vendor, at no expense to the Owner, to comply with the specifications before final acceptance of work. Examination of or failure to examine Work by the Owner shall not relieve the Vendor from these obligations.

J. The Vendor shall coordinate cable runs, and rack equipment locations with the Owner during the initial design of the cable installation. The Vendor and Owner must agree as to the final location of all devices and the cable plant design.

K. The Vendor shall provide manpower and tools required to participate in Owner's Quality Assurance Testing.

L. Permits and Inspections: The Vendor shall obtain and pay for required permits and inspections; deliver certificates of inspection to the Owner.

M. Use adequate numbers of skilled workers thoroughly trained and experienced on the necessary crafts and completely familiar with the specified requirements and methods needed for the proper performance of the work of this Section. The Vendor is required to provide references of three similar installations completed in the last 12 months.

1.11 WARRANTY

A. Comply with Section 260001.

B. The Electrical Trade Contractor shall warranty that all materials furnished shall be free from defects of material for a period of one year from the date of Substantial Completion.

C. Manufacturer's Warranty

1. Provide a 5-year manufacturer's parts warranty for all system components including but not limited to system CPU, power supply, cards, modules, batteries, telephones, and any ancillary products necessary for the completely operational telecommunications system as specified. The 5-year manufacturers parts warranty entitles the owner to replacement parts as needed free of charge from the date of system acceptance for a period of 5 years.

2. Provide a 5-year software assurance warranty entitling the owner to all manufacturer software upgrades free of charge from the date of system acceptance for a period of 5 years.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. ShoreTel/Mitel.

2.2 TELECOMMUNICATIONS EQUIPMENT

A. Telecommunications system shall be furnished with a minimum of one cabinet/rack including capacity to be determined site specific, using fully digital control circuits, line cards, and trunk cards. Voice over IP functionality is required. Equipment shall be registered and approved for direct access to line connection of public telephone lines or trunks. Furnish, install and program following components as directed by the Owner:

PART NO.	DESCRIPTION	QTY
10582	Mitel Voice Switch ST100DA - PRI and 100 IP resources	1
10581	Mitel Voice Switch ST100A - analog resources and 100 IP resources	3
ST-SRV-SM-A	Shoreware Director Standard (server) - local voicemail	1
21020	Distributed Voice Services License	1
10495	Mitel IP Phone IP420	200
60153	ShoreTel IP Phone 420 Wall Mount Kit	200
10496	Mitel IP Phone IP480	60
2200-15600-001	Polycom SoundStation IP 6000 (SIP) conference phone - PoE, Expandable	10
30040	Mailbox-only License	1
30145	Connect ONSITE Courtesy license -ext only	16
30146	Connect ONSITE Telephony license - ext and mailbox	280
30147	Connect ONSITE Essentials license bundle -ext, mailbox, client and mobility	20
30044	Additional Site License	2
10223	Kit, rack mounting tray, for ShoreGear Switch	4
Install Kit	Installation Kit	1
EMI117-10	Eaton Metered Outlet Rack PDU, 0U	1
5PX3000RTN	Eaton 5PX UPS	1

2.3 UTILITY COMPANY SERVICE

A. Coordinate the service requirements with the Owner. Schedule the installation of the trunk/PRI/fiber/T1 lines to the building with the utility company. Coordinate the time frame of the installation with the utility company and the Owner.

B. The Owner shall be responsible for any utility company back charges for installation of the telephone service to the building.

PART 3 - EXECUTION

3.1 EXAMINATION

A. The Vendor shall coordinate with the construction schedule to ensure that acceptable conditions exist for installation of all equipment and components.

B. Proceed with installation only after unsatisfactory conditions have been corrected. Provide detailed site survey to ensure acceptable conditions exist.

C. Examine all rooms and areas where equipment and components will be installed. Check all elements for compliance with space allocations, installation tolerances, hazards to equipment installation, and other conditions affecting installation.

D. Examine walls, floors, roofs, and roof supports for suitable conditions where equipment is to be installed.

E. Examine all support systems such as air-conditioning, electrical panels, receptacles, UPS, lighting, etc. are installed and functioning correctly.

F. Examine all equipment racks and cabinets installations to ensure acceptable conditions exist for installation of all equipment and components.

G. Ensure that all rooms and any areas where equipment and components are installed are physically secured at all times from theft, vandalism, etc.

H. Report unacceptable installation or unsafe conditions to the Construction Manager.

I. Under no condition shall the vendor install any equipment or component that will void Manufacturer warranty or such conditions that will reduce equipment performance, longevity, and life.

3.2 INSTALLATION

A. General

1. The Vendor shall be knowledgeable of work to be performed by other trades and take necessary steps to integrate and coordinate their work with other trades.

2. The Vendor shall be responsible for furnishing all equipment, components, and cabling as specified herein and as indicated on the drawings.

3. All equipment, components and cabling shall be new.

4. All equipment, components, and cabling shall be installed in a manner neatly and consistent with this type of work.

5. All equipment, components, and cabling shall be installed for optimal performance.

6. All equipment, components, and cabling shall be installed to allow for easy adds, moves, and other changes in the future.

7. Final labeling scheme shall be coordinated with the Owner during the shop drawings process, prior to initiating work. Labeling scheme shall include all equipment, components, and cabling with all appropriate references such as communications rooms, cabinets, racks, cable terminal blocks, patch panels, antennas, outlets, cables, etc.

8. Construction within telecommunications rooms must be substantially complete before the installation of equipment, components, and cabling. This includes, but is

not limited to, the installation of plywood backboard, cable tray or ladder rack, electrical outlets, light fixtures, sprinklers and ductwork. All walls shall also be painted by others before the installation. The telecommunications rooms must be free from dust, dirt, and other foreign materials before the installation of any equipment and components. The door to the communication rooms must be installed and closed during termination.

9. All equipment, components, and cable noted in this Specification and associated drawings shall be provided and completely setup and installed.
10. The Vendor is required to coordinate their efforts with the other trades and Contractors who may be working within the same vicinity to avoid conflict and lost time.
11. The Vendor shall supply all necessary tools, equipment, accessories, safety equipment, protective clothing, etc., as customary for the craft and necessary for the installation.
12. All mis-installed components will be removed and replaced with new at the Vendors expense. No additional cost will be submitted to Owner.
13. All equipment shall be installed in a neat and workmanlike manner, arranged for convenient operation, testing and future maintenance.

B. Implementation

1. The Owner requires the successful vendor to provide a full suite of installation services.
2. The project shall be executed under the direction of the Owner's IT department.
3. Review, and coordinate system parameters such as DHCP, TFTP, DNS, IP addressing scheme and other parameters with the Owne, and other building systems being interfaced. The vendor shall recommend changes in writing to insure QoS and a robust IP network.
4. Prepare implementation, phasing, cutover and testing plans.
5. Record serial numbers and provide to Owner.
6. Record telephone MAC addresses in an Excel spreadsheet to provide to Owner.
7. Setup, program, and test all equipment and components offsite at Contractor's labs.
8. Load and configure implementation-specific call servers, voice mail servers, gateways, 3rd party applications, etc.
9. Coordinate and develop a dialing plan.
10. Coordinate and develop security levels and access privileges.
11. Coordinate and develop routing plan.
12. Coordinate, develop and configure security settings and backup processes.
13. Coordinate, develop and configure call park ranges, pickup groups, and shared line appearances, messaging configuration, paging and music on hold.
14. Configure attendant console.
15. Configure and program voicemail message stores.
16. Configure time synchronization.
17. Configure IP address for management interface.

18. Configure SNMP community names.
19. Establish, determine, and configure VLAN(s).
20. Configure 802.1Q VLAN Trunks.
21. Install all system management software on Owner provided computers, if not provided as part of this scope of work.
22. Coordinate computer and VoIP network requirements with Owner's IT Group. This should include MAC and IP addressing, VLAN assignment, bandwidth requirements, class of service (CoS), quality of service (QoS), VPN requirements, etc.
23. The system management and monitoring software shall be fully setup, programmed, and configured.

C. Cable and Patch Cord Installation relating to Voice Communications Equipment

1. All cable and patch cords shall be provided and installed per Specifications Sections 271300 and 271500. The vendor will be responsible for patching ALL fiber and copper data cables into VoIP electronics.
2. All cables and patch cords routed within communications rooms shall be bundled and combed with Velcro to provide a neat and organized appearance. This includes horizontal and vertical cables routed on cable tray, d-rings, vertical cable managers, equipment rack cable managers, etc. Cables shall be bundled using only manufacturer and industry approved Velcro ties with tensions that do not deform and damage cable resulting in loss of transmission or performance. Any bundles and combing methods used shall not exceed manufacturer or industry standards recommendations for that cable type.
3. Within communications rooms, cables and patch cords shall be snugly wrapped using Velcro reusable cable ties, a minimum of every 3'-0" for cable organization. Velcro ties shall be tightened so as not to deform cable jackets and thus affect cable performance. Plastic cable tie wraps shall not be used and will prevent system acceptance.
4. Cable bends shall not be less than that recommended by the manufacturer of the cable. Do not exceed manufacturer's minimum bending radii and other cable requirements. Provided below are some examples but all requirements shall be verified.
5. Care shall be taken so as not to damage cable and patch cords during the installation process and that the manufacturer's and industry standard's pull tension specification is not exceeded.
6. Do not install bruised, kinked, scored, deformed, or abraded cable or patch cords. Remove and discard cable if damaged during installation and replace it with new cable.
7. All cables and patch cords shall be installed in vertical and horizontal cable management within cabinets and racks.
8. Cable and patch cords routed outside of racks and cabinets shall be in cable tray and ladder rack. Fiber optic patch cords shall be routed in fiber trough.
9. Provide independent circuit grounding recommended by manufacturer.
10. Under no circumstances shall the cable or patch cords be painted, treated, or covered with other material unless approved by manufacturer, Owner and Engineer.

D. Telephone Handset Placement

1. The Vendor shall evaluate each space prior to handset installation. Areas shall be free from dust and debris; room shall be complete and sealed against further dust and debris. Contractor shall notify Construction manager of any rooms that don't meet this requirement.
2. Install handsets in each location, verifying/providing specified 12' line cords between wall outlet and handset device. Provide extra patch cable for computer workstation, if applicable.
3. Configure handsets, confirming each handset is setup and configured as per coordination with Owner.

E. Security Hardening of the VoIP Communication System

1. The Vendor shall review and perform a security audit and assessment in accordance with the Owner's requirements for ensuring that proper internal and external security controls are enabled.
2. Contractor shall review with the Owner any unique requirements for Class of Services (CoS) configuration based on user type, tenant type, or management type.
3. VoIP security hardening and security controls shall be recommended by the Contractor in accordance with the Owner's existing requirements, policies, and procedures. Security hardening shall include but not be limited to:
    a. Network Infrastructure
        1) Encrypt voice streams and call signaling, ideally, end-to-end.
        2) Networks should be evaluated for VoIP readiness, pre-assessment, QoS/Network Perf.
        3) VLANs should be used to segment voice and data traffic.
        4) Secure mechanisms should be used for passing VoIP traffic and collaborative communications packets through firewalls.
    b. Management
        1) Stringent password controls.
        2) Remote management via IP-VPNs only.
        3) Enable audit logging on call servers and core VoIP systems.
        4) Utilize secured connections for web access, SSL/HTTPS.
    c. Management
        1) Stringent password controls.
        2) Remote management via IP-VPNs only.
        3) Enable audit logging on call servers and core VoIP systems.
        4) Utilize secured connections for web access, SSL/HTTPS.
    d. Endpoints/IP Phone Sets
        1) Software loads should be encrypted and tamper-proof.
        2) IP Phone sets should run the minimum of services required.
        3) Connection of an IP Phone set to the system must require an initial authentication.
    e. Servers (Call Servers, Signaling Servers, etc.)

1) Servers should be managed with stringent OS and software patch management and anti-virus systems.

2) All telephony equipment and servers should be located in a location with maximum physical security (e.g. Data Center) and deep within the core network with VLANs and firewalls.

f. Wireless

1) Use WiFi Protected Access and/or WPA2 versus WEP.

2) Enable WPA/WPA2 IEEE 802.1X authentication.

3.3 PROJECT RECORD DOCUMENTATION

A. Prepare and submit as-builds and logical network diagrams updated to reflect the new work completed for the project (i.e. site plans, cable, pathways, TER/TR cabinet elevations, equipment configuration spreadsheets, etc.). Submit hard copies and electronic files.

B. Documentation Requirements

1. Initial set-up and configuration.

2. Configuration management for adds and changes. (Including emergency board replacement.)

3. Problem solving and resolution procedures.

4. A custom operations manual in support of the day-to-day operations unique to Network.

5. The vendor shall provide all products standard documentation in printed and electronic format. Two copies of the printed documentation are required for all equipment and software products proposed in this section.

3.4 MAINTANANCE

A. The vendor shall provide one-year maintenance on all equipment and software provided during the course of this contract. In addition, the vendor shall provide a limited lifetime hardware and software warranty on all products supplied. The vendor will warrant the system to perform in the intended use as indicated in this section.

B. The system is expected to operate 24 hours/day, 7 days/week. At a minimum, the Owner expects an uptime of 99 percent for any single switch component during the hours of 7:00 a.m. to 7:00 p.m. (and 98 percent uptime when calculated over a 24-hour day).

C. The vendor shall commit that major component failures will be replaced within a four-hour period. A major component shall be considered any hub or switch component that affects 10 or more user devices or affects the ability of the user to make emergency calls.

D. Once work has begun on repair of a critical problem, a technician shall remain on-site until the problem has been repaired. The vendor shall be allowed to change technicians at shift changes, however, the first technician shall not leave the site until the second has arrived and has been briefed on the problem.

E. The vendor shall provide a toll-free hotline and support center to assist the Owner in the installation, tuning, maintenance and updating of the systems hardware and software for the term of this contract.

F. The vendor shall maintain an inventory of critical spare parts that shall be available locally, in a location approved by the Owner, so as to ensure the repair response times required in this section.

G. If parts are required to fix a critical problem that are not available locally, they shall be shipped by the fastest possible means at no cost to the Owner.

H. The vendor shall keep on-site detailed maintenance records of all maintenance calls made to the facility.

I. The maintenance contract shall include the following:

1. Phone/Port Support Plan: (per month based off 60 phones and 4 copper lines)
2. 24x7 Monitoring, Remote and On-Site Support
3. Support:
    a. Unlimited Phone Support
    b. Unlimited Remote Support
    c. Unlimited On-Site Support
    d. Equipment Availability Monitoring and Maintenance
    e. Patch Management
    f. Online Asset Management
    g. Online Trouble Ticket Management
4. Remote support is primary remediation method. On-site support performed if required (3 per year).

3.5 COORDINATION AND INTEGRATION WITH OTHER SYSTEMS

A. The Vendor shall work with the Data Network Vendor in enabling security hardening for the VoIP communication system throughout the communication infrastructure.

B. The vendor shall work with the Public Address (PA) system Vendor and shall provide phone lines for interface with the PA system and shall configure the equipment in enabling paging over the PA system through the handsets.

3.6 COMMISSIONING

A. Comply with requirements specified in Division 1.

B. Engage a factory-authorized service representative to supervise and assist with startup service. Complete installation and startup checks according to the approved manufacturer's written instructions.

3.7 TRAINING AND SERVICE

A. Comply with Section 26 00 01.

B. Conduct two 4-hour system. Train the Owner’s maintenance personnel on procedures and schedules related to start up and shutdown, troubleshooting, servicing, and preventive maintenance.

C. Conduct four 4-hour training sessions. Train teachers and administration personnel on system operation.

End of Section

Section 27 41 00

AUDIO-VIDEO COMMUNICATIONS

(TRADE CONTRACT REQUIRED AS PART OF SECTION 26 00 01)

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. PUBLICLY BID TRADE CONTRACT REQUIREMENTS: As provided under Section 26 00 01 - ELECTRICAL and supplemented under the Bidding Requirements, Contract Forms, and Conditions of the Contract, and applicable parts of Division 1 - GENERAL REQUIREMENTS.

1. Work of this Trade Contract includes all individual specification sections listed in Section 26 00 01.

1.2 RELATED DOCUMENTS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications

1.3 SCOPE

A. It is the intent of these specifications that the Contractor, Manufacturer and/or it's Authorized System Integrator expeditiously furnishes and installs a system complete in every respect and ready to operate. All miscellaneous items and accessories required for such installation, whether or not each such item or accessory as shown on the plans or mentioned in these specifications, shall be furnished and installed.

B. The audio-video systems shall be installed as shown on the drawings and as specified herein. The work covered by this section of the specifications includes the furnishing of all labor, equipment, materials and performance of all operations associated with the audio-video systems for a fully functional system.

1.4 CODES AND STANDARDS

A. Complete installation shall meet or exceed the latest edition of following standards:

1. TIA-568: Commercial building telecommunications wiring standard and all current addenda.
2. TIA-569: Commercial building standard for telecommunications pathways and spaces.
3. TIA-606: Administration standard for telecommunications infrastructure of commercial buildings.
4. TIA-607: Commercial building grounding and bonding requirements for telecommunications.
5. ANSI, ASTM, UL, NEMA, IEEE and FCC standards as applicable.
6. BICSI Telecommunications Distribution Methods Manual, current edition.

1.5 PROGRAMMING

A. Coordinate and obtain a written approval of system functionality from the Owner prior to programming.

B. Perform a walk-through with the Owner and demonstrate the system functionality.

C. Make any adjustments to system functionality after initial programming if necessary to achieve the desired functionality requested by the Owner. Coordinate all required reprogramming with the Owner as required as part of this contract.

D. Obtain a written final letter of acceptance from the Owner upon completion of system functionality programming and demonstration.

1.6 SUMMARY

A. The Contractor shall furnish and install all equipment including, but not limited to, projectors, projection screens, wiring, connection plates, controllers, signal amplifiers and mounting hardware as shown on the plans, and all other equipment necessary to provide a complete and operating system.

B. Equipment supplied by Contractor shall be considered as meeting these specifications and as the base bid. Any prior approval of an alternate system does not exempt the supplier from meeting the intent of these specifications. If the alternate system fails to provide all the requirements specified in this document, the Contractor shall be responsible for all costs associated with the removal and replacement of said equipment.

1.7 SUBMITTALS

A. Comply with requirements specified in Division 01 and the following:

1. The vendor shall submit certification letter from the manufacturer of submitted equipment certifying that the installer is an authorized and certified installer of the submitted equipment.

2. The vendor shall make all connections at all field devices and at the head-end; and shall make all necessary field adjustments for a fully functional system.

B. Shop Drawings

1. Prior to assembling or installing the system, the Contractor shall provide complete shop drawings which include the following:

a. List the name of the manufacturer’s local representative and his/her phone number.

b. Table of contents.

c. Manufacturer’s parts lists

d. Product serial numbers

e. Catalog cut sheets

f. Installation instructions

g. Typical wiring diagrams

h. Drawings showing equipment locations

i. Manufacturer’s warranty documents

2. All drawings shall be fully dimensioned.

3. Operating License: Submit evidence of application for FCC Radio Station Authorization prior to installing equipment when required for operation of the equipment.

C. As-Built Drawings

1. At the conclusion of the project, the Vendor shall provide “as built” drawings. The “as built” drawings shall be a continuation of the Contractors shop drawings as modified, augmented, and reviewed during the installation, check out and acceptance phases of the project. All drawings shall be fully dimensioned and prepared in DWG format using the latest version of AutoCAD.

2. The as-built drawings shall incorporate all updated system riser diagrams prepared in DWG format using the latest version of AutoCAD.

D. Manuals

1. At the conclusion of the project, the Vendor shall provide copies of the manuals as described herein. Each manual’s contents shall be identified on the cover. The manual shall include names, addresses, and telephone numbers of each system integrator installing equipment and systems and the nearest service representatives for each item of equipment for each system. The manuals shall have a table of contents and labeled sections. The manuals shall include all modifications made during installation, checkout, and acceptance. The manuals shall contain the following:

   a. Hardware Manual

      1) The hardware manual shall describe all equipment furnished including:

      2) General description and specifications

      3) Installation and check out procedures

      4) Equipment layout and electrical schematics to the component level

      5) System layout drawings and schematics

      6) Alignment and calibration procedures

      7) Manufacturers repair parts list indicating sources of supply

   b. Software Manual

      1) The software manual shall describe the functions of all software and shall include all other information necessary to enable proper loading, testing, and operation. The manual shall include:

      2) Definition of terms and functions

         a) Use of system and applications software

         b) Initialization, start up, and shut down

         c) Alarm reports

         d) Reports generation

         e) Data base format and data entry requirements

         f) Directory of all disk files

2. Operators Manual

a. The operator's manual shall fully explain all procedures and instructions for the operation of the system including:

1) Computers and peripherals
2) System start up and shut down procedures
3) Use of system, command, and applications software
4) Recovery and restart procedures
5) Use of report generator and generation of reports
6) Data entry
7) Operator commands
8) Alarm messages and reprinting formats
9) System access requirements

3. Maintenance Manual

a. The maintenance manual shall include descriptions of maintenance for all equipment including inspection, periodic preventive maintenance, fault diagnosis, and repair or replacement of defective components.

1.8 QUALITY ASSURANCE

A. The Contractor shall currently maintain a locally run business for a minimum of five years and shall be an authorized distributor of the supplied equipment with full warranty privileges.

B. The Contractor shall maintain at his facility the necessary spare parts in the proper proportion as recommended by the equipment manufacturer to maintain and service the equipment being supplied. This facility shall be available for inspection by the engineer.

C. The supplying Contractor shall have attended the manufacturer's installation and service school.

D. The Contractor shall furnish manufacturer's manuals of the completed system including individual specification sheets, schematics, inter-panel and intra-panel wiring diagrams. In addition, all information necessary for the proper operation of the system must be included. Any bidder using other than the specified equipment must provide this information prior to bidding.

E. As built drawings that include any changes to wiring, wiring designations, junction box labeling and any other pertinent information shall be supplied upon completion of project.

F. Vendors providing equipment installation services shall use adequate numbers of skilled workmen who are certified by the component manufacturer, thoroughly trained and experienced with the necessary technology and systems, and completely familiar with the specified requirements and methods needed for proper performance of work. The system head-end installation, start-up and commissioning shall be by the manufacturer certified vendor.

G. Each vendor is required to provide a certificate from the manufacturer indicating that they hold a current certification for the specified system.

H. Use adequate numbers of skilled workers thoroughly trained and experienced on the necessary crafts and completely familiar with the specified requirements and methods

needed for the proper performance of the work of this Section. Contractor is required to provide references of three similar installations completed in the last 12 months.

I. Contractor must provide a project manager who has demonstrated the ability to supervise a project of this magnitude. The Project Manager must be available to attend meetings as required. Acceptance will not be unreasonably withheld.

1.9 WARRANTY

A. Comply with Section 260001.

B. The Electrical Trade Contractor shall warranty that all materials furnished shall be free from defects of material for a period of one year from the date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MEDIA CENTER SOUND SYSTEM

A. Basis of design recommendations:

1. Shure UA820 antennas (Qty. 2)
2. Shure UA505 antenna brackets (Qty. 2)
3. Shure UA844 antenna combiner (Qty. 1)
4. Shure ULXS24/58 handheld wireless (Qty. 1)
5. Shure ULXS14/85 lavalier wireless (Qty. 1)
6. RDL CP-2 dual decora plate (Qty. 1)
7. RDL D-CIJ3D line level input plate (Qty. 1)
8. RDL D-J1 mic input plate (Qty. 1)
9. Symmetrix ARC2E Control Wall Plate
10. Denon DN-500C CD/iPod Dock (Qty. 1)
11. RDL ST-MX2 Stereo Mixer (Qty. 1)
12. Lowell TLM600 transformer (Qty. 1)
13. Symmetrix Symnet Radius 12x8 DSP (Qty. 1)
14. Crown CTS 2000 Amplifier (Qty. 1)
15. JBL Control 26CT 7.5W/70V Speakers (Qty. 16)
16. Telex SM-2 ALS kit (Qty. 1)
17. Telex RM-S rack kit (Qty. 1)
18. Listen Tech. LA-122 antenna (Qty. 1)
19. Telex BC-102 charger (Qty. 4)
20. MISC. ALS receiver re-chargeable battery (Qty. 8)
21. Linier – FWM18U (Qty. 1)
22. Middle Atlantic vented front door VFD-18 (Qty. 1)
23. Middle Atlantic DWR-RR-18 rack rails (Qty. 1)

24. Middle Atlantic DWR-FK26 fan control (Qty. 1)
25. Middle Atlantic D4 drawer (Qty. 1)
26. Middle Atlantic PDS-620R power sequencer (Qty. 1)
27. Middle Atlantic blank and vent panels (LOT)
28. Shure SM-58 microphone (Qty. 2)
29. Proco M-25 25' mic cord (Qty. 2)
30. On Stage DS-7200QRB mci stand (Qty. 2)

B. Furnish and install necessary cables, connectors, or devices necessary for a complete working system.

C. Conduit, back-boxes and electrical power by the Electrical Trade Contractor.

D. Fire Alarm System Interface: All systems shall include a relay to interface to the fire alarm system for sound reinforcement system mute during the activation of the fire alarm system. Provide an Altronix RBST relay and power supply or equal.

E. Public Address System Interface: All systems shall include a relay to interface to the fire alarm system for sound reinforcement system mute during the activation of the fire alarm system. Provide an Altronix RBST relay and power supply or equal.

F. Projection System Interface: Integrate with the projection system to play the audio over the sound system. Provide an additional input to the sound system.

G. Accessories: Provide any distribution amplifiers, transformers, mute-switching, special connectors, cable, modules etc. as required for a complete working system.

H. Impedance and Level Matching: Carefully match input and output impedances and signal levels at signal interfaces. Provide matching networks where required.

I. Part numbers and quantities are for references only. The Contractor shall be responsible for providing all material, equipment and labor for a fully functional system.

2.2 WEIGHT ROOM SOUND SYSTEM

A. Basis of design recommendations:

1. Basis of design recommendations:
2. Shure UA820 antennas (Qty. 2)
3. Shure UA505 antenna brackets (Qty. 2)
4. Shure UA844 antenna combiner (Qty. 1)
5. Shure ULXS24/58 handheld wireless (Qty. 1)
6. Shure ULXS14/85 lavalier wireless (Qty. 1)
7. Symmetrix ARC2E Control Wall Plate
8. Denon DN-500C CD/iPod Dock (Qty. 1)
9. RDL ST-MX2 Stereo Mixer (Qty. 1)
10. Lowell TLM600 transformer (Qty. 1)
11. Symmetrix Symnet Radius 12x8 DSP (Qty. 1)

12. Crown CTS 2000 Amplifier (Qty. 1)
13. JBL Control 25T-W Speakers (Qty. 6)
14. Telex SM-2 ALS kit (Qty. 1)
15. Telex RM-S rack kit (Qty. 1)
16. Listen Tech. LA-122 antenna (Qty. 1)
17. Telex BC-102 charger (Qty. 4)
18. MISC. ALS receiver re-chargeable battery (Qty. 8)
19. Linier – FWM18U (Qty. 1)
20. Middle Atlantic vented front door VFD-18 (Qty. 1)
21. Middle Atlantic DWR-RR-18 rack rails (Qty. 1)
22. Middle Atlantic DWR-FK26 fan control (Qty. 1)
23. Middle Atlantic D4 drawer (Qty. 1)
24. Middle Atlantic PDS-620R power sequencer (Qty. 1)
25. Middle Atlantic blank and vent panels (LOT)

B. Furnish and install necessary cables, connectors, or devices necessary for a complete working system.

C. Conduit, back-boxes and electrical power by the electrical contractor.

D. Fire Alarm System Interface: All systems shall include a relay to interface to the fire alarm system for sound reinforcement system mute during the activation of the fire alarm system. Provide an Altronix RBST relay and power supply or equal.

E. Public Address System Interface: All systems shall include a relay to interface to the fire alarm system for sound reinforcement system mute during the activation of the fire alarm system. Provide an Altronix RBST relay and power supply or equal.

F. Projection System Interface: Integrate with the projection system to play the audio over the sound system. Provide an additional input to the sound system.

G. Accessories: Provide any distribution amplifiers, transformers, mute-switching, special connectors, cable, modules etc. as required for a complete working system.

H. Impedance and Level Matching: Carefully match input and output impedances and signal levels at signal interfaces. Provide matching networks where required.

I. Part numbers and quantities are for references only. The contractor shall be responsible for providing all material, equipment and labor for a fully functional system.

2.3 WELLNESS CENTER SOUND SYSTEM

A. Basis of design recommendations:

1. Basis of design recommendations:
2. Shure UA820 antennas (Qty. 2)
3. Shure UA505 antenna brackets (Qty. 2)
4. Shure UA844 antenna combiner (Qty. 1)

5. Shure ULXS24/58 handheld wireless (Qty. 1)
6. Shure ULXS14/85 lavalier wireless (Qty. 1)
7. Symmetrix ARC2E Control Wall Plate
8. Denon DN-500C CD/iPod Dock (Qty. 1)
9. RDL ST-MX2 Stereo Mixer (Qty. 1)
10. Lowell TLM600 transformer (Qty. 1)
11. Symmetrix Symnet Radius 12x8 DSP (Qty. 1)
12. Crown CTS 2000 Amplifier (Qty. 1)
13. JBL Control 25T-W Speakers (Qty. 6)
14. Telex SM-2 ALS kit (Qty. 1)
15. Telex RM-S rack kit (Qty. 1)
16. Listen Tech. LA-122 antenna (Qty. 1)
17. Telex BC-102 charger (Qty. 4)
18. MISC. ALS receiver re-chargeable battery (Qty. 8)
19. Linier – FWM18U (Qty. 1)
20. Middle Atlantic vented front door VFD-18 (Qty. 1)
21. Middle Atlantic DWR-RR-18 rack rails (Qty. 1)
22. Middle Atlantic DWR-FK26 fan control (Qty. 1)
23. Middle Atlantic D4 drawer (Qty. 1)
24. Middle Atlantic PDS-620R power sequencer (Qty. 1)
25. Middle Atlantic blank and vent panels (LOT)

B. Furnish and install necessary cables, connectors, or devices necessary for a complete working system.

C. Conduit, back-boxes and electrical power by the electrical contractor.

D. Fire Alarm System Interface: All systems shall include a relay to interface to the fire alarm system for sound reinforcement system mute during the activation of the fire alarm system. Provide an Altronix RBST relay and power supply or equal.

E. Public Address System Interface: All systems shall include a relay to interface to the fire alarm system for sound reinforcement system mute during the activation of the fire alarm system. Provide an Altronix RBST relay and power supply or equal.

F. Projection System Interface: Integrate with the projection system to play the audio over the sound system. Provide an additional input to the sound system.

G. Accessories: Provide any distribution amplifiers, transformers, mute-switching, special connectors, cable, modules etc. as required for a complete working system.

H. Impedance and Level Matching: Carefully match input and output impedances and signal levels at signal interfaces. Provide matching networks where required.

I. Part numbers and quantities are for references only. The contractor shall be responsible for providing all material, equipment and labor for a fully functional system.

2.4 AUDIO CABLES AND CONNECTIONS

A. Manufacturers

1. Belden.
2. Canare.
3. Clark.
4. Or approved equal.

B. Audio cables shall be subdivided into three classes: Microphone level circuits, Line level circuits and Speaker level circuits.

C. Microphone level circuits shall be kept at least three inches from any other parallel signal circuits and at least six inches from any parallel AC power circuits.

D. All audio connectors must conform to IEC standards; the convention is pin 1 shield, pin 2 HOT and pin 3 low. If any equipment is supplied wired as pin three hot, it should be changed or adapted to conform to the IEC standard.

E. Ground each audio cable shield at one point and one point only. Terminate shields at the "floating" end with insulating collars or heat shrink. Bare shields or wires in the system will not be acceptable. Connect all electronics grounds to a common point on the equipment rack(s). Ground this point and the rack(s) to the building main service ground point using a ground cable sized for a DC resistance of less than 0.1 ohm.

F. Line level and microphone audio cable shall be 100 percent shielded, 22 gauge twisted pair plenum cable.

G. Speaker level cable shall be unshielded twisted pair, 12 AWG plenum cable.

H. Constant current (70.7 Volt) speaker cable shall be unshielded twisted pair, 18 AWG, plenum cable.

I. Employ multi-conductor cables appropriate to the system and/or equipment to be interfaced.

PART 3 - EXECUTION

3.1 METHODS

A. Install wiring in conduit and raceways except as indicated.

B. Conceal wiring installations where possible.

C. INSTALLATION

D. The ceiling cavity is being used as plenum return. Provide plenum rated cables, conduit, backboxes in all plenum rated ceilings, rated walls, penetrations though wall, floors and ceilings and where required by Local, State or Federal Codes.

E. System wiring shall be in accordance with good engineering practices as established by the EIA and NEC. Wiring hall meet all established state and local electrical codes. All

wiring shall test free from grounds and shorts. Complete system shall be installed in strict accordance with manufacturer's recommendations.

F. Cable Support: Securely fasten to the permanent building structure where not installed in raceway. Support at regular intervals appropriate to the cable and wire size. Cable and wiring shall not lay loose on ceiling tiles or grids. Install parallel to building lines and follow building structure. Use cable support equipment/hardware recommended by the manufacturer.

G. Cable Pulling: Do not exceed manufacturer's recommended pulling tensions. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between indicated termination, tap, or junction points. Remove and discard cable where damaged during installation and replace it with new cable.

H. Wiring within Enclosures: Bundle, lace, and trim the conductors to terminal points with no excess. Provide and use lacing bars and distribution spools.

I. Identify and tag all cables with permanent type markers to denote location served.

J. Surge Suppressers: Where AC power-operated devices are not protected against voltage transients by integral surge suppressers conforming to UL Standard 1449, install surge suppressers at the device power line terminals.

K. Install and wire equipment in accordance with accepted engineering and installation practices. Only the highest degree of workmanship will be accepted.

L. Arrange equipment to facilitate access for maintenance and working space.

3.2 TERMINATIONS

A. All video wiring shall use BNC connectors suitable for the cable specified. Crimp connectors shall be installed using manufacturers tooling and procedure.

3.3 COMMISSIONING

A. Comply with requirements specified in Division 1.

B. Engage a factory-authorized service representative to supervise and assist with startup service. Complete installation and startup check according to the approved manufacturer's written instructions.

3.4 TRAINING AND SERVICE

A. Comply with Section 26 00 01.

B. Conduct two 4-hour training sessions. Train the Owner’s maintenance personnel on procedures and schedules related to start up and shutdown, troubleshooting, servicing, and preventive maintenance.

C. Conduct four 4-hour training sessions. Train teachers and administration personnel on system operation.

End of Section

SECTION 27 41 16

INTEGRATED AUDIOVISUAL SYSTEMS

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. The Trade Contractor for this Section shall examine all Drawings and all Sections of the Specification for requirements therein that may affect the Work of this Section, not just those Drawings and Specifications particular to the Work of this Section. The Work of this Section is shown primarily on the following listed Drawings:

1. Architectural
2. Electrical
3. Audiovisual
4. Theatrical Lighting
5. Theatrical Rigging

B. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.

C. Examine all other Sections of the Specifications for requirements that affect work of this Section whether or not such work is specifically mentioned in this Section.

D. Coordinate work with that of all other trades affecting, or affected by work of this Section. Cooperate with such trades to assure the steady progress of all work under the Contract.

1.2 EXAMINATION OF SITE AND DOCUMENTS

A. Bidders are expected to examine and to be thoroughly familiar with all contract documents and with the conditions under which work will be carried out. The Awarding Authority (Owner) will not be responsible for errors, omissions and/or charges for extra work arising from General Contractor's or Trade Contractor's failure to familiarize themselves with the Contract Documents or existing conditions. By submitting a bid, the Bidder agrees and warrants that he has had the opportunity to examine the site and the Contract Documents, that he is familiar with the conditions and requirements of both and where they require, in any part of the work a given result to be produced, that the Contract Documents are adequate and that he will produce the required results.

1.3 RELATED DOCUMENTS

A. Refer to AV drawings and project architectural, structural and electrical drawings for information related to the work specified herein.

1.4 RELATED WORK SPECIFIED ELSEWHERE

A. Carefully examine all of the Contract Documents for requirements which affect the Work of this Section.

B. Other Specification Sections which directly relate to the Work of this Section include, but are not limited to, the following:

1. Section 01 00 00 - General Requirements
2. Section 26 50 00 – Stage and House Lighting and Controls
3. Section 26 00 00 - Electrical

4. DIVISION 27 - COMMUNICATIONS; including all Sections contained therein

1.5 DESCRIPTION OF WORK

A. Furnish and install sound, video and communication systems as shown on drawings and as specified herein, complete with all apparatus, equipment, power supplies, wiring, labor, and services necessary to ensure a complete working system. Verify completeness of equipment listed and correctness of type numbers. Furnish and install supplementary equipment needed to meet system requirements, without claim for added payment.

B. The work includes, but is not limited to, the following:
1. Submission of shop drawings prior to fabrication.
2. Verification of dimensions and conditions at the job site.
3. Installation in accordance with these specifications, manufacturer's recommendations, and all applicable code requirements.
4. Setup and adjustment of signal processing, system tests and adjustments, written report, demonstration for approval, participation in acceptance tests, and final adjustments as required.
5. Programming and documenting of all software controlled devices including initial setup of presets in all devices.
6. Coordination with the Electrical contractor
7. Coordination with the Lighting contractor.
8. Coordination with the Fire Alarm Systems Contractor
9. Coordination with Tel/Data Contractor and other Low Voltage Contractors
10. Coordination with Owner’s Audio-Visual Personnel
11. Coordination with the Owner’s IT department and installers
12. Performance standards, without claim for additional payment
13. System documentation.
14. Instruction of owner's operating personnel.
15. Maintenance services for one year.
16. Guarantee.

1.6 SUBMITTALS

A. Provide submittals in accordance with requirements of Section 01 33 00 – Submittal Procedures and as detailed herein.

B. Alternates
1. With system bid price, submit prices for equipment and installation of additional or reduced quantities of equipment as stated herein. Unless otherwise stated, all items herein are part of the base bid system. Input and output jacks, test points, terminal blocks and wiring for add or deduct alternate equipment should be included in the Alternate.

C. First Submittal
1. Timing: within 45 days of contract award
2. Conduit size verification
   a. Review and confirm that audiovisual system conduit as shown on the Drawings and where applicable, as built drawings, is sufficient and appropriately sized for system.
   b. Note where conduit system is not sufficient and indicate any additional conduit required for system.
3. Key project personnel
   a. Provide names, resumes, addresses, mobile and office phone numbers, and e-mail addresses of key project personnel.

4. Milestone dates
    a. Dates for each Submittal
    b. Shop fabrication complete
    c. Initial equipment ship to site
    d. Start of installation
    e. Second equipment ship to site
    f. Control system programming complete
    g. Field testing
    h. Correction of punch list items
    i. Training

D. Second Submittal
1. Timing: 90 days before equipment purchase or commencement of wiring.
2. Before ordering equipment or beginning work, submit list showing quantities and manufacturer and model number for items of equipment to be used in assembling this system, including all items of equipment specified herein. Attach copies of catalog sheets for all items of equipment submitted.
    a. Submit cut sheets in same order as this specification with table of contents, specification paragraph reference and page numbers.
3. Shop Drawings
    a. Submit all drawings in a single submittal, except if specified otherwise.
    b. Submit the following drawings for approval, prior to fabrication and installation:
    c. A block diagram indicating proposed interconnections of all equipment and indicating equipment types and model numbers.
    d. Drawings of loudspeaker mounting arrangements, equipment rack layouts, and receptacle and control plates and boxes.
    e. Plate and panel schedule listing all plates individually with size, mounting condition (surface or flush), back box size and plate finish color.
    f. Drawings of projector mounting arrangements and sight line studies showing proper alignment and dimensions with the projection screen and projection equipment.
    g. Drawings of custom plate and panel details, patch bay layouts and all other necessary wiring diagrams.
    h. Drawings showing cable pull assemblies and schedule complete with all wiring requirements for the project
    i. Drawings of all final assemblies of loudspeaker and projector suspension equipment stamped by a certified structural engineer.
    j. Drawings of anchoring system for loudspeaker suspension.
    k. Submit samples of all panels, custom loudspeaker grills, and loudspeaker cabinet finishes.
    l. List of radio frequencies used by system. Coordinate frequency usage with Owner’s designated representative prior to submitting shop drawings.
    m. List of Ethernet devices in system with device name, manufacturer, purpose, MAC address and IP address.

E. Touch Panel
1. Submit the following for approval prior to programming
2. First Submittal

a. Timing: 150 days before substantial completion
b. Line drawings of touch panel layouts button functions listed.
c. Detailed narrative and demonstration mockup/simulation of all touch panel programming based on design process specified herein.
d. Three fully designed sample screens for evaluation of graphical look.

3. Second Submittal
a. Timing: 120 days before substantial completion
b. After approval of first touch panel submittal, submit electronic color images of touch panel layouts.

F. Finishes
1. Obtain Consultant and Architect approval of all panel and furniture finishes prior to fabrication. The Architect will specify exact finishes.

G. Field Supervisor
1. Before beginning installation, submit the name of the employee who will be the on-site field supervisor through the completion of this project.

H. Copies
1. Submit a minimum five (5) copies of all required submittals.

I. Qualifications
1. Bidder shall be a system contractor, normally engaged in the full time business of audiovisual and sound reinforcement system installation. Provide evidence that the bidder has been in business for at least five years prior to bid date and has completed projects of similar size and scope.
2. References, including names and telephone numbers of individuals who may be contacted, showing satisfactory completion of three or more projects similar in scope and type to that specified herein.
3. Provide additional evidence of satisfactory completion of audio-visual system installations involving suspended loudspeakers and complex control system integration.
4. Evidence of ability and affirmation of intent to meet the guarantee and service requirements stated herein.
5. Qualifications of certified control system programmer who will be working on this project.
6. Each vendor shall include a description of the professional and technical experiences background, qualifications and expertise of the organization’s key personnel assigned to this project. The description shall show that bidder possesses the demonstrated skills and experience in specific areas of the project scope. In addition, Bidder shall identify a project manager for the project and shall provide resumes of all personnel who shall be assigned to this project. Bidder shall estimate the percentage of time each individual shall be working on this project.

1.7 MATERIALS AND EQUIPMENT

A. All systems proposed herein shall meet the best commercial practices of the applicable industries, except where alternatives are noted. Publications of issues of the following standards form a part of this specification:
1. American Institute of Architects (AIA)
2. Americans with Disabilities Act (ADA)
3. American National Standards Institute (ANSI)
4. Audio Engineering Society (AES)
5. Computer Security Institute (CSI)
6. Federal Communications Commission (FCC)

7. Institute of Cable Engineers (ICEA)
8. Institute of Electrical and Electronic Engineers (IEEE)
9. International Standards Organization (ISO)
10. International Telecommunications Union (ITU)
11. National Association of Broadcasters (NAB)
12. National Electric Code (NEC)
13. National Electrical Manufacturers Association (NEMA)
14. National Fire Protection Association (NFPA)
15. National Institute for Certification in Engineering Technology (NICET)
16. Occupational Safety and Health Administration (OSHA)
17. Society of Motion Picture and Television Engineers (SMPTE)
18. Telecommunications Industry Association (TIA)
19. Underwriters Laboratories (UL)
20. Nationally recognized standards of the various construction trades, as may be applicable.

B. References shall meet the latest edition of that standard

C. Certain items of equipment are specified by manufacturers' type numbers to indicate an acceptable standard of quality and performance. Substitutions of equal equipment beyond the alternatives listed will be permitted only if such equipment is listed in an addendum to this specification. Address requests for listing of substitutions to the Architect. With any request for substitution, include measured data proving the equivalence of the proposed substitute in quality and performance. The Architect shall be the final judge of the validity of the data submitted.

D. Provide only current-model materials and equipment. Do not provide obsolete or discontinued models unless specifically directed to do so in the Equipment section of this specification. Review all materials and equipment immediately prior to installation, and inform the Architect of any obsolete or discontinued items.

1.8 COORDINATION AND CLARIFICATION

A. Refer to the Architect before the bid date for coordination and clarification of any discrepancies among drawings and specifications. Where discrepancies occur and pre-bid instructions have not been obtained, abide by the Architect's reasonable decisions.

B. No extras will be allowed because of the audio-visual system contractors or any installation subcontractor’s misunderstanding as to the amount of work involved or his lack of knowledge of any of the conditions pertaining to the work based on neglect or failure to visit or make a proper examination of the site.

1.9 EXISTING CONDITIONS

A. Verify all existing conditions. Refer to the Architect for coordination and clarification before the bid date of any discrepancies concerning existing conditions. Clarify with the Architect all locations including conduit and cable routings. Where discrepancies occur and pre-bid instructions have not been obtained, abide by the Architect’s reasonable decision.

B. Furnish, install, and terminate all required wire and cable into conduit provided under Division 26.

C. Comply with all requirements regarding the use of cable with respect to spread of fire. Refer to the General Construction drawings for identification of air plenum and other spaces having special cabling requirements. Field-survey the jobsite to determine spaces having special cabling requirements. It is the responsibility of the Audiovisual Contractor to provide wiring that is in compliance with all applicable building codes of the authority(ies) having jurisdiction.

1.10 DELIVERY, STORAGE AND HANDLING

A. All equipment shall be appropriately packed for shipment.

B. All shipping costs to the job site are the responsibility of the Audiovisual Contractor. Determination of the shipping method and company is the responsibility of the Audiovisual Contractor in order to meet the published project schedule.

C. Completed systems shall be shipped FOB inside and in place.

D. Note that drop shipment of equipment to the Owner's site directly from the manufacturer, or other supplier will not be allowed.

E. Upon delivery all materials shall be stored under cover in a clean and dry location. Materials which are damaged during shipping, storage or handling or are otherwise not suitable for installation shall be removed from the job site and replaced, at no additional cost to the Project, with acceptable materials.

1.11 FUNCTIONAL REQUIREMENTS

A. The systems shall provide the following functions:

1. Auditorium Audiovisual System

a. Reinforcement of speech and music from wired microphone receptacles and wireless microphone systems to listeners in the auditorium through a centralized group of loudspeakers located above the stage.

b. Supplemental reinforcement of audio signals to listeners in the front of the Auditorium through front-fill loudspeakers installed in the stage apron.

c. Supplemental reinforcement of audio signals to listeners in the rear seating section of the Auditorium through electronically delayed loudspeakers.

d. Operator controlled mixing of microphone signals using a mixing console.

e. Automatic mixing of dedicated wired microphone receptacles and wireless microphone systems (lavalier and handheld) using an automatic mixer system.

f. Assistive listening system using portable wireless FM receivers.

g. Reproduction of pre-recorded audio material using a compact disc player unit located unit in a portable equipment rack for use with mixing console.

h. Loudspeaker receptacles and wiring located in and around the stage for portable loudspeakers.

i. Recording from ceiling-suspended microphones and main audio system signals using a recording mixer and a solid state recorder.

j. Monitoring of audio system signals through wall-mounted control room monitor loudspeakers.

k. Two-channel production intercom system for cueing of technical personnel with wired headsets at locations throughout the Auditorium and related spaces.

l. Reinforcement of announcements from the Auditorium to backstage zones through ceiling mounted loudspeakers.

m. Monitoring of Auditorium activities using a ceiling suspended microphone to backstage zones through ceiling mounted loudspeakers.

n. Preset switching and routing for preset event modes and loudspeaker configurations.

o. Muting of all audio signals in response to fire alarm control signal from fire alarm system.

p. Switching of video signals from a Bluray player, multiple computer inputs and multiple composite video inputs for output to a video projector.
q. Remote control of Bluray player, switcher, video projector, and projection screen.
r. Reproduction of Bluray and computer audio.
s. Reproduction of program material from AV switcher.
t. Monitoring of video system signals using a flat panel display located in the control room.
u. Automatic shut down of video projector and retraction of projection screen in response to fire alarm control signal from fire alarm system.

2. Gymnasium Sound System
   a. Announcements for games and small speech events from a rolling portable equipment rack.
   b. A hand-held wireless microphone system and wired microphones connected to a portable equipment rack.
   c. Reproduction of pre-recorded audio material using a compact disc player, iPod dock and auxiliary interfaces located in a portable equipment rack.
   d. Mixing of microphone and program signals using a small mixer located in a portable equipment rack.
   e. A distributed loudspeaker system with multiple full-range loudspeakers suspended above the playing surfaces and bleachers.
   f. Wall box inputs for connecting audio sources in the portable equipment rack to the installed loudspeaker system.
   g. Assistive listening system using portable wireless FM receivers.
   h. Flexible presets that allow loudspeaker zones to be turned off when not in use.
   i. Overflow audio to and from the Auditorium and Cafeteria sound systems.
   j. Muting of all audio signals in response to fire alarm control signal from fire alarm system.
3. Cafeteria Sound System
   a. Reinforcement of speech from wired and microphone receptacles and wireless microphones to listeners in the Cafeteria through a distributed system of pendant and ceiling-mounted loudspeakers.
   b. Automatic mixing of microphone inputs using a digital signal processor.
   c. Reproduction of pre-recorded audio material using playback devices located in an equipment rack, including the following:
      i. compact disc player
      ii. iPod interface
      iii. Auxiliary source inputs
   d. Control of loudspeaker zones with DSP via rack-mounted and remote volume controls.
   e. Reinforcement of announcements through ceiling-mounted loudspeakers.
   f. Switching of video signals from a Bluray player, computer inputs and multiple composite video inputs for output to a video projector.
   g. Remote control of Bluray player, switcher, video projector, and projection screen.
   h. Reproduction of Bluray and computer audio.
   i. Reproduction of program material from AV switcher.

j.

k. Assistive listening system using portable wireless FM receivers.

l. Muting of all audio signals in response to fire alarm control signal from fire alarm system.

m. Serve as auxiliary lobby space for Auditorium.

4. Large Group Seminar Audiovisual System
   a. Reinforcement of speech from wired and microphone receptacles and wireless microphones to listeners in the room through a distributed system ceiling-mounted loudspeakers.
   b. Automatic mixing of microphone inputs using a digital signal processor.
   c. Assistive listening system using portable wireless FM receivers.
   d. Switching of video signals from a Bluray player, wireless presentation and computer input for output to a video projector.
   e. Remote control of Bluray player, switcher, video projector, and projection screens.
   f. Reproduction of Bluray and computer audio.
   g. Reproduction of program material from AV switcher.
   h. Muting of all audio signals in response to fire alarm control signal from fire alarm system.
5. Music Classroom Sound Systems
   a. Reproduction of pre-recorded music to listeners through wall-mounted left and right loudspeakers.
   b. Reproduction of pre-recorded audio material using a compact disc player unit with pitch control.
   c. Reproduction of pre-recorded audio material from owner supplied equipment using AV inputs intended for portable devices.
   d. Reinforcement of announcements and monitoring of activities in Auditorium for events via Ethernet audio protocol.
   e. Assistive listening using portable wireless FM receivers.
6. Athletic Field Sound System
   a. Reproduction of pre-recorded music to listeners in the bleaches and on the field.
   b. Reinforcement of announcements to listeners in the bleachers and on the field.
   c. Digital signal processor control from press box.
   d. Connection points for portable media players, portable audio mixer and microphones in the press box.
   e. Wiring infrastructure to support portable cameras on filming platform.

1.12 ACOUSTICAL PERFORMANCE CRITERIA

A. The overall space-average acoustical frequency response criterion, as measured within the coverage area of the system loudspeakers, is within ±3 dB of a spectrum which is flat from 125 to 2500 Hz and slopes downward thereafter at a rate of 3 dB per octave to 12,500 Hz. Test signals shall be broad-band "pink" noise applied to any system input, measured using 1/3-octave filters centered on ANSI preferred frequencies.

B. Measurements of system performance will be made using a calibrated ANSI or IEC precision sound level meter set for "slow" meter damping and flat response, 4 feet above the floor (seated ear height) within the system coverage area. All interior finishes and furnishings shall be in

place, and system gain shall be adjusted to provide levels of at least 70 dB, or 10 dB above background noise levels, whichever is higher, at the measuring locations for these tests.

C. The spatial level uniformity criterion, throughout the sound system coverage areas, is that amplified sound levels shall not vary more than ±2 dB as measured using a test signal consisting of an octave band of "pink" noise centered at 2,000 Hz.

D. To meet the acoustical performance criteria, be responsible for:
   1. Use of the equipment specified in the manner specified.
   2. Each component's conformance with its manufacturer's published specifications and other requirements as stated herein.
   3. Detailed checking of each item of equipment provided, each portion of the installation, and of the complete installation to find and remedy any defects therein.
   4. Setting and documenting the adjustments of loudspeakers, equalizers, and other signal-processing equipment, pads, and gain controls, and if so directed by the Architect making the further adjustment of these items, providing additional field-assembled resistive pads and/or resistor-capacitor equalizers.
   5. Adjust all equalizers to realize maximum gain and optimal tonal balance from the sound system throughout the audience area.

E. Output level of all program sources arriving at switching or routing equipment shall be within ±0.25 dB of each other as measured at the input to the switcher or router. Provide pads, line amplifiers or other gain control devices as required to achieve this specification.

F. System frequency response shall be 20 - 20 KHz ±3 dB, unless the known, published specifications of a particular piece of mixing, processing, amplification or transducing equipment limit this specification.

G. System signal to noise ratio shall be 60 dB or greater, unless the known, published specifications of a particular piece of mixing, processing, amplification or transducing equipment limit this specification.

1.13 VIDEO PERFORMANCE CRITERIA

A. Provide systems that meet the performance requirements stated in this section. Perform any work required to modify the performance of the system in order to meet these requirements. Perform whatever tests are necessary to confirm compliance with these requirements, before commencement of acceptance testing.

B. Analog Signal Distribution and Cabling
   1. The video distribution and cabling system shall meet or exceed the following electrical specifications, measured at any point in the system. Compliance with these specifications shall be determined by introducing a standard video reference signal at points normally used for origination (e.g., camera, DVD player, workstation) and measuring the signal characteristics at points normally serving as destinations (e.g., monitor, projector, DVD player). Note that these are end-to-end performance requirements to be met under all conditions of switcher re-entrance.
   2. For purposes of this paragraph, the distribution and cabling system shall include all equipment and cabling normally within the signal path.
   3. Frequency Response shall be ±1.5 dB, DC to 100 MHz for computer and component video signals and ±0.5 dB; DC to 5.0 MHz for NTSC encoded composite video signals.
   4. Rise time shall be 250 V/microseconds minimum.
   5. Crosstalk shall be 45-dB minimum below nominal signal level, unweighted DC to 70 MHz.
   6. Signal to Noise Ratio shall be 45-dB minimum, peak noise to RMS signal, unweighted DC to 70 MHz.
   7. Signal Gain shall be unity (1.00) terminated into 75 ohms.

8. Line and Field Tilt shall be less than 2 percent.
9. Differential Gain shall be less than 3 percent.
10. Differential Phase shall be less than 3 degrees.
11. Color Timing (where applicable) shall be within 2 degrees at 3.58 MHz.
12. Input Return Loss shall be 40-dB minimum, DC to 70 MHz.
13. Path Length Inequality for Y/C and RGBS cable sets where the signals are not subject to subsequent matrixing or encoding shall be within 12 inches of cable length, or 1.6 nsec.
14. If cable length results in the deterioration of gain and frequency response characteristics and cable compensation equipment are not specified, the system shall be adjusted for best performance. The Audiovisual Contractor shall be able to demonstrate that any inability to meet gain and frequency response specification is due solely to length of cable.

C. Digital Signal Distribution and Cabling
1. Provide digital signal distribution system with the following features:
a. EDID management
b. HDCP compliant
c. HDMI, DVI and DisplayPort signal transport
d. Troubleshooting tools
e. Support for video formats up to and including 1920x1200.
f. Manufacturer-approved cabling

D. Displays (Monitors and Projectors)
1. All displays shall meet manufacturers' published specifications for brightness, contrast, focus, convergence, linearity, distortion, and purity, across the entire range of horizontal and vertical scan frequencies of which the display is capable. In the absence of such specifications, no convergence, linearity, distortion, or purity errors shall be visible from a viewing distance equal to the image width, and brightness, contrast, and focus shall meet standard performance guidelines.
2. Projectors shall be installed and adjusted so that the resultant images are free from all keystone and barrel distortion and vignetting.
3. Projectors shall exhibit correct color balance, both at black and at peak white, and proper gray scale tracking.
4. All displays shall meet manufacturers' published specifications for horizontal and vertical scan frequency ranges. Where appropriate, adjustments shall be made to allow for automatic scan locking across specified ranges. Image quality specifications discussed above shall be met throughout the horizontal and vertical scan frequency ranges.

1.14 CONTROL SYSTEM CRITERIA

A. General Requirements
1. Provide programming and otherwise configure control system to achieve fully functional system. Coordinate with the Owner. In addition to all other operating controls, ensure that the conditions in this section are met.
2. Provide programming and otherwise configure control system to achieve control as identified below. Sections below do not define panel layouts; refer to drawings.
3. Reliability
a. Operation shall be 100% reliable. Occasional spurious operation shall not be acceptable.
b. Every control panel pushbutton shall work as intended when pressed just once. The excuse of "Try it again" shall not be acceptable.

c. Equipment shall remain operable from its own front panel even when under control from the remote control system. For example, unused outputs on a video router shall be available for manual operation even when other outputs are being switched by the control system.

d. When a portable control panel is disconnected and re-connected, the panel shall return to normal operation with system status correctly indicated for all functions. If necessary, an initialization pushbutton may be used to force a panel update.

4. Usability

a. A sub-page or individual function which appears on two different pages shall operate in the same way on each page.

b. Feedback (tally) shall be accurate 100% of the time. If true feedback cannot be achieved, then feedback generated by the control system must be 100% accurate. If such feedback cannot be accurately generated, then momentary tally (to confirm pushbutton press only) shall be used.

c. Every function required for proper operation of the audiovisual system shall be under the control of the remote control system, regardless of whether or not that function is in use. For example, a video document camera may have an Internal/External mode function, permitting the display of an external device such as a notebook computer. If the user inadvertently selects External mode, the document camera will be inoperable. The Internal/External mode function shall therefore be under control of the remote control system, so that when the document camera is selected for display, Internal mode is forced.

d. Functions with an inherent delay (eg. video projector turn-on and warm-up) shall be accompanied by an indication of time remaining until ready (touch panels only). Otherwise, there shall be no perceptible delay either in system response or in status indication.

e. Ramping functions (such as volume control) shall operate smoothly, with a ramp rate of approximately 5 seconds from minimum to maximum. System response to ramping commands shall be immediate, and there shall be no perceptible delay in the response of any bargraph indicator.

5. Control Panel Graphics

a. A conservative graphical standard suitable for an educational application shall be developed and adhered to. This standard shall include the following:

i. Limited color palette, generally with colored pushbuttons on a light background

ii. No background texture or wallpaper

iii. Limited number of typefaces and type sizes for legends

iv. Pushbuttons properly aligned horizontally and vertically

v. Consistent and logical use of color - ie. green for normal condition, red for alert.

vi. There shall be no perceptible delay in control panel page flips. Page flips shall be executed without any spurious flashes of unwanted pages or sub-pages.

vii. Control panel pushbuttons shall not be present for functions which will not be required (eg. DVD record) or which are not supported in the application (MCU functions for a video codec without an integral MCU).

b. In absence of specific direction from Owner or Consultant use Crestron “Standard” Theme or similar as a basis for touch panel graphics.

c. Develop panel graphics within an independent graphics design program, Adobe PhotoShop or similar, that provides 32-bit color selection and color matching, color and grey scale shading, infinitely-variable light source direction and intensity, and custom typefaces. Import panel graphics thus developed into Crestron VisionTools

or AMX TPDesign panel creation software. Do not perform initial graphics development within these Crestron or AMX applications.

6. Other

a. Configure control system hardware and programming so that the system will recover from a loss of power to any portion of the system or to the system as a whole without operator intervention. Configure so that control system does not lockup during loss of power, and that manual operation of equipment is possible under all conditions.

b. Provide resistive pull-ups or other means as required to reliably interface to low-voltage remote control systems provided by others, including (but not limited to) projection screens.

c. Provide other hardware and programming not specifically enumerated herein in order to provide a complete and functioning system that meets the performance requirements identified in this section.

1.15 NETWORKING

A. Implement Quality of Service on all Ethernet switches as recommended by Digital Audio Networking Best Practices.

B. Coordinate IP addressing scheme with Owner for connection of AV network to Owner's building network.

1.16 DIAGRAMS, INSTRUCTION MANUALS

A. Provide draft copies of all required diagrams and instruction manuals on-site for inspection during the demonstration and acceptance testing of the system; submit final copies thereafter.

B. Simplified Line Diagram

1. Show the essential parts of the completed installation and their functional relations, including all jacks, numbered according to their position on the system patch panels (A, B, etc., for horizontal rows, 1-26 for vertical columns). Mount one copy of the diagram behind clear plastic on the wall near the equipment rack, or as directed. Bind one copy of the diagram into each instruction manual. Reduce the mounted copy to 11" x 17" maximum; insure that it is legible at that size.

C. Receptacle Plans

1. Provide 11x17 plans showing the location and designation of all receptacles and loudspeakers. Provide separate plans for line/microphone receptacles, loudspeaker receptacles and other receptacles. Indicate jack numbering on plans. Mount one copy and bind other copies into manuals as specified for the line diagram.

D. Operating Manual

1. Create system specific user manual for the complete system including user instructions for accessing all the system functionality specified in Function Requirements. Manual should describe how to use individual components in their context as part of a larger system. A compilation of manufacturer's manuals for components does not meet this requirement.

E. Complete Instruction Manuals

1. Provide complete instruction manuals which include the following:

a. Table of contents.

b. List of loose items furnished (microphones, stands, cables, etc.).

c. List of functional requirements.

d. Operating manual (described above).
e. List of settings and adjustments for semi-fixed controls.
f. Manufacturer's sheets of specifications, operating instructions, and service information arranged alphabetically by manufacturer and then by model number, for each item of equipment specified herein.
g. Detailed system wiring diagrams, including cable schedules, DSP functional diagram print-outs and copies of all drawings specified above. Also include all submitted shop drawings to indicate as-built conditions.
h. Provide to Owner and retain a copy of all operating software, if any, and manuals, including custom software.
i. Provide source code for all custom programming created for this project on USB drive.
j. Provide print-out of all touch panel pages.
k. Submit a copy of the manufacturer’s standard software and firmware licensing agreement for the Owner’s signature. Such license shall grant use of all programs and application software to Owner as defined by the manufacturer’s license agreement, but shall protect manufacturer’s rights to disclosure of trade secrets contained within such software.
l. Provide five (5) bound copies.

F. Record Drawings
1. Provide record drawings of as-built conditions in AutoCAD and PDF file format based on contractor’s updated base drawings. Drawings shall include at a minimum:
a. Device location plan
b. Functional diagram with wire numbering
c. Panel and rack details.
d. Wiring details
e. Loudspeaker suspension details.
2. Provide USB key with AutoCAD files and one (1) blackline print of drawings.

G. Control System
1. Provide a control system. User interface will be through wireless and wired touch panels.
2. Provide the services of a Manufacturer Certified programmer. Programming by non-certified personnel is not acceptable.
3. Perform all terminations and wiring required to connect to third-party systems as shown on the Drawings including, but not limited to:
a. Theatrical Lighting System
4. Touch Panel Pages
a. Splash Screen
b. Main Screen Source Selection Page
i. Sources on left hand side or top of page
ii. Destination selection
1) Auto-select between HDMI and VGA in floor boxes
iii. Speech and Program volume and mute on right hand side of page
iv. Audio-only mode
v. Video mute

c. Indication of which source has been routed to which output
d. Projection Screen Source Selection
    i. Sources on left hand side of page
    ii. Destination selection
    iii. Video mute
    iv. Indication of which source has been routed
e. Preview monitor source selection
    i. Break-away and setting to make output follow projector
f. Blu-Ray Player
    i. Transport controls, disc menu, player menu setup, return, menu navigation
g. Audio Switcher
    i. Source select
h. Audio Recorder
    i. Transport controls, media select, recording time
i. Digital Signal Processor
    i. Program and Speech Volumes
    ii. Muting Presets
    iii. Mode Presets
    iv. Trigger audience recall chime.
    v. Additional functions per Functional Diagram
j. Lighting
    i. Sixteen presets
    ii. Push and hold preset selection button to rename preset with soft keyboard entry
k. Projector
    i. On, off, native, zoom to fit, stretch to fit, video mute

1.17 INSTRUCTION

A. Provide instruction of Owner's designated operating personnel. Include a minimum of six sessions for a total of twenty-four hours of instruction in the operation, care and maintenance of the installation. Schedule multiple sessions over a one or two year period across both Fall and Spring School Sessions.

B. Schedule instruction at the mutual convenience of the Owner and contractor, after demonstration and acceptance testing. Provide a DVD recording or otherwise coordinate with the Owner the recording of all instruction sessions and provide a copy of each major session to the Owner.

C. Six months after completion of the installation, the Audiovisual Contractor shall provide a control system review making any minor changes to the control system as the Owner may request based on the configuration at system sign-off.

1.18 GUARANTEE AND SERVICE

A. Guarantee all equipment and installations to be free of faulty workmanship and defective components for a period of one year from date of final acceptance.

B. During this period, replace defective materials and repair faulty workmanship within 24 hours of report of malfunction at no additional cost to the Owner. If specified materials and installations cannot be made good within 24 hours of report of malfunction, provide approved temporary alternate equipment and facilities, complete and operational, within 24 hours of report of malfunction, at no additional cost to the Owner.

C. Maintain a 24-hour-per-day, 365-day-per-year telephone response facility for receipt of service calls.

D. Respond to service calls and provide restoration of service within the time limits stated, weekends and holidays included.

E. Provide at no additional charge preventive maintenance service for a period of one year after final acceptance of installation. This service shall consist of at least two semi-annual visits to the site for checking and adjustment of equipment.

F. Provide with bid annual cost to extend the preventive maintenance agreement from two to five years after completion.

PART 2 - EQUIPMENT

2.1 WIRING AND CONNECTORS

A. Audio Installed Lines
1. For cables installed in conduit and entirely within racks, use cable with a foil-shielded pair of stranded #22 AWG conductors, with a stranded shield drain wire. For single pair, use a miniature cable, nominal outside diameter 0.135". Use of multi-pair cable is optional. Provide plenum rated equivalent as required.
   a. Belden 8451
   b. Liberty 22-1P-EZ
   c. West Penn 452

B. Audio Portable Cables
1. For line and microphone level audio umbilical cords use cable with stranded #20 AWG conductors, braided shield, and EPDM rubber jacket.
   a. Belden 8412
   b. Equal

C. Loudspeaker Wiring
1. Provide unshielded loudspeaker wiring for connection to loudspeakers and loudspeaker receptacles. For lines in rigid conduit or electrical tubing, use stranded or solid conductors. For lines in flexible conduit or electrical tubing and for all wiring to equipment within equipment racks, use only stranded conductors.
2. Use color-coded #12 AWG conductors for all loudspeakers and electronically-delayed loudspeakers except for 70 V ceiling-mounted loudspeakers and loudspeaker receptacles.
   a. Belden 8477
   b. West Penn 227
   c. Approved Equal
3. For all ceiling-mounted loudspeaker wiring using 70.7 Volt lines provide color-coded #18 AWG loudspeaker wiring.

a. Belden 8461
b. West Penn 224
c. Approved Equal

4. Use color-coded #14 AWG conductors for all loudspeaker receptacle wiring.
   a. Belden 8473
   b. West Penn 226

D. 75 Ohm Video Input/Output Lines
1. Provide video lines with a maximum loss of 20dB at 750MHz for single run.
2. For cable length runs between 0 and 300 feet:
   a. Canare L-5CFB
   b. Belden 1505A
   c. West Penn 819
3. For cable length runs between 300 and 500 feet:
   a. Canare L-7CFB
   b. Belden 1694A
   c. West Penn 6350
4. For multi-cable RGBHV runs under 100 feet:
   a. Belden 1279P
   b. Extron MHR-5
   c. West Penn 255CRGB

E. Fiber Optic Termination Panel
1. Provide 2 RU fiber optic patch panel complete with pass-through modules, locking hinged front cover and rack mount hardware.

F. Fiber-Optic Wiring, Two Fiber
1. Provide multi-mode, OM3, two-fiber cable for connection from wall plates to patch bays.
   a. Belden B9C037
   b. Equal

G. Fiber Optic Wiring, Six Fiber
1. Provide multi-mode OM3, six-fiber cable for connection between equipment racks. Terminate all fibers with connectors.
   a. Belden B9C039
   b. Equal

H. Antenna Wiring
1. Provide coaxial antenna wiring for connections from wireless transmitters and receivers to antenna connection panels.
   a. Belden 7810A
   b. Equal

I. Category Wiring
1. Provide shielded Category 6 8-conductor twisted pair cable with 23 AWG solid conductors and bandwidth of 250 Mhz for computer data and audiovisual transport wiring.
   a. Belden DataTwist series

b. Equal

J. HDBT Wiring

1. Provide shielded Category5e 8-conductor twisted pair cable tested to 350 Mhz and suitable for use with the supplied video distribution system.
   a. Crestron DM-CBL-8G
   b. Equal

K. Microphone and Line Level Patch Panel

1. Provide programmable patch panels to fulfill the requirements shown on the functional diagram. Wire jacks with bridging and normalled-through connections as detailed. Use patch panels which include designation strips with transparent plastic label covers; vertical strips at each side and a three-line (minimum) horizontal strip for each row of jacks. Place jacks close to each other on the patch panel which are shown close to each other on the functional diagram. Locate each bridging jack above the associated normalled-through jack. Use bantam type tip-ring-sleeve jacks with cross-bar palladium or Western Electric #1 gold alloy switching contacts. Both factory-wired and shop-wired patch panels are acceptable. Insulation-displacement terminals are included with the factory-wired patch panels specified herein; other terminal strips or terminal blocks may be substituted, including both solder and screw types. Supply two-foot long red patch cords with nickel-plated plugs. Attach patch cord holder to side of rack or wall near jack field.
   a. Acceptable patch panel:
      i. Audio Accessories WQP-05-P-C-48-N-2
      ii. Equal
         1) Quantity: As required
   b. Acceptable patch cord:
      i. Audio Accessories 822A
      ii. Equal
         i) Quantity: 40
   c. Acceptable patch cord holder:
      i. Audio Accessories MAXI
      ii. Pomona 4408
         1) Quantity: 1

L. Video Patch Panel

1. Provide 2x32 75 ohm patch panels for video signals.
   a. Acceptable patch panel:
      i. Audio Accessories 32MV2/MVJ-3T
      ii. ADC equal
         1) Quantity as required
   b. Acceptable patch cord:
      i. VPCM-24
      ii. ADC equal
         1) Quantity: 20

M. Category Patch Panel
   1. Provide 48-port rack-mount category 6 patch panel. Provide one 2-foot patch cable per wired port on patch bay.
      a. Leviton eXtreme
      b. Hubbell NextSpeed
      c. Approved equal
      d. Quantity: per Drawings

N. Connectors
   1. Connectors from the following manufacturers shall be considered acceptable. Install connectors appropriate for the installed cable and equipment interface.
      a. ADC
      b. Amp
      c. Amphenol
      d. Canare
      e. H.H. Smith
      f. Kings
      g. Neutrik
      h. Pomona
      i. Switchcraft
      j. Trompeter
      k. Approved equal

O. Input Connection Plates
   1. All plates are black anodized aluminum with engraved or laser etched white lettering unless otherwise noted.
      a. Wall and ceiling mounted plates visible to public: stainless/brushed aluminum
      b. Wall-mounted plates in stage areas (behind proscenium): black
      c. Wall-mounted plates at catwalk and auditorium overhead areas: black
      d. Wall-mounted plates in Control Room: stainless/brushed aluminum
      e. Floor-Box Mounted plates: white

P. AV Input Plate, Analog
   1. Provide custom plate with balancing and to transformer unbalanced input to balanced output.
      a. ProCo iPlate
      b. Equal

Q. AV Input Plate, Networked
   1. Provide Dante-based input/output plate with 2-channel Bluetooth audio input, pairing button, RCA and 3.5 mm stereo analog input, 3.5mm stereo analog output. Provide unit that that receives power and signal via Power Over Ethernet.
      a. Atterotech unD6IO-BT
      b. Equal

R. Surface Mount Electrical Gang Boxes

1. Provide surface mount electrical gang boxes for all surface and pipe mount audiovisual devices in project. Coordinate mounting condition and requirements with electrical contractor. Provide in black or white as required to match faceplate.
    a. FSR SMWB Series
    b. Levition BKBX Series
    c. Electronic Theatre Controls Equal

S. Press Feed
1. Provide jacks and transformer as shown to combine low-impedance line level outputs and match them to inputs of consumer-type (“Hi-Fi”) recording equipment. Provide three-pin receptacles to interface "pro-level” recording equipment to same low-impedance line level outputs. Locate in audio equipment rack. Provide custom assembly on panel using the following components:
    a. Phono Receptacles
    b. Use female phono ("RCA") panel mounted jacks, as shown below, which are insulated from the mounting panel and which use D-holes or other positive means to prevent jack rotation. Provide sufficient clearance so that inserted plugs do not short to the plate.
    c. Three-pin Receptacle
    d. Provide three-pin receptacle with black finish, for connection to “pro-level” equipment.

T. Microphone Extension Cable
1. Provide 25-foot long rubber-covered flexible microphone extension cables. Fit each flexible extension cable with black three conductor XLR microphone receptacles. Provide one microphone cable per microphone.
    a. Wireworks C25
    b. Pro Co M25
    c. Approved equal assembly
    d. Quantity: As required by number of microphones provided.

U. Isolation Transformer
1. Jensen Transformer JT-11SSP-6M
2. ProCo LOT-1
    a. Quantity: As required

V. Dual Line Output Transformer
1. Jensen Transformer DIN-2LO-11FL
2. Equal

W. Dual Two-Way Microphone Splitter
1. Jensen Transformer DIN-MS-2P
2. Equal

X. Audio Combiner
1. Provide passive audio combiner network. Provide with power supply as required. Mount in equipment rack.
    a. RDL STD series
    b. Equal

Y. Speaker Level Interface

1. Provide device to convert speaker level to line level for use with paging system. Coordinate with paging system contractor.
    a. RDL TX-70A
    b. Equal

Z. 2x2 Audio Interface, Networked
1. Provide two input, two output interface to Dante audio network. Provide surface-mounted unit with balanced audio inputs and outputs, selectable microphone/line level input gain and all required power supplies.
    a. Atterotech Dante unDIO2x2
    b. Lectrosonics DNT22
    c. Equal

AA. Terminal Blocks
1. Provide DIN-rail mounted terminal blocks where indicated on functional diagrams for microphones and line level lines.
    a. Acceptable manufacturers:
    b. Wago
    c. Entrelec
    d. Equal
2. Provide DIN-rail terminal blocks, barrier strips or euro-style blocks for loudspeaker level lines.

BB. Rack-Mounted Power Strips
1. For racks without sequenced power control provide vertical power strip as required for rack size and number of circuits. Provide power strip with only circuit breaker protection. No MOV surge protection is required. Provide power strip with NEMA 5-20R (IG) outlets.
    a. Middle Atlantic PD series
    b. Equal

CC. Rack Shelf
1. Provide utility rack shelf for mounting of wireless microphone chargers.
    a. Middle Atlantic UTR1
    b. Equal

2.2 AUDITORIUM AUDIO INPUT EQUIPMENT

A. Lectern Microphone
1. Provide microphone with shock isolation. Supply microphone with 18-inch long flexible extension tube, stand clamps and foam windscreen. These microphones are intended for general use at lecterns, or on stands for reception of speech or music at distances of approximately 12 to 24 inches from source to microphone. For units without electronic vibration isolation provide additional shock-mount stand adapter. Install one microphone on lectern. Second microphone is provided for portable use.
    a. Countryman Isomax 4RF, M4HP5RF24EB
    b. Clock Audio C 35E-RF
    c. Equal
        i. Quantity: 2

B. Wireless Microphone System
   1. Provide all antennas, transmitters, and receivers by a single manufacturer.
   2. Provide digital wireless microphone system with AES 256-bit encryption, Dante audio networking, allow up to 16 active transmitters on one 6 Mhz TV channel, switching diversity.
   3. Provide all required power supplies and accessories to achieve intent of Drawings.
   4. Provide complete with rack-mounting kits.
   5. Provide with rack shelves for charging stations.
   6. Provide antenna with all required hardware to mount to lighting position and point at stage.
      a. Four-Channel Receiver
         i. Shure ULXD4Q
         ii. Equal
            1) Quantity: 1
      b. Handheld Transmitter
         i. Shure ULXD2/SM58
         ii. Equal
            1) Quantity: 3
      c. Belt Pack Transmitter
         i. Shure ULXD1
         ii. Equal
            1) Quantity: 2
      d. Lavalier Microphone, Cardioid
         i. Shure MX150/C
         ii. Equal
            1) Quantity: 2
      e. Rechargeable Battery
         i. Shure SB900
         ii. Equal
            1) Quantity: 6
      f. Charging Station
         i. Shure SBC200-US
         ii. Equal
            1) Quantity: 4
      g. Active Directional Antenna
         i. Shure UA874
         ii. Equal
            1) Quantity: 2

C. Vocal Microphone
   1. Provide microphone for "close-miked" use by popular, jazz, or folk singers. Provide complete with stand adapters as necessary. Provide with flexible microphone cable as specified above.

a. Shure SM58-LC
b. Electro-Voice N/D 267
c. Audix OM-3xb
d. Sennheiser E835
    i. Quantity: 4

D. Hanging Microphone
1. Provide hanging condenser microphone suitable for group pickup.
    a. Audio-Technica U853R
    b. Equal
        i. Quantity: 6

E. Boundary Microphone
1. Provide durable condenser microphone designed for use as a group pickup at edge of stage.
2. Provide with vibration isolation pad.
    a. Crown PCC160
    b. Equal
        i. Quantity: 6

F. Instrument/Vocal Microphone
1. Provide microphone for “close-miked” use with instruments. Provide complete with stand adapters as necessary. Provide with flexible microphone cable as specified above.
    a. Shure Beta 57A
    b. Electro-Voice N/D 478
    c. Audix i5
    d. Sennheiser E840
        i. Quantity: 2

G. Microphone Floor Stand (metal base)
1. Provide an adjustable black microphone stand with 5/8-inch thread and round, weighted metal base.
    a. AKG KM-260/1-black
    b. Atlas MS-12CE
    c. On-Stage MS9201B
        i. Quantity: 4

H. Boom for Floor Stand
1. Provide black, counter-balanced, tiltable boom arm, 32-inches to 34-inches long, compatible with floor stand provided.
    a. AKG KM-211/2-black
    b. Atlas PB-21XE
    c. On-Stage MSA9040TB
        i. Quantity: 4

I. Microphone Floor Stand (tripod base)

1. Provide adjustable black microphone stand with 5/8-inch thread and tripod base. Provide with adjustable-length boom arm.
    a. Atlas TL34-21XE
    b. On-Stage MS7701TB
    c. Equal
        i. Quantity: 4

J. Microphone Table Stand
1. Provide a round base stand with 5/8" thread, round weighted metal base with adjustable height from approximately 8" - 13". Provide stand in black finish.
    a. Atlas DS-7E
    b. AKG Equivalent
    c. On-Stage DS-7200QRB
        i. Quantity: 2

K. Headphone Interface
1. Provide passive stereo 3.5mm to balanced XLR converter.
    a. Switchcraft #318 Mini Audiostix
    b. Equal
        i. Quantity: 2

L. Stage Floor Box (FB1)
1. Provide floor box complete with back box, basket insert and hinged cover. Installation of floor box and back box by Electrical Contractor. Mount floor box cover flush with stage floor, unless directed otherwise by Architect. Provide for wiring of audiovisual receptacles. Coordinate installation with flooring installer. Provide flat or insert hinged cover, per Architect
    a. FSR FL-600P-6 back box w/cover.
    b. Equal
        i. Quantity: 2

2.3 AUDITORIUM AUDIO CONTROL AND AMPLIFICATION EQUIPMENT

A. Digital Mixing Console
1. Provide digital audio mixing console with 64x64 Dante interface and a minimum of 16 analog microphone inputs and 2 stereo line input pairs. Provide with a minimum of 6 auxiliary outputs. Provide any additional switches, input cards, etc. necessary for the function of the console as shown on the functional diagrams.
2. Provide with dimmable gooseneck work light
3. Provide with dust cover.
    a. Yamaha TF5 w/ NY64-D card and accessories
    b. Equal
        i. Quantity: 1

B. Digital Mixing Console Input/Output Box
1. Provide rack-mountable remote I/O device compatible with digital mixing console. Provide device with 16 analog microphone inputs with console-controllable pre-amplifiers, 8 analog line level outputs on 3-pin XLR connectors which connects to the digital mixing

console over Digital Audio Network. Provide device which can simultaneously receive 16 channels and send 8 channels of full bit rate digital audio over the single UTP connection. Provide all required input card, switches, etc, to connect to mixing console.

a. Yamaha Tio1608-D

b. Equal

i. Quantity: 2

C. Virtual Soundcard Software

1. Provide license for Dante Virtual Soundcard. Install on Owner's Computer.

i. Quantity: 1

D. Digital Audio Software

1. Provide license for Dante Via. Install on Owner's Computer.

i. Quantity: 1

E. 8-Channel Automatic Mixer

1. Provide rack-mounted mixer with at least 8 microphone/line inputs and Dante digital audio network connection. Provide with rack-mounting kit. Mount in stage equipment rack.

a. Shure SCM820-DAN

b. Equal

i. Quantity: 1

F. Uninterruptible Power Supply

1. Provide 1000VA minimum rack-mounted UPS system to provide power-surge and power-loss protection to digital signal processor system.

a. APC SUA1000RM2U

b. Powerware 5125 1000 RM

c. Middle Atlantic UPS-1000R

i. Quantity: 1

G. Digital Signal Processor

1. Provide digital signal processing system with inputs and outputs as shown on drawings, and the following functions. Provide all required devices, accessories, switches and cables to achieve a complete working system.

a. Feedback suppression

b. Nine bands of parametric equalization per signal input group

c. Crossover

d. Compressor

e. Digital delay

f. Signal limiting

g. Digital audio signal routing

h. Signal flow as shown on sound system functional drawing(s)

i. Volume control

j. Dante digital audio networking

i. BSS London BLU

ii. Biamp Tesira
iii. Symetrix EDGE
iv. QSC Q-Sys
1) Quantity: 1 complete system, as required

H. Ethernet Switch
1. Provide SNMP capable, POE+ enabled, managed, gigabit Ethernet switches as required to support a Dante audio network with functionality equivalent to audio network shown on drawings and control system network. Provide Ethernet products compliant with IEEE 802.3.
2. Provide switch with multi-mode fiber interfaces to create network topology, per Drawings.
a. Pakedge
b. Cisco
c. HP
d. Equal

I. Router
1. Provide router with 2 WAN, 5 LAN, 1 DMZ ports. Provide unit with 1 Gps throughput from WAN to LAN ports. Provide unit capable of 255 VLAN.
2. Provide with rack-mounted hardware.
3. Coordinate connection to school network with Owner's IT personnel.
a. Pakedge K60D
b. Equal
i. Quantity: 1

J. Digital Signal Processor Preset Description
1. Provide digital signal processing settings as described below. Exact determination of digital processor settings is an iterative process and final settings should be determined and documented with careful field measurements. Configure the default mode (with no muting) when master power switch is turned on. Configure so that all inputs are routed to appropriate outputs unless complete routing/rewiring of the internal DSP software devices is required. Presets are described below as parameter changes that do not require a muting and reinitializing of the digital signal processor. Provide access to muting presets through control system if included with project.
a. Presets required:
i. Lobby feed on/off
ii. Gymnasium overflow on/off
iii. Cafeteria overflow on/off
iv. Central Loudspeaker Cluster on/off
v. Front-Fill Loudspeakers on/off
vi. Delay Loudspeakers on/off
vii. Backstage Loudspeakers on/off
viii. Overflow volume

K. Power Amplifier Serving Center Cluster and Fill

1. Provide 4-channel power amplifier with balanced bridging inputs and variable-speed fan(s). Provide amplifier which is 2-rack space units high. Provide amplifier which supplies at least 300-watts (nominal) per channel at 8-ohms or 70-volts.
    a. Crown DCi 4|300
    b. Lab Gruppen C16:4
    c. Equal
        i. Quantity: 1

L. Power Amplifier Serving Central Cluster and Fill Loudspeakers
1. Provide four-channel power amplifier with balanced bridging inputs and variable-speed fan(s). Provide amplifier which is 2-rack space units high. Provide amplifier which supplies at least 500-watts (nominal) per channel at 8-ohms and at least 500-watts (nominal) per channel at 4-ohms.
    a. Crown DCi 4|600
    b. Lab.gruppen C28:4
    c. QSC CXD4.2Q
        i. Quantity: 1

M. Power Amplifier Serving Front Fill and Delay Loudspeakers
1. Provide eight-channel power amplifier with balanced bridging inputs and variable-speed fan(s). Provide amplifier which is 2-rack space units high. Provide amplifier which supplies at least 200-watts (nominal) per channel at 8-ohms.
    a. Crown DCi 8|300
    b. Lab Gruppen C 20:8X
    c. Equal
        i. Quantity: 1

2.4 AUDITORIUM EQUIPMENT RACKS AND ACCESSORIES

A. Main Equipment Rack
1. Provide modular rack with bolt-together frame, side panels, locking rear door, and vented, locking front door, which accepts extra panel-mounting angles. Fill in unused rack space with blank solid panels, per industry best practices for air flow. Recess rack rails to allow front doors to close when patch cords are in use. Provide rack, accessories, and filler panels in smooth (not wrinkle) matte black finish. Provide rack with minimum 30-inch depth.
    a. Raxxess GAR-XX-32 Series Assembly
    b. Middle Atlantic WRK-XX32 Series Assembly
    c. Lowell LGR-XX32 Series Assembly
        i. Quantity: 1

B. Main Equipment Rack Cooling Fan
1. Provide cooling fan compatible with and from same manufacturer as equipment rack specified above. Provide with thermostatic automatic fan control.
    a. Middle Atlantic MW-4QFT-FC
    b. Equal
        i. Quantity: 1

C. Swing-Out Equipment Rack
   1. Provide floor-mounted equipment rack with pivoting center section, floor base, and vented, lockable front door. Fill in unused rack space with blank solid panels, per industry best practices for air flow. Provide rack, accessories, and filler panels in smooth (not wrinkle) matte black finish. Provide with thermostatically controlled fan kit.
      a. Middle Atlantic SR-40-32 w/ DWR-FK32, FC-2-215-1CA
         i. Quantity: 1

D. Rack Power Wiring
   1. Furnish equipment racks with permanently-mounted 3-conductor AC power receptacles with sufficient outlets to meet system needs plus at least 2 spares per rack. Provide raceway configured with separately circuited receptacle groups as required to distribute load across multiple circuits. Provide whip with plug to match for connection to power outlet box as indicated on the power plan drawings.
      a. Juice Goose CQ-PD1-4, CQ2200, CQ2000 (special order IG version)
      b. Middle Atlantic MPR Series w/ RLM-20IG modules
      c. Equal
         i. Quantity: As required

E. Portable Input/Output Equipment Rack
   1. Provide portable equipment rack for use of stage box equipment. Provide complete with rack mount power strip and cables as shown on the Drawings. Provide with 25 foot extension cord and 25 foot hard-service Ethercon cable for connection to wall.
      a. SKB 1SKB19-8U
      b. Technomad (Hardigg) ProRack 8U
      c. Gatorcases GR-8L
         i. Quantity: 1

F. Portable Equipment Rack Power Strip
   1. Provide 1 rack unit 15-amp surge-protector and power strip with EMI/RFI filtering, series mode surge protection, and integrated gooseneck rack lighting receptacles.
      a. Surge-X SX1115-RL w/ (2) LED gooseneck rack lights
      b. Equal
         i. Quantity:
            1) 1 – portable equipment rack
            2) 1 – Mixing Console Desk

G. System Power Control
   1. Provide a relay-controlled power switching system with a master power switch and power-on indicator for the system. Connect the master power switch to control each receptacle in the rack except for one of the spare receptacles. Label unswitched receptacles "UNSWITCHED". Connect power for rack illumination to bypass the system master power switch. Provide a means to cycle the system power amplifiers on sequentially at intervals of approximately one second whenever the power switch is activated.
      a. Middle Atlantic USC-6R
      b. Atlas Sound SACR-191
      c. Juice Goose CQ1520

i. Quantity: 1

H. System Power Control Remote
1. Provide rack-mounted remote switch for System Power Control.
a. Middle Atlantic RPS w/ DECP-1X1
b. Equal
i. Quantity: 2

I. Rack Work Light
1. Provide magnetically mounted gooseneck locally switched LED utility lighting. Connect to unswitched receptacle. Mount in back of equipment racks.
a. Middle Atlantic LT-GN-WL
b. Equal
i. Quantity: 2

J. Rack Lighting
1. Littlite Raklite RL-10-D-LED
2. Equal
a. Quantity: 1

K. 4 Rack Unit Locking Storage Drawer
1. Provide 4 rack space locking rack mounted drawer.
a. Middle Atlantic D4-LK
b. Raxxess SDR-4 w/ lock
c. Equal
i. Quantity:1

L. 2 Rack Unit Locking Storage Drawer
1. Provide 2 rack space locking rack mounted drawer.
a. Middle Atlantic D2-LK
b. Raxxess SDR-2 w/ lock
i. Quantity:3

M. Mixing Console Desk
1. Provide two-section custom rolltop desk for mixing console with adjacent 18 RU equipment rack. Sizes per Drawings.
2. Provide desk with lockable wood tambours for mixing console work space and front of equipment rack.
3. Provide desk with plastic laminate finish to be selected by Architect.
a. HSA
b. Designcraft
i. Quantity: 1

2.5 AUDITORIUM LOUDSPEAKER COMPONENTS

A. Loudspeaker Manufacturer
1. All loudspeakers shall be supplied by the same manufacturer, except where that manufacturer does not make one of the specified loudspeakers.

B. Central Cluster Loudspeaker
   1. Provide 3-way full range loudspeaker with 15-inch low-frequency drivers, 3-inch voice coil, rotatable waveguide. Provide with all necessary suspension hardware, including supplemental steel as required to create rigging points above loudspeaker. Provide loudspeaker and mounting hardware with black finish.
      a. Fulcrum Acoustic DX1565
      b. Eastern Acoustic Works QX566i
      c. Equal
         i. Quantity: 2

C. Side Fill Loudspeaker
   1. Provide passive 2-way loudspeaker with 8-inch low frequency transducer, 2-inch voice coil high frequency compression driver, and rotatable waveguide. Provide with all necessary mounting hardware. Provide loudspeaker and mounting hardware with finish as directed by architect.
      a. Fulcrum Acoustic CX896
      b. Eastern Acoustic Works
      c. Equal
         i. Quantity: 2

D. Delay Loudspeaker
   1. Provide passive 2-way loudspeaker with 8-inch low frequency transducer, 2-inch voice coil high frequency compression driver, and rotatable waveguide. Provide with all necessary mounting hardware. Provide loudspeaker and mounting hardware with black finish.
      a. Fulcrum Acoustic CX896
      b. Eastern Acoustic Works
      c. Equal
         i. Quantity: 4

E. Front Fill Loudspeaker
   1. Provide compact 2-way loudspeaker with 4-inch concentric driver. Flush-mount in vertical face of stage apron as shown on the Drawings. Provide with grille and bezel with finish as directed by Architect.
      a. Tannoy iw4 DC
      b. Equal
         i. Quantity: 4

F. Loudspeaker Rigging Suspension Equipment
   1. Provide loudspeaker rigging for loudspeaker clusters and suspended loudspeakers. Suspend loudspeaker components from brackets and any necessary suspension frames to minimize total number of ceiling hanging points. Provide with a sufficient number of suspension points for field adjustment of loudspeaker aiming. Provide with color as designated by the Architect. During fabrication and installation verify that adequate clearance from all other hanging components and adequate clearance from structural steel is provided. Provide any additional rigging hardware necessary for the safe and proper installation of these loudspeakers.

2. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated in the Work include, but are not limited to, the following:
    a. Ape Rigging
    b. Polar Focus
    c. ATM-Flyware
    d. Approved Contractor-Fabricated Assembly (*Show evidence of successful completion of previous projects)
3. Submit all drawings of the complete final loudspeaker rigging assemblies to a certified structural engineer and obtain approval and stamped copies of the drawings. Drawings should detail all connections from attachment to building structure to loudspeaker.

2.6 AUDITORIUM PLAYBACK EQUIPMENT

A. CD/Media Player
1. Provide 1U compact disc player with balanced outputs, auxiliary input, Bluetooth audio input, and IR remote.
    a. Denon DN-300Z
    b. Equal
        i. Quantity
            1) 1 – stage equipment rack
            2) 1 – Mixing Console Desk

B. Media Shelf
1. Provide rack-mounted compartment with cabling grommets designed for use with portable media players. Provide with integral power/USB outlets mounted on back panel of shelf, per Drawings.
    a. Middle Atlantic SH-DMP-S
    b. Equal Assembly
        i. Quantity: 1 stage equipment rack

2.7 AUDITORIUM ASSISTIVE LISTENING EQUIPMENT

A. Provide wireless assistive listening system consisting of an FM transmitter, an antenna mounted as indicated on drawings, and portable battery-operated receivers with earphones and inductive couplers (the latter for use with hearing aids with "T" switches). Provide frequencies separate and free from interference with other FM systems. Provide all assistive listening system components from the same manufacturer.

B. Transmitter
1. Listen Technologies LT800 with LA-326 rack mounting kit
2. Williams PPA T35 with RPK 006 rack mounting kit
3. Equal
    a. Quantity: 1

C. Transmitter Antenna
1. Listen Technologies LA-122
2. Williams ANT 005 with extension cable
3. Equal
    a. Quantity: 1

2.8 AUDITORIUM RECORDING SYSTEM

A. Recording Microphone
1. Provide ceiling suspended microphone with extension cables and mounting bracket. Suspend microphone assembly from catwalk. Provide phantom powered condenser microphone with cardioid pickup pattern. Secure rotation with mono-filament fishing line.
a. AKG C391B
b. Shure SM81
c. Equal
i. Quantity: 2

B. Stereo XY Mounting Bracket
1. Provide suspended microphone mount for configuration of recording microphones in XY pair. Provide all required accessories to mount recording microphone in stereo XY pair. Suspend bracket as shown on Drawings.
a. On Stage Stand MY700
b. Equal contractor assembly
i. Quantity: 1

C. Recording Mixer
1. Provide six-input microphone/line mixer with high-gain (60dB) microphone pre-amplifiers, 2-band EQ on each input, phantom power and stereo output.
a. Ashly MX-406
b. Equal
i. Quantity: 1

D. Combination Solid State and CD Recorder
1. Provide 1U device capable of recording stereo audio either directly to a removable flash memory card in WAVE and MP3 format, or to compact disc. Provide device with balanced analog audio inputs and outputs and coaxial digital inputs and outputs. Mount in under counter equipment rack in control room.
a. Tascam SS-CDR250N w/ 32GB CF Card
b. Equal
i. Quantity: 1

E. Headphones
1. Provide monitor headphones for recording mixer.
a. Sony MDR7506
b. Sennheiser HD280
c. AKG K240S
i. Quantity: 1

2.9 PROGRAM MONITOR/ANNOUNCEMENT SYSTEM

A. Audience Suspended Microphone
1. This microphone is intended for use with the backstage monitor system. Suspend below ceiling above the audience. Provide with color as directed by Architect. Secure rotation with mono-filament fishing line.
a. Countryman Isomax II-H, M2CP6F50

b. Shure MX202 X/C

c. Equal

i. Quantity: 1

B. Desktop Announce Microphone Console

1. Provide console assembly with gooseneck microphone and weighted base. Provide base with 2 momentary switches for paging zone selection and 6-pin output receptacle. Provide with cable for connection to wall plate in Control Room and at tech table location.
2. Label buttons with black background, white text labels.
   a. Clockaudio DMB 2 w/D43 Gooseneck
   b. Equal
      i. Quantity: 1

C. Desktop Announce Console Cable

1. Provide 15-foot 6-conductor microphone cable with 6-pin male and female XLR connectors.
   a. Pro-Co
   b. Whirlwind
   c. Lex Products
      i. Quantity: 1

D. Stage Equipment Rack Cue Microphone

1. Provide cardioid dynamic microphone for use in cue microphone rack assembly per Drawings. Provide push—to-talk close-talking microphone with 12-inch black gooseneck and flange mounted in custom 2 rack unit high open-front chassis.
   a. Shure 515SBGX w/ G12B, A12HDB
   b. Equal
      i. Quantity: 1

E. Ceiling Mounted Loudspeaker (S)

1. Provide 70.7-volt loudspeaker/transformer assembly with back box enclosure and grille. Furnish back box enclosure to Electrical Contractor. Connect to 4-watt taps.
   a. Atlas FA134T87 w/ FA720-4 Grill and FA97-4 loudspeaker enclosure
   b. Equal
      i. Quantity: per Drawings

F. 70-Volt Loudspeaker Volume Control

1. Provide wall and rack mounted loudspeaker attenuators for volume control. Coordinate exact electrical device box size requirements with electrical contractor.
2. Wall-Mounted. 10W
   a. Atlas AT10
   b. Lowell 25LC2
   c. Equal
      i. Quantity: per Drawings
3. Wall-Mounted, 35W
   a. Atlas AT35
   b. Lowell 50LVC

c. Equal

i. Quantity: per Drawings

4. Wall-Mounted, 50W
   a. Atlas AT35
   b. Lowell 50LVC
   c. Equal
      i. Quantity: per Drawings
5. Wall-Mounted, 100W
   a. Atlas AT100
   b. Equal
      i. Quantity: per Drawings

2.10 AUDITORIUM PORTABLE LOUDSPEAKERS

A. Active Portable Loudspeaker
   1. Provide 2-way loudspeaker with integrated amplifier, 8” low-frequency driver, detented gain control, balanced audio line input and output.
   2. Provide each loudspeaker with 25-foot XLR extension cable and 25-foot power cable.
      a. QSC K8.2
      b. Yamaha DXR8
      c. Electro-Voice ZxA1
         i. Quantity: 4

2.11 AUDITORIUM PRODUCTION INTERCOM SYSTEM

A. Provide a two-channel production intercom system as shown on the Drawings. Homerun circuits as enumerated to the master station in equipment rack. Connect circuits to master station output channels as shown. Connect power cable to "unswitched" receptacle in equipment rack. Provide single channel belt-packs, headsets and extension cables compatible with the production intercom systems specified below. Provide all equipment from the same manufacturer.

B. Main Station
   1. Provide 2-channel production intercom master station with gooseneck microphone. Locate in main equipment rack. Provide with additional power supplies as required.
      a. Telex MS-2002 with MCP-90-8” microphone
      b. Clear-Com MS-702 with GM-9 microphone
         i. Quantity: 1

C. 1-Channel Belt-Pack Station
   1. Telex BP-1002
   2. Clear-Com RS-701
      a. Quantity: 6

D. Headset
   1. Telex PH-1
   2. Clear-Com CC-300
      a. Quantity: 6

E. Handset
   1. Telex HS-6
   2. Clear-Com HS-6
      a. Quantity: 1

F. Intercom Extension Cable
   1. Provide twenty-five foot long rubber-covered flexible microphone extension cables. Fit each flexible extension cable with black three conductor XLR microphone receptacles. Provide color-coded shrink-wrap tubing to designate these extension cables separate from the microphone extension cables.
      a. Wireworks C25
      b. Pro Co M25
      c. Whirlwind Equivalent
         i. Quantity: 6

2.12 AUDITORIUM VIDEO SYSTEM INPUT EQUIPMENT

A. Custom Lectern
   1. Provide custom lectern with all related audio, video and control equipment securely installed.
   2. Provide lectern with the following features:
      a. Standard 19-inch equipment rack mounting
      b. Locking casters
      c. Space for two laptops to sit on work surface
      d. Space for cable management (specified below)
      e. Pull-out drawer for document camera.
      f. Reading light
      g. Clock
      h. Gooseneck microphone
      i. AC power distribution
      j. Locking storage drawer or compartment
      k. Flat zone for setting touch panel
   3. Wood Species and Finish: per Architect
   4. Hardware Finish: per Architect
   5. Acceptable Manufacturers:
      a. Middle Atlantic
      b. Miller’s Millwork
      c. Marshall Furniture
         i. Quantity: 1

B. Lectern Equipment
   1. Integrate specified equipment within lectern specified above. Coordinate installation with Owner’s Designated Representative. Secure all equipment neatly within lectern. Provide a means for coiling, storing, and securing excess umbilical cabling within lectern. Provide with all required power supplies and distribution.
   2. Cable Management

a. Provide cable management enclosure mounted in lectern. Provide with cables and cable umbilical as shown on the functional diagram. Label all cables near connector with function. Install in top of lectern as directed by Owner's Designated Representative.
b. Provide unit with the following:
    i. Two 120V AC Power Outlets
    ii. Two powered USB outlets
    iii. HDMI cable with retractor
    iv. VGA/Audio cable with retractor
    v. UTP network cable with retractor
c. Extron Cable Cubby 1200 assembly
d. Equal
    i. Quantity: 1

3. Gooseneck Microphone Mount
    a. Provide gooseneck microphone mount flush-mounted in top of lectern. Provide with finish chosen from manufacturer's standard options as directed by Architect.
    b. FSR T3-MJ-XXX
    c. Equal
        i. Quantity: 1
4. Cables
    a. HDMI
        i. Extron HDMI Ultra/15
        ii. Crestron CBL-HD-20
            1) Quantity: 4
    b. VGA
        i. Extron VGA-A M-M MD/25
        ii. Crestron CBL-VGA-AUD-20
            1) Quantity: 2
5. Cable Adapters
    a. DVI to HDMI
        i. Extron HDMIF-DVIDM
        ii. Equal
            1) Quantity: 2
    b. Displayport to HDMI
        i. Extron DPM-HDMIF
        ii. Equal
            1) Quantity: 2
6. Umbilical Cord
    a. Provide 15-foot long umbilical cord for lectern with power, data, and signal cables bundled within a flexible synthetic mesh, clearly labeled and provided with appropriate strain relief. All cables in the umbilical should be designed for hard usage and repeated handling. Use of cables designed for installation in conduit will not be accepted.

i. Quantity: 1

C. Floor Box Input Panel
1. Provide two-gang digital transport input panel with support for HDMI, DVI, DisplayPort, RGB, component, S-Video and composite video signal formats. Provide unit with support for HDMI and analog stereo audio signal formats. Provide device which transports all video signals digitally to the A/V switcher over a single CAT5e cable. Provide with cover plate suitable for floor box.
a. Crestron DM-TX-200-C-2G
b. Extron DTP T UWP 232D
c. AMX Equal
i. Quantity: 2

D. Blu-ray Player
1. Provide Blu-ray disc player with RS-232 and Ethernet control, DVD support and rack mounting kit.
a. Denon DN-500BD
b. Equal
i. Quantity: 1

E. Network Presentation Gateway
1. Provide presentation gateway designed to receiver wireless audio and video signals and transmit over HDMI connector. Provide with rack-mount shelf. Coordinate networking with Owner's IT department.
a. Crestron AM-101
b. Extron ShareLink 250
c. Mersive Solstice Pod
i. Quantity: 1

F. Pan/Tilt/Zoom Camera
1. Provide full-HD pan/tilt/zoom camera with HD-SDI output, H.264 IP streaming output, line level input, and IP remote control. All outputs shall be active simultaneously. Provide with remote power supply, wiring and accessories as required to power from main equipment rack. Provide with wall mount.
a. Panasonic AW-HE130N
b. Sony equal
i. Quantity: 1

G. 1x8 Video Distribution Amplifier
1. Provide composite video distribution amplifier with one input and eight outputs. Provide device with separate gain and equalization controls for each channel pair.
a. Extron DA 8V/4V Dual EQ
b. Equal
i. Quantity: 1

H. Fixed Monitor Camera

1. Provide fixed day/night color camera with auto-iris, 480 lines of horizontal resolution in color, auto white balance, gain control, wide dynamic range and backlight compensation. Provide unit with varifocal lens. Provide unit with remote power supply as required.
2. Provide with pipe-clamp mount to mount to control booth wall pipe.
    a. Pelco C20-DW series w/ lens
    b. Equal
        i. Quantity: 1

I. Composite Video Monitor
1. Provide 15-inch diagonal color flat panel monitor designed for 24-hour, 7-day a week use with minimum 1024x768 native resolution and composite video input. Provide unit with adjustable tilt and desk stand.
    a. Orion Images
    b. AG Neovo
    c. Equal
        i. Quantity: 1

2.13 AUDITORIUM VIDEO SYSTEM PROCESSING AND CONTROL EQUIPMENT

A. Integrated Audiovisual Matrix Switcher and Controller
1. Provide audiovisual matrix switcher and integrated system control processor with the following properties:
    a. Local HDMI inputs: 4
    b. Local RGB inputs: 2
    c. Remote category cable digital video inputs: 2
    d. Local HDMI outputs: 2
    e. Remote category cable digital video outputs: 2
    f. Bidirectional RS-232 ports: 2
    g. Logic inputs: 4
    h. IR Outputs: 4
    i. Program audio output
    j. Ethernet support
    k. HDCP key management
    l. EDID management
    m. Fast HDMI switching
    n. CEC signal management
    o. HDBT-compatible projector output
    p. iPad control license or application credit
        i. Crestron DMPS3-4k-300-C
        ii. Extron DTP CrossPoint 84 IPCP
        iii. AMX Equal
            1) Quantity: 1

2.14 AUDITORIUM VIDEO SYSTEM OUTPUT EQUIPMENT

A. Video Projector
   1. Provide video projector with laser phosphor light source, 11,500 ANSI lumen output (minimum), 7500:1 contrast ratio (minimum), 133% vertical lens shift, HDBaseT input, and a native aspect ratio of 16:9 and minimum resolution of 1920x1080. Provide projector with zoom lens and recallable zoom, focus and lens shift presets. Verify final throw distance to projection screen, screen size and geometry before ordering lens.
      a. Christie D13HD-HS w/ zoom lens
      b. Equal
         i. Quantity: 1

B. Video Projector Mount
   1. Provide mount for projector with all required accessories to suspend projector from structure. Provide in black or white, per Architect.
      a. Chief VCMU
      b. Equal
         i. Quantity: 1

C. Video Monitor
   1. Provide 24-inch diagonal flat-panel LCD with matte screen, 16:9 aspect ratio, 1920x1080 resolution, HDCP support, and HDMI input. Provide unit from one of the following manufacturers.
      a. Samsung
      b. HP
      c. NEC
      d. LG
         i. Quantity: 1

2.15 AUDITORIUM CONTROL SYSTEM EQUIPMENT

A. Touch Panel
   1. Provide 10” diagonal touch panel. Provide touch panel that can be controlled and powered by single Category cable. Mount one touch panel in rack panel, one touch panel mounted on lectern and portable touch panel with table-top kit.
      a. Crestron TSW-1052-B-S
      b. Extron equal
      c. AMX Equal
         1) Quantity: 3

B. Touch Panel Mounting Kit
   1. Provide table-top mounting kit for 10” touch panel.
      a. Crestron TSW1050-TTK-B-S
      b. Extron Equal
      c. AMX Equal
         1) Quantity: 2

C. Cables

1. Provide serial interface cables, infrared emitters, and line amplifiers as required to control devices shown on the Drawings.

2.16 GYMNASIUM AUDIO CONTROL AND AMPLIFICATION EQUIPMENT

A. 8-Channel Mixer
   1. Provide rack-mounted mixer with at least 8 microphone/line inputs. Provide with rack-mounting kit. Mount in rolling portable equipment rack.
      a. Shure SCM800
      b. Equal
         i. Quantity: 1

B. Uninterruptible Power Supply
   1. Provide 1000VA minimum rack-mounted UPS system to provide power-surge and power-loss protection to digital signal processor system.
      a. APC SUA1000RM2U
      b. Powerware 5125 1000 RM
      c. Middle Atlantic UPS-1000R
         i. Quantity: 1

C. Digital Signal Processor
   1. Provide digital signal processing system with inputs and outputs as shown on drawings, and the following functions. Provide all required devices, accessories, switches and cables to achieve a complete working system.
      a. Feedback suppression
      b. Nine bands of parametric equalization per signal input group
      c. Crossover
      d. Compressor
      e. Digital delay
      f. Signal limiting
      g. Digital audio signal routing
      h. Signal flow as shown on sound system functional drawing(s)
      i. Volume control
      j. Dante Ethernet based digital audio networking
         i. BSS London BLU
         ii. Biamp Tesira
         iii. Symetrix EDGE
         iv. QSC Q-Sys
            1) Quantity: 1 complete system, as required

D. Digital Signal Processor Preset Description
   1. Provide digital signal processing settings as described below. Exact determination of digital processor settings is an iterative process and final settings should be determined and documented with careful field measurements. Configure the default mode (with no muting) when master power switch is turned on. Configure so that all inputs are routed to appropriate outputs unless complete routing/rewiring of the internal DSP software

devices is required. Presets are described below as parameter changes that do not require a muting and reinitializing of the digital signal processor.

a. Muting Presets:
    i. East Court Loudspeakers on/off
    ii. West Court Loudspeakers on/off
    iii. End Court Loudspeakers on/off
    iv. Home Bleachers on/off
    v. Visitor Bleachers on/off

E. Digital Signal Processor Volume Control
1. Provide multi-station volume control compatible with Digital Signal Processor.
    a. Symetrix ARC-K1
    b. Biamp TEC-1s
    c. BSS Contrio EC-V
        i. Quantity: 2

F. Volume Control Protection
1. Provide clear polycarbonate vandalism protection for Digital Signal Processor Volume Control. Provide in size as required to fit volume control. Provide with custom label, per Drawings. Provide with custom faceplate to mount Volume Control. Label color per Architect.
    a. STI Universal Stopper
    b. Equal
        i. Quantity: 2

G. Touch Panel
1. Provide 5 inch touch panel (minimum) mounted in rack panel to control digital signal processor functions per functional diagrams. Provide with any required power supply and connection cables required to control Digital Signal Processor.
    a. Crestron TSW-550-B-S
    b. AMX Equal
    c. Extron Equal
        i. Quantity: 1 assembly

H. Room Controller
1. Provide compact control processor with Ethernet and RS-232 connections. Connect to build-wide control system. Provide with power supply. Mount to blank rack panel on rear rack rails.
    a. Crestron RMC3
    b. Extron Equal
    c. AMX Equal
        i. Quantity: 1

I. Ethernet Switch
1. Provide SNMP capable, POE enabled, managed, gigabit Ethernet switches as required to support a Dante audio network with functionality equivalent to audio network shown on

drawings and control system network. Provide Ethernet products compliant with IEEE 802.3.

2. Provide switch with multi-mode fiber interfaces to create network topology, per Drawings.
    a. Pakedge
    b. Cisco
    c. HP
    d. Equal
        i. Quantity: 1

J. Power Amplifier
1. Provide eight-channel, power amplifiers with balanced bridging inputs, continuously variable-speed fan(s). Provide amplifier which are 2-rack space units high. Provide amplifier which provide at least 600 watts output (nominal) per channel into 4 ohms and 600 watts output (nominal) per channel into 8 ohms or 70 volts.
    a. Crown DCi 8|600
    b. QSC CXD8.4Qn
    c. Equal
        i. Quantity: 1

K. Power Amplifier
1. Provide four-channel power amplifier with balanced bridging inputs and variable-speed fan(s). Provide amplifier which is 2-rack space units high. Provide amplifier which supplies at least 300-watts (nominal) per channel at 8-ohms and at least 500-watts (nominal) per channel at 4-ohms.
    a. Crown DCi 4|600
    b. Lab.gruppen C28:4
    c. QSC CXD4.2Q
        i. Quantity: 1

2.17 GYMNASIUM EQUIPMENT RACKS AND ACCESSORIES

A. Main Equipment Rack
1. Provide floor-mounted equipment rack with pivoting center section, floor base, and vented, lockable front door. Fill in unused rack space with blank solid panels, per industry best practices for air flow. Provide rack, accessories, and filler panels in smooth (not wrinkle) matte black finish. Provide with thermostatically controlled fan kit.
    a. Middle Atlantic SR-40-32 w/ DWR-FK32, FC-2-215-1CA
    b. Equal
        i. Quantity: 1

B. Rolling Portable Equipment Rack
1. Provide 14-rack unit rolling portable equipment case for wireless microphone system, microphone mixer, CD player, portable media player interfaces, rack drawer and power and light units. Provide unit with 4-inch casters, front and rear racks rails, wood top and metal front and rear doors. Provide complete with rack-mounted power strip and at least two (2) spare power receptacles. Provide 25-foot balanced audio cables for connecting equipment outputs to input receptacles.
    a. Middle Atlantic PTRK-14MDK

b. Equal

i. Quantity: 1

C. Rack Power Wiring

1. Furnish equipment racks with permanently-mounted 3-conductor AC power receptacles with sufficient outlets to meet system needs plus at least 4 spares per rack. Provide raceway configured with separately circuited receptacle groups as required to distribute load across multiple circuits. Provide whip for connection to power junction box as indicated on the power plan drawings.

a. Juice Goose CQ-PD1-4, CQ2200, CQ2000 (special order IG version)

b. Middle Atlantic MPR Series w/ RLM-20IG modules

i. Quantity: As required

D. System Power Control

1. Provide a relay-controlled power switching system with a master power switch and power-on indicator for the system. Connect the master power switch to control each receptacle in the rack except for one of the spare receptacles. Label unswitched receptacles "UNSWITCHED". Connect power for rack illumination to bypass the system master power switch. Provide a means to cycle the system power amplifiers on sequentially at intervals of approximately one second whenever the power switch is activated.

a. Middle Atlantic USC-6R

b. Atlas Sound SACR-191

c. Juice Goose CQ1520

i. Quantity: 1

E. Rack Work Light

1. Provide magnetically mounted gooseneck locally switched LED utility lighting. Connect to unswitched receptacle. Mount in back of equipment racks.

a. Middle Atlantic LT-GN-WL

b. Equal

i. Quantity: 1

F. 2 Rack Unit Locking Storage Drawer

1. Provide 2 rack space locking rack mounted drawer.

a. Middle Atlantic D2-LK

b. Raxxess SDR-2 w/ lock

c. Quantity:

i. 1 main equipment rack

ii. 1 rolling portable equipment rack

2.18 GYMNASIUM LOUDSPEAKER COMPONENTS

A. Loudspeakers

1. Provide passive 2-way loudspeaker with 12-inch low frequency transducer, 2-inch voice coil high frequency compression driver, and rotatable waveguide. Provide with all necessary mounting hardware. Provide loudspeaker and hanging hardware in finish per Architect.

a. EAW VFR129i
b. JBL AC299
c. Electro-Voice EVF-S/12
    i. Quantity: 24

B. Loudspeaker Rigging Suspension Equipment
1. Provide contractor fabricated and designed loudspeaker rigging for loudspeaker clusters and suspended loudspeakers. Suspend loudspeaker components from brackets and any necessary suspension frames to minimize total number of ceiling hanging points. Provide with a sufficient number of suspension points for field adjustment of loudspeaker aiming. Provide with color as designated by the Architect. During fabrication and installation verify that adequate clearance from all other hanging components and adequate clearance from structural steel is provided. Provide any additional rigging hardware necessary for the safe and proper installation of these loudspeakers.
2. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated in the Work include, but are not limited to, the following:
    a. Ape Rigging
    b. Polar Focus
    c. ATM-Flyware
    d. Approved Contractor-Fabricated Assembly (*Show evidence of successful completion of previous projects)
3. Submit all drawings of the complete final loudspeaker rigging assemblies to a certified structural engineer and obtain approval and stamped copies of the drawings. Drawings should detail all connections from attachment to building structure to loudspeaker.

2.19 GYMNASIUM AUDIO SOURCE EQUIPMENT

A. Handheld Wireless Microphone System
1. Provide all antennas, transmitters, and receivers by a single manufacturer. Provide dual-channel UHF system which allows simultaneous and independent operation from other wireless systems at the school. Provide complete with rack-mounting kit. Provide with handheld microphone transmitters.
    a. Shure BLX288/SM58 system
    b. Sennheiser Equal
        i. Quantity: 1

B. Vocal Microphone
1. Provide microphone for "close-miked" use by popular, jazz, or folk singers. Provide complete with stand adapters as necessary. Provide with flexible microphone cable as specified above.
    a. Shure SM58-LC
    b. Electro-Voice N/D 267
    c. Audix OM-3xb
    d. Sennheiser E835
        i. Quantity: 2

C. Microphone Floor Stand (tripod base)

1. Provide adjustable black microphone stand with 5/8-inch thread and tripod base. Provide with adjustable-length boom arm.
    a. Atlas TL34-21XE
    b. On-Stage MS7701TB
        i. Quantity: 2

D. Microphone Table Stand
1. Provide a round base stand with 5/8-inch thread, round weighted metal base with adjustable height from approximately 8" - 13". Provide stand in black finish.
    a. Atlas DS-7E
    b. AKG Equivalent
    c. On-Stage DS-7200QRB
        i. Quantity: 2

E. CD/Media Player
1. Provide 1U compact disc player with balanced outputs, auxiliary input, Bluetooth audio input, and IR remote.
    a. Denon DN-300Z
    b. Equal
        i. Quantity: 1

F. Line Level Audio Volume Control
1. Provide line level audio volume control assembly.
    a. RDL ST-VCA3 w/ D-RLC10K mounted in rack panel
    b. Equal assembly
        i. Quantity: 1

G. Media Shelf
1. Provide rack-mounted compartment with cabling grommets designed for use with portable media players. Provide with integral power/USB outlets mounted on back panel of shelf, per Drawings.
    a. Middle Atlantic SH-DMP-S W/ custom plates
    b. Equal Assembly
        i. Quantity: 1 stage equipment rack

2.20 GYMNASIUM ASSISTIVE LISTENING EQUIPMENT

A. Provide wireless assistive listening system consisting of an FM transmitter, an antenna mounted as indicated on drawings, and portable battery-operated receivers with earphones and inductive couplers (the latter for use with hearing aids with "T" switches). Provide frequencies separate and free from interference with other FM systems. Provide all assistive listening system components from the same manufacturer.

B. Transmitter
1. Listen Technologies LT800 with LA-326 rack mounting kit
2. Williams PPA T35 with RPK 006 rack mounting kit
    a. Quantity: 1

C. Transmitter Antenna

1. Provide coaxial di-pole antenna suitable for use with FM transmitter.
    a. Listen Technologies LA-116
    b. Williams ANT 005 with extension cable
        i. Quantity: 1

2.21 CAFETERIA AUDIO EQUIPMENT

A. Wireless Microphone System
1. Provide all antennas, transmitters, and receivers by a single manufacturer.
2. Provide digital wireless microphone system with AES 256-bit encryption, Dante audio networking, allow up to 16 active transmitters on one 6 Mhz TV channel, switching diversity.
3. Provide all required power supplies and accessories to achieve intent of Drawings.
4. Provide complete with rack-mounting kits.
    a. Dual-Channel Receiver
        i. Shure ULXD4D
        ii. Equal
            1) Quantity: 1
    b. Handheld Transmitter
        i. Shure ULXD2/SM58
        ii. Equal
            1) Quantity: 2
    c. Rechargeable Battery
        i. Shure SB900
        ii. Equal
            1) Quantity: 4
    d. Charging Station
        i. Shure SBC200-US
        ii. Equal
            1) Quantity: 1
    e. Wall-Mount Antenna
        i. Shure UA864US
        ii. Equal
            1) Quantity: 2

B. Digital Signal Processor
1. Provide digital signal processing system with inputs and outputs as shown on drawings, and the following functions. Provide all required devices, accessories, switches and cables to achieve a complete working system.
    a. Feedback suppression
    b. Nine bands of parametric equalization per signal input group
    c. Crossover
    d. Compressor
    e. Digital delay

f. Signal limiting
g. Digital audio signal routing
h. Signal flow as shown on sound system functional drawing(s)
i. Volume control
j. Dante Ethernet-based digital audio networking
    i. BSS London BLU
    ii. Biamp Tesira
    iii. Symetrix EDGE
    iv. QSC Q-Sys
        1) Quantity: 1 complete system, as required

C. Digital Signal Processor Preset Description
1. Provide digital signal processing settings as described below. Exact determination of digital processor settings is an iterative process and final settings should be determined and documented with careful field measurements. Configure the default mode (with no muting) when master power switch is turned on. Configure so that all inputs are routed to appropriate outputs unless complete routing/rewiring of the internal DSP software devices is required. Presets are described below as parameter changes that do not require a muting and reinitializing of the digital signal processor.
    a. Source Selection Presets
        i. CD Player
        ii. Wall Input
        iii. Auditorium (act as lobby)
    b. Microphone volume control
    c. Program volume control

D. Ethernet Switch
1. Provide SNMP capable, POE+ enabled, gigabit Ethernet switches as required to support a Dante audio network with functionality equivalent to audio network shown on drawings and control system network. Provide Ethernet products compliant with IEEE 802.3.
2. Provide switch with multi-mode fiber interfaces to create network topology, per Drawings.\
    a. Cisco
    b. Pakedge
    c. HP
    d. Equal

E. CD/Media Player
1. Provide 1U compact disc player with balanced outputs, auxiliary input, Bluetooth audio input, and IR remote.
    a. Denon DN-300Z
    b. Equal
        i. Quantity: 1

F. Media Shelf

1. Provide rack-mounted compartment with cabling grommets designed for use with portable media players. Provide with pair stereo phone (RCA) connectors with 1/8-inch stereo phone plug to RCA cable for connection to portable media players.
    a. Middle Atlantic SH-DMP-S w/ custom plate
    b. Equal Assembly
        i. Quantity: 1

G. Ceiling Mounted Loudspeaker, Pendant
1. Provide 2-way pendant loudspeaker with 8-inch low frequency driver, 1.4-inch high frequency driver and 70-volt transformer with selectable tap. Provide unit with 85 degree nominal coverage angle.
2. Provide with all required hanging hardware.
3. Provide unit in black or white, per Architect.
    a. Soundtube HP890i
    b. Equal
        i. Quantity: per Drawings

H. Ceiling Mounted Loudspeaker, Flush
1. Provide flush-mounted 70.7 Volt loudspeaker/transformer assembly with 4.5 inch full-range driver, 70-volt transformer with selectable tap and all required mounting hardware.
2. Provide grill and surround baffle in black or white, per Architect.
    a. QSC AC-C4T
    b. JBL equal
    c. Equal
        i. Quantity: per Drawings

I. Power Amplifier
1. Provide eight-channel power amplifier with balanced bridging inputs, continuously variable-speed fan(s) or convection cooled. Provide amplifier which provides at least 300 watts output (nominal) per channel into 70 volts.
    a. Crown DCi 8|300
    b. Equal
        i. Quantity: 1

2.22 CAFETERIA EQUIPMENT RACK AND ACCESSORIES

A. Equipment Rack
1. Provide floor-mounted equipment rack with pivoting center section, floor base, and vented, lockable front door. Fill in unused rack space with blank solid panels, per industry best practices for air flow. Provide rack, accessories, and filler panels in smooth (not wrinkle) matte black finish. Provide with thermostatically controlled fan kit.
    a. Middle Atlantic SR-40-28 w/ DWR-FK32, FC-2-215-1CA
    b. Quantity: 1
        i. Quantity: 1

B. Rack Power Wiring
1. Furnish equipment racks with permanently-mounted 3-conductor AC power receptacles with sufficient outlets to meet system needs plus at least 2 spares per rack. Provide raceway configured with separately circuited receptacle groups as required to distribute

load across multiple circuits. Provide whip with plug to match for connection to power outlet box as indicated on the power plan drawings.

a. Juice Goose CQ-PD1-4, CQ2200, CQ2000 (special order IG version)
b. Middle Atlantic MPR Series w/ RLM-20IG modules
c. Equal
    i. Quantity: As required

C. Power Sequencer
1. Provide a relay-controlled power switching system with a master power switch and power-on indicator for the system. Connect the master power switch to control each receptacle in the rack except for one of the spare receptacles. Label unswitched receptacles "UNSWITCHED". Connect power for rack illumination to bypass the system master power switch. Provide a means to cycle the system power amplifiers on sequentially at intervals of approximately one second whenever the power switch is activated.
    a. Middle Atlantic USC-6R
    b. Atlas Sound SACR-191
    c. Juice Goose CQ1520
        i. Quantity: 1

D. 4 Rack Unit Locking Storage Drawer
1. Provide 4 rack space locking rack mounted drawer.
    a. Middle Atlantic D4-LK
    b. Raxxess SDR-4 w/ lock
    c. Equal
        i. Quantity: 1

E. Uninterruptible Power Supply
1. Provide 1000VA minimum rack-mounted UPS system to provide power-surge and power-loss protection to digital signal processor system.
    a. APC SUA1000RM2U
    b. Powerware 5125 1000 RM
    c. Middle Atlantic UPS-1000R
        i. Quantity: 1

2. CAFETERIA VIDEO EQUIPMENT

a. Input Panel
    i. Provide two-gang digital transport input panel with support for HDMI, DVI, DisplayPort, RGB, component, S-Video and composite video signal formats. Provide unit with support for HDMI and analog stereo audio signal formats. Provide device which transports all video signals digitally to the A/V switcher over a single category cable.
        1) Crestron DM-TX-200-C-2G
        2) Extron DTP T UWP 232D
        3) AMX Equal
            i) Quantity: 1

b. Audiovisual Matrix Switcher and Controller

i. Provide audiovisual matrix switcher and integrated system control processor with the following properties:
   1) Local HDMI inputs: 4
   2) Local RGB inputs: 4
   3) Remote category cable digital video inputs: 1
   4) Local HDMI outputs: 1
   5) Remote category cable digital video outputs: 1
   6) Bidirectional RS-232 ports: 1
   7) Microphone Input
   8) Logic inputs: 2
   9) IR Outputs: 1
   10) Program audio output
   11) Ethernet support
   12) HDCP key management
   13) EDID management
   14) Fast HDMI switching
   15) CEC signal management
   16) HDBT-compatible projector output
      i) Crestron DMPS3-4K-150-C
      ii) Extron DTP Series Equal
      iii) AMX Equal
         a) Quantity: 1

c. Video Projector
   i. Provide solid-state video projector with 10,000 ANSI lumen output (minimum), 2,000,000:1 contrast ratio (minimum), HDBaseT input, and a native aspect ratio of 16:9 and minimum resolution of 1920x1080. Provide projector with zoom lens and recallable zoom, focus and lens shift presets. Verify final throw distance to projection screen, screen size and geometry before ordering lens.
      1) Christie DHD1075-GS w/ zoom lens
      2) Equal
         i) Quantity: 1

d. Video Projector Security Enclosure
   i. Provide steel security cage sized to fit provide projector. Provide with integrated projector mount and all accessories required to hang from structure above. Provide in black or white, per Architect.
      1) Display Devices SC-PCM
      2) Equal
         i) Quantity: 1

3. DINING CONTROL EQUIPMENT

a. Touch Panel
   i. Provide 7” diagonal touch panel with 800x480 resolution. Provide touch panel that can be controlled and powered by single Category cable. Provide on rack mount panel.
      1) Crestron TSW-760-B-S
      2) Extron TLP Pro 720M
      3) AMX Equal
         i) Quantity: 1

2.23 CAFETERIA ASSISTIVE LISTENING EQUIPMENT

A. Assistive Listening Transmitter
   1. Listen Technologies LT800 with LA-326 rack mounting kit
   2. Williams PPA T35 with RPK 006 rack mounting kit
   3. Equal
      a. Quantity: 1

B. Assistive Listening Antenna
   1. Listen Technologies LA-124
   2. Williams Equal
   3. Equal
      a. Quantity: 1

2.24 MUSIC CLASSROOM SYSTEMS

A. System below is typical. Provide one system each for each room:
   1. Choral
   2. Band
   3. Piano Lab

B. Recording Microphone
   1. Provide suspended microphone with extension cable and isolation mount. Suspend from ceiling for optimum pickup of room activities. Determine final location with Architect. Provide phantom powered condenser microphone with cardioid pickup pattern. Secure rotation with mono-filament fishing line.
      a. Audio-Technica BP4025
      b. Sennheiser MKE 44P w/ shock absorber and extension cable
         i. Quantity: 1

C. Recording Microphone Suspension Mount
   1. Provide hanging accessory to allow suspended microphone to be suspended in its stand attachment using its signal cable. Secure rotation with monofilament line.
      a. Ace Backstage Microphone Hanger Slug #42
      b. Equal
         i. Quantity: 1

D. CD/Media Player
   1. Provide 1U compact disc player with balanced outputs, auxiliary input, Bluetooth audio input, and IR remote.
      a. Denon DN-300Z
      b. Equal
         i. Quantity: 1

E. Recording Mixer
   1. Provide six-input microphone/line mixer. Connect to other devices, as shown on Drawings, with XLR audio cables similar to construction of cables specified herein for use with portable microphones.
      a. Ashly MX-406
      b. Equal
         i. Quantity: 1

F. Combination Solid State and CD Recorder
   1. Provide 1U device capable of recording stereo audio either directly to a removable flash memory card in WAVE and MP3 format, or to compact disc. Provide device with balanced analog audio inputs and outputs and coaxial digital inputs and outputs.
      a. Tascam SS-CDR250N w/ 32GB CF Card
      b. Equal
         i. Quantity: 1

G. Integrated Amplifier
   1. Provide integrated amplifier, unbalanced inputs, pre-amplifier line-level output and power amplifier with 90 watts continuous (minimum) into 8 ohms. Provide with rack mount hardware.
   2. Label unit to correspond to inputs.
      a. Yamaha A-S1100
      b. Marantz PM8006
      c. Equal
         i. Quantity: 1

H. Equipment Rack
   1. Provide 20 rack space equipment rack with locking 3” casters, locking front door and laminate top. Provide with fan cooling kit. Finish per Architect.
      a. Middle Atlantic MFR-2027-XX w/ MFR-FANKIT-2
      b. Equal
         i. Quantity: 1

I. Rack Mounted Power Strip
   1. Provide 1 rack unit 15-amp surge-protector and power strip with EMI/RFI filtering, series mode surge protection. Provide unit with remote control contact closure.
      a. Surge-X SX1115-RT
      b. Equal
         i. Quantity: 1

J. Program Loudspeakers
   1. Provide two wall-mounted playback loudspeakers with 10-inch low-frequency drivers. Mount on wall with swivel mount as designated by Architect. Provide complete with all necessary mounting hardware. Color per Architect.
      a. QSC AD-S10T w/ X-Mount
      b. Equal
         i. Quantity: 2

K. Assistive Listening System
   1. Provide assistive listening system complete with rack-mount transmitter, antenna, signage, belt-pack receivers, headphones and neck loops.
      a. Listen Technologies LS-17-072
      b. Equal
         i. Quantity: 1

2.25 LARGE GROUP SEMINAR EQUIPMENT

A. Wireless Microphone System
1. Provide all antennas, transmitters, and receivers by a single manufacturer.
2. Provide digital wireless microphone system with AES 256-bit encryption, Dante audio networking, allow up to 16 active transmitters on one 6 Mhz TV channel, switching diversity.
3. Provide all required power supplies and accessories to achieve intent of Drawings.
4. Provide with 1/2 –wave antenna mounted to outside of equipment rack.
5. Provide complete with rack-mounting kits.
a. Dual-Channel Receiver
i. Shure ULXD4D
ii. Equal
1) Quantity: 1
b. Handheld Transmitter
i. Shure ULXD2/SM58
ii. Equal
1) Quantity: 2
c. Rechargeable Battery
i. Shure SB900
ii. Equal
1) Quantity: 4
d. Charging Station
i. Shure SBC200-US
ii. Equal
1) Quantity: 1

B. Digital Signal Processor
1. Provide digital signal processing system with inputs and outputs as shown on drawings, and the following functions. Provide all required devices, accessories, switches and cables to achieve a complete working system.
a. Feedback suppression
b. Nine bands of parametric equalization per signal input group
c. Crossover
d. Compressor
e. Digital delay
f. Signal limiting
g. Digital audio signal routing
h. Signal flow as shown on sound system functional drawing(s)
i. Volume control
j. Dante Ethernet based digital audio networking
i. BSS London BLU
ii. Biamp Tesira
iii. Symetrix EDGE

iv. QSC Q-Sys

1) Quantity: 1 complete system, as required

C. Ethernet Switch

1. Provide SNMP capable, POE+ enabled, gigabit Ethernet switches as required to support a Dante audio network with functionality equivalent to audio network shown on drawings and control system network. Provide Ethernet products compliant with IEEE 802.3.

a. Cisco

b. Pakedge

c. HP

d. Equal

D. Power Amplifier

1. Provide 4-channel power amplifier with balance bridging inputs and variable speed fan(s). Provide amplifier which is 2-rack space units high. Provide amplifier which supplies at least 300-watts (nominal) per channel at 8-ohms or 70-volts

a. Crown Dci 4|300

b. Equal

i. Quantity: 1

E. Ceiling Loudspeakers

1. Provide low-profile 70-volt ceiling loudspeaker with 6.5 inch driver and 110 degree conical coverage pattern.

a. JBL Control 26CT

b. Equal

i. Quantity: per Drawings

F. Wall-mounted Equipment Rack

1. Provide wall-mounted swing out equipment rack. Provide unit with minimum 24 inches of usable depth.

a. Middle Atlantic DWR series

b. Equal

i. Quantity: 1

G. 2 Rack Unit Locking Storage Drawer

1. Provide 2 rack space locking rack mounted drawer.

a. Middle Atlantic D2-LK

b. Raxxess SDR-2 w/ lock

i. Quantity: 1

H. Input Panel

1. Provide two-gang digital transport input panel with support for HDMI, DVI, DisplayPort, RGB, component, S-Video and composite video signal formats. Provide unit with support for HDMI and analog stereo audio signal formats. Provide device which transports all video signals digitally to the A/V switcher over a single category cable.

a. Crestron DM-TX-200-C-2G

b. Extron DTP T UWP 232D

c. AMX Equal
    i. Quantity: 1

I. Audiovisual Matrix Switcher and Controller
1. Provide audiovisual matrix switcher with the following properties:
    a. Local HDMI inputs: per Drawings
    b. Remote category cable digital video inputs: per Drawings
    c. Local HDMI outputs: per Drawings
    d. Remote category cable digital video outputs: per Drawings
    e. HD-SDI Inputs: per Drawings
    f. Program audio output
    g. Ethernet support
    h. HDCP key management
    i. EDID management
    j. Fast HDMI switching
    k. CEC signal management
    l. HDBT-compatible projector output
        i. Crestron DMPS3-4K-350-C
        ii. Extron DTP Series
        iii. AMX Equal
            1) Quantity: 1

J. Control Panel
1. Provide wall-mounted control panel.
    a. Crestron MPC3-302-W
    b. Equal
        i. Quantity: 1

K. Blu-ray Player
1. Provide Blu-ray disc player with RS-232 and Ethernet control, DVD support and rack mounting kit.
    a. Denon DN-500BD
    b. Equal
        i. Quantity: 1

L. Network Gateway
1. Provide presentation gateway designed to receiver wireless audio and video signals and transmit over HDMI connector. Provide with rack-mount shelf. Coordinate networking with Owner’s IT department.
    a. Crestron AM-101
    b. Extron ShareLink 250
    c. Mersive Solstice Pod
        i. Quantity: 1

M. Video Projector

1. Provide solid-state video projector with 6,000 ANSI lumen output (minimum), 5000:1 contrast ratio (minimum), HDBaseT input, and a native aspect ratio of 16:9 and minimum resolution of 1920x1080. Provide projector with zoom lens and recallable zoom, focus and lens shift presets. Verify final throw distance to projection screen, screen size and geometry before ordering lens.
    a. Christie DHD700-GS w/ zoom lens
    b. Equal
        i. Quantity: 2

N. Video Projector Mount
1. Provide mount for projector with all required accessories to suspend projector from structure above or projector lift. Provide in black or white, per Architect.
    a. Chief VCMU
    b. Equal
        i. Quantity: 2

O. Assistive Listening System
1. Provide assistive listening system complete with rack-mount transmitter, antenna, signage, belt-pack receivers, headphones and neck loops.
    a. Listen Technologies LS-17-072
    b. Equal
        i. Quantity: 1

2.26 ATHLETIC FIELD SYSTEM

A. Main Equipment Rack
1. Provide floor-mounted equipment rack with pivoting center section, floor base, and vented, lockable front door. Fill in unused rack space with blank solid panels, per industry best practices for air flow. Provide rack, accessories, and filler panels in smooth (not wrinkle) matte black finish. Provide with thermostatically controlled fan kit.
    a. Middle Atlantic SR-24-32 w/ DWR-FK32, FC-2-215-1CA
    b. Equal
        i. Quantity: 1

B. Rack Power Wiring
1. Furnish equipment racks with permanently-mounted 3-conductor AC power receptacles with sufficient outlets to meet system needs plus at least 4 spares per rack. Provide raceway configured with separately circuited receptacle groups as required to distribute load across multiple circuits. Provide whip for connection to power junction box as indicated on the power plan drawings.
    a. Juice Goose CQ-PD1-4, CQ2200, CQ2000 (special order IG version)
    b. Middle Atlantic MPR Series w/ RLM-20IG modules
        i. Quantity: As required

C. System Power Control
1. Provide a relay-controlled power switching system with a master power switch and power-on indicator for the system. Connect the master power switch to control each receptacle in the rack except for one of the spare receptacles. Label unswitched receptacles "UNSWITCHED". Connect power for rack illumination to bypass the system

master power switch. Provide a means to cycle the system power amplifiers on sequentially at intervals of approximately one second whenever the power switch is activated.

a. Middle Atlantic USC-6R
b. Atlas Sound SACR-191
c. Juice Goose CQ1520
    i. Quantity: 1

D. Rack Work Light
1. Provide magnetically mounted gooseneck locally switched LED utility lighting. Connect to unswitched receptacle. Mount in back of equipment racks.
    a. Middle Atlantic LT-GN-WL
    b. Equal
        i. Quantity: 1

E. 2 Rack Unit Locking Storage Drawer
1. Provide 2 rack space locking rack mounted drawer.
    a. Middle Atlantic D2-LK
    b. Raxxess SDR-2 w/ lock
        i. Quantity: 1

F. Wireless Microphone System (Main Rack)
1. Provide all antennas, transmitters, and receivers by a single manufacturer.
2. Provide digital wireless microphone system with AES 256-bit encryption, Dante audio networking, allow up to 16 active transmitters on one 6 Mhz TV channel, switching diversity.
3. Provide all required power supplies and accessories to achieve intent of Drawings.
4. Provide complete with rack-mounting kits.
    a. Dual-Channel Receiver
        i. Shure ULXD4D
        ii. Equal
            1) Quantity: 1
    b. Handheld Transmitter
        i. Shure ULXD2/SM58
        ii. Equal
            1) Quantity: 2
    c. Beltpack Transmitter
        i. Shure ULXD1
        ii. Equal
            1) Quantity: 1
    d. In-Line Mute Switch
        i. Shure WA611
        ii. Equal
            1) Quantity: 1

e. Headworn Microphone
   i. Provide hypercardioid headworn condenser microphone.
      1) Shure WCM16
      2) Equal
         i) Quantity: 1
f. Rechargeable Battery
   i. Shure SB900
   ii. Equal
      1) Quantity: 4
g. Charging Station
   i. Shure SBC200-US
   ii. Equal
      1) Quantity: 2
h. Antenna
   i. Provide weatherproof antenna suitable for use with wireless microphone receiver. Provide with power inserter.
   ii. Mount to top of Press Box.
      1) Winegard FlatWave Air
      2) Equal
         i) Quantity: 2

G. Desktop Microphone
   1. Provide console assembly with gooseneck microphone and weighted base. Provide base with one momentary for push-to-talk. Provide with cable for connection to wall plate in in Press Box.
      a. Clock Audio DMB 1 w/D43 Gooseneck
      b. Equal
         i. Quantity: 1

H. Digital Signal Processor
   1. Provide digital signal processing system with inputs and outputs as shown on drawings, and the following functions. Provide all required devices, accessories, switches and cables to achieve a complete working system.
      a. Feedback suppression
      b. Nine bands of parametric equalization per signal input group
      c. Crossover
      d. Compressor
      e. Digital delay
      f. Signal limiting
      g. Digital audio signal routing
      h. Signal flow as shown on sound system functional drawing(s)
      i. Volume control
      j. Dante Ethernet based digital audio networking

i. BSS London BLU
ii. Biamp Tesira
iii. Symetrix EDGE
iv. QSC Q-Sys
1) Quantity: 1 complete system, as required

I. Ethernet Switch
1. Provide SNMP capable, POE+ enabled, gigabit Ethernet switches as required to support a Dante audio network with functionality equivalent to audio network shown on drawings and control system network. Provide Ethernet products compliant with IEEE 802.3.
a. Cisco
b. Pakedge
c. HP
d. Equal

J. DSP Control Panel
1. Provide desktop control surface compatible with Digital Signal Processor. Provide unit with POE+ power, six motorized faders, Ethernet-based control communications and a minimum of twelve programmable back-lit push buttons.
2. Provide with 15-foot Ethernet cable to connect to panel in Press Box.
a. Mystery Electronics EM12-Desktop
b. Equal
i. Quantity: 1

K. Portable Audio Mixing Console
1. Provide 12-channel compact audio mixer with four microphone level inputs, 12 line-level inputs, control room outputs, balanced main output, sealed rotatory controls, and steel chassis.
2. Provide with 15-foot cable to connect to wall panel in Press Box.
3. Provide with dustcover.
a. Mackie 1202VLZ4
b. Equal
i. Quantity: 1

L. Power Amplifier, Field Loudspeakers Low Frequency
1. Provide two-channel, power amplifier with balanced bridging inputs, continuously variable-speed fan(s). Provide amplifiers which are 2-rack space units high. Provide amplifiers which provide at least 1200 watts output (nominal) per channel into 4 ohms and 1200 watts output (nominal) per channel into 8 ohms.
a. Crown DCi 2|1250
b. Equal
i. Quantity: 1

M. Power Amplifier, 8 Channel
1. Provide eight-channel, power amplifier with balanced bridging inputs, continuously variable-speed fan(s). Provide amplifiers which are 2-rack space units high. Provide amplifiers which provide at least 600 watts output (nominal) per channel into 4 ohms and 600 watts output (nominal) per channel into 8 ohms.

a. Crown DCi 8|600
b. Equal
    i. Quantity: 1

N. Field Loudspeaker
1. Provide 3-way full range weather-resistant loudspeaker with dual 12-inch low-frequency drivers, 2-inch mid-range driver and 1.4-inch compression driver, and 90x40 degree coverage pattern. Provide with U-bracket to attach to pole mount.
    a. Community R2-94MAX
    b. Equal
        i. Quantity: 2

O. Bleacher Loudspeaker
1. Provide 2-way full range weather-resistant loudspeaker with 8-inch low-frequency driver and .75-inch high-frequency driver, and 90x40 degree coverage pattern. Provide with U-bracket to attach to pole mount.
    a. Community R.25-94z
    b. Equal
        i. Quantity: 3

P. Bleacher Loudspeaker Mounting Hardware
1. Provide wind-rated pole mount designed to mount to outdoor athletic light pole. Provide with all required accessories and hardware to suspend loudspeaker from u-bracket.
    a. Polar Focus PM2-10
        i. Quantity: 2

Q. Loudspeaker Suspension Equipment
1. Provide contractor fabricated and designed loudspeaker rigging for loudspeaker clusters and suspended loudspeakers. Suspend loudspeaker components from brackets and any necessary suspension frames to minimize total number of ceiling hanging points. Provide with a sufficient number of suspension points for field adjustment of loudspeaker aiming. Provide with color as designated by the Architect. During fabrication and installation verify that adequate clearance from all other hanging components and adequate clearance from structural steel is provided. Provide any additional rigging hardware necessary for the safe and proper installation of these loudspeakers.
2. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated in the Work include, but are not limited to, the following:
    a. Ape Rigging
    b. Polar Focus
    c. ATM-Flyware
    d. Approved Contractor-Fabricated Assembly (*Show evidence of successful completion of previous projects)
3. Submit all drawings of the complete final loudspeaker rigging assemblies to a certified structural engineer and obtain approval and stamped copies of the drawings. Drawings should detail all connections from attachment to building structure to loudspeaker.

2.27 ATHLETIC FIELD ASSISTIVE LISTENING EQUIPMENT

a. Provide wireless assistive listening system consisting of an FM transmitter, an antenna mounted as indicated on drawings, and portable battery-operated receivers with earphones and inductive couplers (the latter for use with hearing aids with "T" switches). Provide frequencies separate and free from interference with other FM systems. Provide all assistive listening system components from the same manufacturer.

b. Transmitter

2. Listen Technologies LT800 with LA-326 rack mounting kit
3. Williams PPA T35 with RPK 006 rack mounting kit
    a. Quantity: 1

b. Transmitter Antenna

4. Provide coaxial di-pole antenna suitable for use with FM transmitter.
    a. Listen Technologies LA-116
    b. Williams ANT 005 with extension cable
        i. Quantity: 1

2.28 SHARED ASSISTIVE LISTENING RECEIVERS

A. Receiver

1. Provide belt-pack receiver capable of receiving signals in each room with an FM-based ALS system. Provide with rechargeable batteries.
    a. Listen Technologies LR-300 w/ LA-162, batteries
    b. Williams PPA R35-8N with EAR 014 earphones
        i. Quantity: 55

B. Replacement Cushion

1. Listen Technologies LA-163
2. Williams EAR 015-10
    a. Quantity: 200 replacement pads

C. Over-Ear Earphones

1. Listen Technologies LA-164
2. Williams EAR 008
    a. Quantity: 55

D. Neckloop Induction Coil

1. Listen Technologies LA-166
2. Williams NKL 001
    a. Quantity: 14

E. Portable Charging Case

1. Provide portable charging cases with total capacity equal to or greater than quantity of receivers specified above.
    a. Listen Technologies LA-311
    b. Williams CHG 3512 PRO
    c. Quantity: as required

PART 3 - EXECUTION

3.1 INSTALLATION

A. Supply and install any racks, wire, conduits, pull boxes, junction boxes and raceways required to provide a complete system, to the extent that such items are not provided by others. Unless specifically instructed to the contrary, install all system wiring in steel conduit. Do not exceed 30% fill in conduits.

B. Use separate steel conduits for microphone-level circuits (below -20 dBm), line-level circuits (up to +30 dBm), loudspeaker circuits (above +30 dBm), control circuits, and power circuits. Use audio conduit which is spaced well away from power conduit. Insulate all conduit from the equipment rack(s); ground conduit only to power system ground. Do not splice lines in conduit. Connect each input receptacle by an individual, insulated line to the system equipment rack.

C. Secure equipment firmly in place, including control panels, loudspeakers, conduit, amplifiers, racks, and cables. Make fasteners and supports adequate to support their loads with a safety factor of at least three.

D. Take precautions to prevent electromagnetic and electrostatic hum. Install the equipment to provide safe operation.

E. Use terminal strips or blocks in all audio lines entering or leaving the system equipment rack(s). Make all joints and connections with rosin-core solder or with mechanical connectors appropriate for the service. Execute all wiring in strict adherence to standard broadcast practices.

F. Assemble and install equipment racks to permit access to connections and adjustments on the rear of rack-mounted components and to permit removal of components for servicing. For any components which, for purposes of adjustment or calibration, must be removed from an equipment rack while in use, provide adequate service loops on all connecting cables.

G. Provide safety cables prevent individual loudspeaker components from falling in case of failure or loosening of the primary component support. Paint all exposed components as directed by the Architect.

H. Locate microphone and line receptacles as directed by the Architect. Except for receptacles mounted in equipment cabinets or in floors or designated as surface-mounted, flush-mount other receptacles on cover plates in gang boxes recessed in vertical surfaces. Provide plate finish as approved by the Architect.

I. Install work neatly, with boxes, equipment, etc., plumb and square. Keep the job adequately staffed at all times. Designate an employee as field supervisor to be present on the job site and in responsible charge during all phases of installation and check-out. Maintain same supervisor through completion of the work unless the designated supervisor ceases to be an employee or unless by mutual agreement with the Owner or Architect. Install the system in cooperation with other trades in order to achieve coordinated progress and satisfactory final results. Watch for conflicts with work of other trades on the job. Execute, without claim for extra payment, moderate moves or changes as are necessary to accommodate other equipment or preserve symmetry and pleasing appearance.

J. Clearly, consistently, logically and permanently mark switches, connectors, jacks, relays, receptacles, cables, and cable terminations. Engrave and paint-fill all panel and receptacle markings, directly on the material on which controls or receptacles are mounted. Fill engraving with black or white paint, whichever contrasts best with panel finish, or as directed by the Architect. Use no hand-lettering, embossed tape (e.g. "Dymo" labels), or any adhesive- or otherwise mechanically-attached labels for any labels visible to operators or public during

normal system operation. Use adhesive- or screw-attached engraved or laminated labels (e.g., "Kroy" or "Brother") on manufactured assemblies, such as amplifiers, which otherwise would require disassembly for direct engraving. Use printed adhesive cable markers to mark cables, or other labels intended for the purpose. Use "Kroy" or "Brother" or similar machine-produced laminated labels, or "letter quality" or "near letter quality" mechanically-produced lettering for patch panel labels. Insert patch panel labels into clear plastic-covered label holders.

K. Label each receptacle with its type and a unique number; for example, "MIC 18", "FP3" "A/V Input Panel 5". Label each jack with the name of the device to which it is connected, plus "IN" for input or "OUT" for output. In addition, label horizontal rows of jacks with letters "A", "B", etc., and vertical columns with numbers "1", "2", etc.

L. Paint or provide approved factory finishes for all system components exposed to public view as directed by Architect. Paint or otherwise remove all visible manufacturers' trademarks exposed to public view as directed by Architect.

M. If any item of equipment includes exposed controls which are not used in system operation, and if those controls cannot be locked, capped, or concealed behind a security cover, mount said item of equipment recessed behind a blank rack panel.

N. Save all unused products accessories and turn over to Owner at checkout.

3.2 PROTECTION AND REPAIR OF EXISTING FINISHES AND STRUCTURES

A. Cut and patch all holes required for this installation.

B. Make good all materials and finishes cut into or damaged during installation.

C. On completion, remove all rubbish and unused materials from the premises, clean the premises where dirtied, and clean all equipment, removing all dirt, dust, stains, and fingerprints.

3.3 ELECTRONIC TEST EQUIPMENT

A. Provide the following test equipment for use during tests and adjustments and during acceptance testing and final adjustment of the system.
   1. Continuously Variable Sine Wave Generator - 20 Hz to 20,000 Hz range within +1 dB with less than 0.5% THD at 1 volt output into 600 ohms.
   2. AC Voltmeter with frequency response within +1 dB from 20 to 20,000 Hz, 0.0001 volts to 100 volts, minimum input impedance 0.1 meg ohm.
   3. Multimeter (VOM) (may be included with AC Voltmeter)
   4. Oscilloscope with at least 5 MHz bandwidth and external horizontal input. Vertical sensitivity to 10 mV/division or less.
   5. Impedance Measuring Device, capable of measuring at 1,000 Hz and within each loudspeaker's passband (at center of passband or at least one octave removed from crossover frequency), minimum range 0 to 1,000 ohms.
   6. Light Meter: The meter shall be capable of measuring illuminance (foot-candles) and luminance (foot lamberts).
   7. NTSC Color Video Test Signal Generator: The test signal generator shall be capable of generating SMPTE color bars, multiburst, modulated ramp or stair step, and window signals.
   8. Video Sweep Generator: The generator shall be capable of producing sine wave frequency sweep from 30 Hz to 100 MHz, locked to horizontal sync.
   9. Wideband Video Distribution Amplifier: Provide a one input three output (minimum) distribution amplifier with frequency response at least -3dB at 100 MHz.

10. RGB Test Signal Generator: The generator shall be capable of generating the SMPTE RP-133 test pattern and window pattern on black background over entire range of horizontal and vertical scan frequencies of the video projector(s) specified.
11. Waveform Monitor and Vectorscope: The monitor(s) shall provide facilities for complete line select and simultaneous channel A and B display. The unit shall be able to make differential phase and gain measurements. Inputs shall be able to be displayed in one or two line sweeps. The vectorscope shall be able to measure SC/H phasing and color framing.
12. Real Time Audio Analyzer: Shall provide a pink noise generator, a calibrated microphone and graphic representation of the audio spectrum in 1/3-octave increments.
13. Connectors, Adapters, Cables, etc. to permit flexible interconnection of test equipment and convenient, reliable connection to receptacles, patch panels and amplifier terminal strips.
14. Network Cable Analyzer: Certification-grade cable analyzer suitable for testing up to TIA Category 6A cable and testing cable length, bandwidth, and attenuation.
15. Fiber Optic Cable Analyzer: Certification-grade optical power and fiber optic test kit suitable for testing fiber length, bandwidth, and attenuation.
16. Laptop personal computer with software as provided for any computer-controlled equipment.
17. Table to support test equipment at system equipment rack, minimum 30" square. (Required only during acceptance testing.)

3.4 DIGITAL SIGNAL PROCESSOR THEORY OF OPERATION

A. Gain Stage
   1. Introduce noise source at mixer input.
   2. Set input channel to just shy of clipping.
   3. Set output to just shy of clipping.
   4. Work toward amplifier, setting each input and output to just shy of clipping.
   5. Set amplifier gain to just shy of clipping.

B. Loudspeaker Processing
   1. Include any available manufacturer-created loudspeaker processing blocks.
   2. For final two blocks before output to amplifier or loudspeaker include the following:
      a. Compressor/limiter
         i. Attack: .1 ms
         ii. Release: 50 ms
         iii. 10:1 slope
         iv. Threshold: -9 dbu from clipping of processor
      b. Make-up Gain: +6 dbu

3.5 SHOP AND FACTORY TESTING

A. The Audiovisual Contractor shall perform preliminary tests at their shop or factory before the system is shipped to the Owner’s site. The Owner’s Authorized Representative, Owner’s Project Manager, Consultant or other designated representative may be present for these tests. These tests shall include Contractor provided equipment and any Owner provided equipment (equipment that the Owner shipped to the assembly site). The tests shall include equipment provided by other Vendors, if applicable, plus all installation service and materials.

3.6 INITIAL POST-COMPLETION TESTS AND ADJUSTMENTS

A. Perform these tests and adjustments. Furnish equipment necessary to perform these tests, and perform work required to modify the performance of the system in accordance with this specification.

1. Loudspeaker Line Impedance
    a. Measure the resistance and impedance of each loudspeaker line leaving the system equipment rack, with the line disconnected from its normal driving source. Measure impedance within each loudspeaker's passband (at center of passband or at least one octave removed from crossover frequency). Verify that values are within +10% of the value calculated for that circuit based upon the parallel impedances/resistances of the loudspeakers connected plus the resistance of the loudspeaker line. Correct any discrepancies.
2. Loudspeaker Phasing
    a. Perform phasing checks of loudspeaker lines by means of a DC source at one end of each line and a voltmeter at the other end. Phase all loudspeaker lines identically with respect to color coding.
3. Hum and Noise Level
    a. Measure the hum and noise levels of the overall system. Adjust gain controls for optimum signal-to-noise ratio. The adjustment shall also be such that full power amplifier output would be achieved with +8 dBm input. Terminate inputs with shielded resistors of 600 ohms for these measurements. Disconnect the loudspeaker lines and terminate the power amplifier outputs with power resistors for these measurements. Use load resistors matching the rated load impedance and output power of the amplifier.
4. Power Output and Signal Level Adjustments
    a. Measure the electrical distortion of the overall system. Adjust gain controls as for the tests specified in the preceding paragraph. Set variable equalizers for flat response. Apply a 1,000 Hz sine-wave signal to the input tested, at a level required to produce full amplifier output. Use a distortion analyzer to measure the output level and total harmonic distortion of the amplification equipment. (In the absence of a distortion analyzer, a VTVM or transistor voltmeter may be used to measure the output level, and lack of clipping or apparent deformation of a sine-wave input signal at the power amplifier output, as seen on an oscilloscope as specified, may serve as evidence that distortion of amplification and control equipment is within acceptable limits, subject to review by the Architect.) Make all measurements with loads actually incurred in system operation. (Power amplifier loads shall be resistors equal to the nominal impedance of the output terminals used in the system.)
5. Freedom from Parasitic Oscillation and Radio-Frequency Pick-up
    a. Check to insure that the system is free from spurious oscillation and radio-frequency pick-up, both in the absence of any audio input signal and also when the system is driven to full output at 100 Hz. Employ an oscilloscope as specified.
6. Freedom from Buzzes, Rattles, and Objectionable Distortion
    a. Apply a slow sine-wave sweep from 50 to 5,000 Hz at a level of 6 dB below rated power amplifier output voltage. Listen carefully for buzzes, rattles, and objectionable distortion. Correct any causes of these defects, unless the cause is clearly outside the sound amplification system equipment and installation, in which case bring the cause to the attention of the Architect.
7. Gain Control Settings
    a. Establish tentative normal settings for all gain controls. Adjust all gain controls for optimum signal-to-noise ratio and signal balance.
8. Freedom from Switching Transient Noise
    a. Eliminate audible clicks or pops produced by the operation of any controls.
9. Listening Test

a. Listen to normal program material to be sure that there are no remaining defects.

10. Test of Signal Routing
    a. Verify that signal flow is as intended.
11. Digital Signal Transport System
    a. Verify number of HDCP keys supported by each source device.
    b. Video timing and support audio formats (if applicable) for each display device.
    c. Video timing and supported audio formats presented in the EDID for each source. Indicate preferred video timing.
    d. Length of installed twisted pair cables used for signal distribution and control.
12. Video Projectors
    a. Employ an RGB test generator to produce signals with horizontal scan frequencies of 15.75 kHz, 35 kHz, 64 kHz and other frequencies as directed. Align projectors to meet manufacturer's published specifications for all such input signals. Verify that the image size specified can be achieved, and that keystone distortion is absent. Verify the absence of any other geometry errors, including bow, skew, trapezoid, linearity, and vignetting.
    b. Verify proper registration and focus of each tube to within the performance limits of the projector. Adjust horizontal blanking to preclude the loss of image on the sides. Verify that any remaining registration errors do not prevent the projector from performing in the intended application.
13. Subjective Image Quality
    a. Observe the image quality on various displays throughout the system, employing various sources such as workstations and videotape, and check for errors of linearity, chroma-luminance delay, signal to noise performance, blanking and gain shifts, RF interference, crosstalk, and other imperfections. Test for these errors under various operating conditions, including selecting random sources into selected projectors.
14. Control System
    a. Verify that all devices being controlled by the master control system respond to corresponding graphic elements on touch screens. Check all screens for full functionality. Test touch panels at all connection locations.
15. Category Cabling
    a. Verify that all jacks have been terminated properly and conform to ANSI/TIA/EIA-568-C.
    b. Provide list of cable runs each with associated bandwidth and length information, as well as pass/fail for ANSI/TIA/EIA-568-C compliance.
16. Fiber Optic Cabling
    a. Verify that all jacks have been terminated properly and conform to ANSI/TIA/EIA-568-C and related ANSI/TIA/EIA fiber optic standards.
    b. Provide list of fiber runs each with associated bandwidth and length information, as well as pass/fail for ANSI/TIA/EIA-568-C compliance.
17. 75 Ohm Coax Video Cabling
    a. Verify that all jacks have been terminated properly and meet SMPTE SDI, HD-SDI, and 3G-SDI standards 259M, 274M, 292M, 296M, 344M, 327M, and 424M.
    b. Provide list of cable runs each with associated bandwidth and length information, as well as pass/fail for SMPTE SDI, HD-SDI, and 3G-SDI standards 259M, 274M, 292M, 296M, 344M, 327M, and 424M.
18. System Configuration
    a. Perform gain staging, as detailed herein.

B. Report

1. Upon completion of above tests and adjustments submit two copies of a written report presenting test results, including numerical values and corrective actions taken, for review by the Architect and Architect prior to demonstration and acceptance testing. With this report, submit written certification that the installation conforms to the requirements stated herein, is complete in all respects, and is ready for inspection and testing by the Architect.

3.7 DEMONSTRATION AND ACCEPTANCE TESTING OF COMPLETED INSTALLATION:

A. Upon approval of the above test report by the Architect and at a mutually agreeable time, demonstrate operation of each major component and of the complete installation. After demonstration, assist as required in acceptance tests.

B. Listening Tests
   1. Tests will include subjective evaluation by observers listening at various positions under various operating conditions of the system, intended to test its operation in conformance with its functional requirements.

C. Equipment Tests
   1. Perform any measurements of frequency response, distortion, noise or other characteristics and any operational tests deemed necessary by the Architect to determine conformity with these requirements.
   2. If the need for adjustment or modification becomes evident during demonstration and testing, continue working until the installation operates properly.

D. Final Adjustments
   1. Make control adjustments as directed by the Architect. Make a record of these control settings. Provide covers, caps, or shaft-locks for controls not used in system operation.

End of Section

Section 27 41 20

IN-CEILING CLASSROOM AUDIO SYSTEM

(TRADE CONTRACT REQUIRED AS PART OF SECTION 26 00 01)

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. PUBLICLY BID TRADE CONTRACT REQUIREMENTS: As provided under Section 26 00 01 - ELECTRICAL and supplemented under the Bidding Requirements, Contract Forms, and Conditions of the Contract, and applicable parts of Division 1 - GENERAL REQUIREMENTS.

1. Work of this Trade Contract includes all individual specification sections listed in Section 26 00 01.

1.2 RELATED DOCUMENTS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications

1.3 SCOPE

A. It is the intent of these specifications that the Contractor, Manufacturer and/or its Authorized System Integrator expeditiously furnishes and installs a system complete in every respect and ready to operate. All miscellaneous items and accessories required for such installation, whether or not each such item or accessory as shown on the plans or mentioned in these specifications, shall be furnished and installed.

B. The in-ceiling classroom audio system shall be installed as shown on the drawings and as specified herein. The work covered by this section of the specifications includes the furnishing of all labor, equipment, materials and performance of all operations associated with the in-ceiling classroom audio system for a fully functional system.

C. The school district has standardized on the Lightspeed wireless classroom in-ceiling audio system. This Contractor shall provide Lightspeed Flexcat and Topcat Classroom Audio 2-way Communication System at each location where an in-ceiling classroom audio system speaker is shown on the drawings and as specified herein.

1.4 CODES AND STANDARDS

A. Complete installation shall meet or exceed the latest edition of following standards:

1. TIA-568: Commercial building telecommunications wiring standard and all current addenda.

2. TIA-569: Commercial building standard for telecommunications pathways and spaces.

3. TIA-606: Administration standard for telecommunications infrastructure of commercial buildings.

4. TIA-607: Commercial building grounding and bonding requirements for telecommunications.

5. ANSI, ASTM, UL, NEMA, IEEE and FCC standards as applicable.

6. BICSI Telecommunications Distribution Methods Manual, current edition.

1.5 PROGRAMMING

A. Coordinate and obtain a written approval of system functionality from the Owner prior to programming.

B. Perform a walk-through with the Owner and demonstrate the system functionality.

C. Make any adjustments to system functionality after initial programming if necessary to achieve the desired functionality requested by the Owner. Coordinate all required reprogramming with the Owner as required as part of this contract.

D. Obtain a written final letter of acceptance from the Owner upon completion of system functionality programming and demonstration.

1.6 SUBMITTALS

A. Comply with requirements specified in Division 01 and the following:

1. The vendor shall submit certification letter from the manufacturer of submitted equipment certifying that the installer is an authorized and certified installer of the submitted equipment.

2. The vendor shall make all connections at all field devices and at the head-end; and shall make all necessary field adjustments for a fully functional system.

B. Shop Drawings

1. Prior to assembling or installing the system, the Contractor shall provide complete shop drawings which include the following:

a. List the name of the manufacturer’s local representative and his/her phone number.

b. Table of contents.

c. Manufacturer’s parts lists

d. Product serial numbers

e. Catalog cut sheets

f. Installation instructions

g. Typical wiring diagrams

h. Drawings showing equipment locations

i. Manufacturer’s warranty documents

2. All drawings shall be fully dimensioned.

3. Operating License: Submit evidence of application for FCC Radio Station Authorization prior to installing equipment when required for operation of the equipment.

C. As-Built Drawings

1. At the conclusion of the project, the Vendor shall provide “as built” drawings. The “as built” drawings shall be a continuation of the Contractors shop drawings as modified, augmented, and reviewed during the installation, check out and

acceptance phases of the project. All drawings shall be fully dimensioned and prepared in DWG format using the latest version of AutoCAD.

2. The as-built drawings shall incorporate all updated system riser diagrams prepared in DWG format using the latest version of AutoCAD.

D. Manuals

1. At the conclusion of the project, the Vendor shall provide copies of the manuals as described herein. Each manual's contents shall be identified on the cover. The manual shall include names, addresses, and telephone numbers of each system integrator installing equipment and systems and the nearest service representatives for each item of equipment for each system. The manuals shall have a table of contents and labeled sections. The manuals shall include all modifications made during installation, checkout, and acceptance. The manuals shall contain the following:

   a. Hardware Manual

      1) The hardware manual shall describe all equipment furnished including:

      2) General description and specifications

      3) Installation and check out procedures

      4) Equipment layout and electrical schematics to the component level

      5) System layout drawings and schematics

      6) Alignment and calibration procedures

      7) Manufacturers repair parts list indicating sources of supply

   b. Software Manual

      1) The software manual shall describe the functions of all software and shall include all other information necessary to enable proper loading, testing, and operation. The manual shall include:

      2) Definition of terms and functions

         a) Use of system and applications software

         b) Initialization, start up, and shut down

         c) Alarm reports

         d) Reports generation

         e) Data base format and data entry requirements

         f) Directory of all disk files

2. Operators Manual

   a. The operator's manual shall fully explain all procedures and instructions for the operation of the system including:

      1) Computers and peripherals

      2) System start up and shut down procedures

      3) Use of system, command, and applications software

      4) Recovery and restart procedures

      5) Use of report generator and generation of reports

6) Data entry

7) Operator commands

8) Alarm messages and reprinting formats

9) System access requirements

3. Maintenance Manual

a. The maintenance manual shall include descriptions of maintenance for all equipment including inspection, periodic preventive maintenance, fault diagnosis, and repair or replacement of defective components.

1.7 MAINTENANCE SERVICE

A. The Contractor shall provide a one-year guarantee of the installed system against defects in material and workmanship. All labor and materials shall be provided at no expense to the Owner. Guarantee period shall begin on the date of acceptance by the Owner or engineer.

B. A maintenance contract offering continued factory authorized service of this system shall be made available if requested by the Owner.

1.8 QUALITY ASSURANCE

A. The Contractor shall currently maintain a locally run business for a minimum of five years and shall be an authorized distributor of the supplied equipment with full warranty privileges.

B. The Contractor shall maintain at his facility the necessary spare parts in the proper proportion as recommended by the equipment manufacturer to maintain and service the equipment being supplied. This facility shall be available for inspection by the engineer.

C. The supplying Contractor shall have attended the manufacturer's installation and service school.

D. The Contractor shall furnish manufacturer's manuals of the completed system including individual specification sheets, schematics, inter-panel and intra-panel wiring diagrams. In addition, all information necessary for the proper operation of the system must be included. Any bidder using other than the specified equipment must provide this information prior to bidding.

E. As built drawings that include any changes to wiring, wiring designations, junction box labeling and any other pertinent information shall be supplied upon completion of project.

F. Vendors providing equipment installation services shall use adequate numbers of skilled workmen who are certified by the component manufacturer, thoroughly trained and experienced with the necessary technology and systems, and completely familiar with the specified requirements and methods needed for proper performance of work. The system head-end installation, start-up and commissioning shall be by the manufacturer certified vendor.

G. Each vendor is required to provide a letter from the manufacturer indicating that they hold a current certification for the specified system.

H. Use adequate numbers of skilled workers thoroughly trained and experienced on the necessary crafts and completely familiar with the specified requirements and methods

needed for the proper performance of the work of this Section. Contractor is required to provide references of three similar installations completed in the last 12 months.

I. Contractor must provide a project manager who has demonstrated the ability to supervise a project of this magnitude. The Project Manager must be available to attend meetings as required. Acceptance will not be unreasonably withheld.

1.9 WARRANTY

A. Comply with Section 260001.

B. The Electrical Trade Contractor shall warranty that all materials furnished shall be free from defects of material for a period of one year from the date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Lightspeed.

2.2 BASIS OF DESIGN

A. The system specified is based upon the Lightspeed Flexcat + Topcat Classroom Audio 2-way Communication System and represents the performance standard upon which any equivalent solution shall be based.

B. Provide Lightspeed Flexcat and Topcat Classroom Audio 2-way Communication System at each location where an in-ceiling classroom audio system speaker is shown on the drawings.

2.3 DESCRIPTION

A. The system must have specifications and features that are equivalent to the Lightspeed Topcat Access™ In-Ceiling Classroom Audio System including the following:

1. All-in-one, in-ceiling audio system with integrated amplifier, speakers and wireless audio receiver/transmitter.
2. Two-way hybrid speaker system with exciter technology sound panel and low frequency cone driver.
3. Cross over technology to deliver high speech intelligibility and full range sound with even distribution throughout the classroom.
4. Pendant-style Flexmike™ classroom microphone with audio input utilizing Access Technology (1.9 GHz) for transmission. IR not acceptable.
5. PageFirst emergency page priority.
6. In-Ceiling mounted.
7. Suitable for use in air-handling spaces (plenum-rated).
8. Wireless audio integration and device charging with Activate Station utilizing Access Technology and Bluetooth for integration with mobile devices and laptops:
    a. Includes 2 channels of 2-way Bluetooth Audio
    b. 4 audio input connections, 2 audio outputs with volume controls

c. Cradle charging for 2 pendant microphones, eight (8) 2-way audio Pods

d. Bluetooth connection with Activate mobile app for control, streaming and audio/video recording of classroom instruction and interaction.

e. Mobile device control of system volume levels, Activate Pod selection, and advanced system settings.

9. Activate Pods with 2-way audio communication featuring the following functionality:

a. Integrated speaker and microphone to enable 2-way communication between the teacher and each small group.

b. Wireless audio communication and battery power for maximum portability.

c. Up to 12 speaker pods can be connected to Topcat for each small student group.

d. Enables student sharing directly from the Pods so students can be clearly heard by the whole class.

e. Must include a call button allowing students to notify the teacher when then need assistance.

B. The system must produce high speech intelligibility and full-range multimedia quality sound with excellent distribution throughout a classroom.

C. The system must be capable to be installed in a classroom with no wires installed in or on the walls. The system must be fully operational without speaker wires or sensor cables.

D. The system must be compatible and expandable to operate with 2-way small group speaker pods allowing interoperability between both small group and whole group instruction.

E. The system shall carry a “No Audio Dropout Guarantee” between the wireless microphone and the sound system. The guarantee applies to operation in any room up to its expected range of 200 feet (assuming no walls). The guarantee does not extend into other rooms separated by walls as this can limit transmission range significantly. Should any dropout in audio transmission occur, the manufacturer would correct it at no additional charge.

F. The system shall carry a standard warranty equivalent to the Lightspeed 5-year Warranty.

2.4 IN-CEILING CLASSROOM AUDIO SYSTEM

A. Furnish and install in-ceiling classroom audio system at each location shown on the drawings.

B. Overall System:

1. Power output: 20 Watts RMS

2. Acoustic Frequency response: 60 Hz to 18 kHz -10dB

3. AC Mains Power Input: 100-240V ~ 50/60Hz 1.5A

4. DC Power Input: 24V/2.5A

5. Signal-to-noise: 60 dB

6. Total Harmonic Distortion: <1%, 10 W

7. Wireless Communication: Access Technology (1.9 GHz + RF4CE)

8. Automatic power on when Flexmike is powered on and linked
9. Dimensions (W x D x H): 24” x 12” x 3.7” (Removable side spacers to fit international ceiling grids; 595mm x 295mm x 94mm)
10. Weight: 13.5 lbs. (6.1 kg)
11. Controls:
    a. (1) Microphone volume control
    b. (1) Tone control
    c. (1) Audio input volume control
    d. (1) PageFirst sensitivity adjustment
12. Connections:
    a. (1) Direct AC mains power input
    b. (1) Optional DC Power Input
    c. (1) Audio input
    d. (1) Optional Page mute (PageFirst™) input (Euro-block)
13. Device Registration: push button for transmitter(s), remote(s), speaker pods
14. Wireless audio range: up to 200 feet
15. Integrated 2-Way Hybrid Speaker System:
    a. Description: exciter technology sound panel plus low frequency cone driver
    b. Integrated cross-over technology
    c. Panel Size: 13.75” x 6.75”
    d. Cone Driver Size: 5.25”
    e. Overall Frequency Response: 60 Hz to 18 kHz -10dB
    f. Impedance: 8 Ω
    g. Power Handling: 25 W

C. The in-ceiling classroom audio system shall use bi-directional wireless Access Technology to communicate with up to two wireless microphones.

D. The in-ceiling classroom audio system shall use bi-directional wireless Access Technology to integrate with other audio sources in the classroom.

E. The in-ceiling classroom audio system shall use bi-directional wireless Access Technology to send a mixed audio output to a media connector located at a convenient/student accessible location in the classroom.

F. The in-ceiling classroom audio system shall use bi-directional wireless Access Technology to communicate with up to 12 optional tabletop speaker pods available to facilitate small group instruction.

G. The all-in-one system must contain a Page mute function (PageFirst™) that passively detects the audio signal of a page coming through the PA system without compromising system performance or voiding warranties. As an audio signal is sent to the PA speaker, the PageFirst passive sensor clip detects that signal and immediately mutes the Topcat.

2.5 FLEXMIKE PENDANT-STYLE MICROPHONE / TRANSMITTER

A. Furnish and install two (2) Flexmike pendant-style wireless microphones at each in-ceiling classroom audio system.

B. Overall System:

1. Description: the pendant-style wireless microphone
2. Lanyard: adjustable length with magnetic clasp
3. Wireless communication: bi-directional Access Technology (1.9 GHz)
4. Audio distortion: <1%
5. Integrated microphone type: uni-directional electret
6. Audio input: 3.5mm
7. Earbud output: 3.5mm (for to monitor optional Flexcat pods)
8. Push button volume control: +/- 6dB (total range = 12 dB)
9. Power: on/off/mute button
10. Battery Power: 2.4V NiMH battery pack
11. Battery run time: 8 hours (fully charged)
12. Charging: Integrated battery charger. The 5V power can be supplied via a cradle charger (charges two Flexmike transmitters)
13. Alkaline Charge Protection: Yes
14. USB Audio: interface with computer USB audio while charging
15. Registration: push button for registration with Topcat
16. Dimensions (L x W x H): 2.9” x 1.1” x 1.0” (74 x 28 x 25mm)
17. Weight: 1.8 oz. (51g)

2.6 WIRELESS MEDIA CONNECTOR AND CHARGING STATION WITH BLUETOOTH

A. Furnish and install one (1) wireless media connector and charging station with Bluetooth at each in-ceiling classroom audio system.

B. Overall System:

1. Description: Device charging station with wireless audio and Bluetooth connectivity. Activate utilizes 2-way audio communication to integrate audio sources and mobile devices with Topcat in the ceiling.
    a. Integration with Activate mobile app for control, streaming and audio/video recording of classroom instruction and interaction.
    b. Mobile device control of system volume levels, Activate Pod selection, and advanced system settings.
2. Mobile app functionality: Bluetooth interface with companion mobile application with the following functionality:
    a. Control and connect to small group 2-way audio pods.
    b. Adjust system audio levels and tone control.
    c. Mobile device audio streaming from audio books, podcasts, music, etc.

d. Audio/video recording synched with microphone and pod audio.

e. Enable advanced system features.

3. Wireless Communication: Access Technology (1.9 GHz + RF4CE), Bluetooth audio (2 channels), Bluetooth LE (2 channels).

4. Wireless range: Up to 200 ft. (60m) from Topcat, up to 100 ft. (30m) from mobile device.

5. Audio frequency response: 80 Hz to 7 kHz +/- 3 dB.

6. Audio distortion: <1%

7. Cradle charging: 2 Flexmikes; 8 Pods

8. USB charging ports: Two (2) 5V/0.3A charging for pods, remotes, or Sharemikes; Two (2) 5V/1.0A charging for mobile devices or pods.

9. DC Power Input: 24V/1.75A.

10. Auxiliary Power Input: 5V USB from portable power source (no device charging).

11. Audio Inputs: (4) 3.5mm stereo jacks with volume control.

12. Bluetooth Audio: (2) independent 2-way Bluetooth audio channels.

13. Audio Outputs: (2) 3.5mm jack with volume control.

14. Volume controls: Master microphone, audio input, audio output with 10-segment level indicator

15. Device Pairing: (2) Push buttons for Bluetooth device pairing, (1) push button for Access device registration.

16. Mounting: table-top.

17. Dimensions (W x D x H): 13.3”x 5.9”x 1.9” (340 x 150 x 52mm)

18. Weight: 1.85 lbs. (0.84kg).

2.7 2-WAY AUDIO PODS FOR SMALL GROUPS

A. Furnish and install six (6) 2-way audio pods for small groups at each in-ceiling classroom audio system.

B. Overall System:

1. Description: 2-way audio pod with integrated speaker and microphones. Up to 12 pods can be connected to a single audio system.

2. Wireless Communication: Access Technology (1.9 GHz).

3. Wireless range: Up to 200 ft. (60m) from Topcat; up to 100 ft. (30m) with walls

4. Integrated speaker: 1” high output speaker.

5. Power output: 1 Watt per pod speaker.

6. Integrated microphones: Two (2) Omni-directional electret with noise rejection.

7. Headphone output: 3.5mm.

8. Controls: Power on/off button, volume up/down buttons, teacher call button.

9. Battery power: 2.5V NiMH rechargeable battery pack.

10. Battery charging: 2 contact for cradle charging + 5V/0.3A micro-USB.

11. Battery life: 10+ hours (fully charged).
12. Dimensions: 5.2” x 2.1” 1.1” (132 x 54 x 28mm).
13. Weight: 6.4 oz. (181g).

2.8 INTEGRATING THE TOPCAT WITH OTHER AUDIO SOURCES

A. The wireless Media Connector must have four audio inputs to allow other audio sources to be wirelessly transmitted and played through the Topcat system. Computers, DVD/VCR’s, TV’s, CD’s, MP3’s etc. may be connected into the Media Connector using appropriate patch cords. The Media Connector must also receive audio back from the Topcat to output the mixed audio signal of both microphone channels and multimedia for recording purposes and interface with assistive listening devices. See drawings for requirements.

B. The Topcat system vendor will furnish and install 3.5MM stereo input cable from the projector audio out to the Topcat speaker.

C. The Topcat system vendor will make termination of the two conductor cable from the public address (PA) system speaker to the Topcat speaker for PA override. Coordinate requirements with the PA system vendor.

2.9 REGULATORY AND CERTIFICATIONS

A. The classroom audio system and its components shall be manufactured using lead-free processes and free of other materials harmful to the environment (RoHS and WEEE compliant).

B. The classroom audio system and its components shall be listed to UL/CUL standards and requirements for electrical safety by Underwriters Laboratories Inc.

C. The classroom audio system must be suitable for use in air handling spaces and carry appropriate certifications (UL 2043).

D. The classroom audio system and its components shall be CE Certified and conform with the essential requirements of the following European Union Directives: 2014/30 EU Electromagnetic Compatibility (EMC), 2014/35/EC Low Voltage Directive (LVD) and RED 2014/53EU.

E. The classroom audio system and its components shall comply with Part 15 of the FCC rules as a Class B digital device (FCC Certified).

PART 3 - EXECUTION

3.1 INSTALLATION

A. The ceiling cavity is being used as plenum return. Provide plenum rated cables, conduit, backboxes in all plenum rated ceilings, rated walls, penetrations though wall, floors and ceilings and where required by Local, State or Federal Codes.

B. Provide and install in-ceiling classroom audio system at the locations shown on drawings as required.

C. All equipment and enclosures described in this specification shall be permanently attached to the structure and held firmly in place. Supports shall be adequate to support their loads per manufacturers specifications.

D. The process of testing the Audio Sound System may necessitate moving and adjusting certain component parts (ex. loud speakers). Contractor shall provide at no additional cost to the owner.

E. Take precautions as necessary to prevent and guard against electromagnetic and electrostatic noise interference.

F. Wireless Media Connector to be located per Owner’s request. Contractor to ensure all Media Connectors are properly registered and all volume controls are set properly via a field test in every classroom. Ensure power is available for Media Connector.

G. System wiring shall be in accordance with good engineering practices as established by the EIA and NEC. Wiring hall meet all established state and local electrical codes. All wiring shall test free from grounds and shorts. Complete system shall be installed in strict accordance with manufacturer's recommendations.

H. Install wiring in conduit and raceways except as indicated.

I. Conceal wiring installations where possible.

J. Cable Support: Securely fasten to the permanent building structure where not installed in raceway. Support at regular intervals appropriate to the cable and wire size. Cable and wiring shall not lay loose on ceiling tiles or grids. Install parallel to building lines and follow building structure. Use cable support equipment/hardware recommended by the manufacturer.

K. Cable Pulling: Do not exceed manufacturer's recommended pulling tensions. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between indicated termination, tap, or junction points. Remove and discard cable where damaged during installation and replace it with new cable.

L. Wiring within Enclosures: Bundle, lace, and trim the conductors to terminal points with no excess. Provide and use lacing bars and distribution spools.

M. Identify and tag all cables with permanent type markers to denote location served.

N. Install and wire equipment in accordance with accepted engineering and installation practices. Only the highest degree of workmanship will be accepted.

O. Arrange equipment to facilitate access for maintenance and working space.

3.2 SYSTEM PERFORMANCE

A. Install in accordance with Manufacturer’s installation instructions.

B. Final adjustment: Upon completion, the system shall be clean, adjusted and left in perfect operating condition. Transmitters shall be plugged in and charging and user manual should be left in a conspicuous place.

C. Provisions: There shall be no audible components of hum, noise, or distortion.

3.3 COMMISSIONING

A. Comply with requirements specified in Division 1.

B. Engage a factory-authorized service representative to supervise and assist with startup service. Complete installation and startup checks according to the approved manufacturer's written instructions.

3.4 TRAINING AND SERVICE

A. Comply with Section 26 00 01.

B. Conduct two 4-hour training sessions. Train the Owner’s maintenance personnel on procedures and schedules related to start up and shutdown, troubleshooting, servicing, and preventive maintenance.

C. Conduct four 4-hour training sessions. Train teachers and administration personnel on system operation.

3.5 EXTRA MATERIALS

A. Furnish the following component at the end of the project to the Owner:

1. Two (2) complete systems, for each system include:

a. (1) In-ceiling classroom audio system

b. (2) Flexmike microphones

c. (1) Media center with charging station

d. (6) 2-way audio pods

End of Section

Section 27 50 00

IN-BUILDING CELLULAR AMPLIFICATION SYSTEM

(TRADE CONTRACT REQUIRED AS PART OF SECTION 26 00 01)

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. PUBLICLY BID TRADE CONTRACT REQUIREMENTS: As provided under Section 26 00 01 - ELECTRICAL and supplemented under the Bidding Requirements, Contract Forms, and Conditions of the Contract, and applicable parts of Division 1 - GENERAL REQUIREMENTS.

1. Work of this Trade Contract includes all individual specification sections listed in Section 26 00 01.

1.2 RELATED DOCUMENTS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications

1.3 SCOPE OF WORK

A. It is the intent of these specifications that the Contractor, Manufacturer and/or its Authorized System Integrator expeditiously furnishes and installs a system complete in every respect and ready to operate. All miscellaneous items and accessories required for such installation, whether or not each such item or accessory as shown on the plans or mentioned in these specifications, shall be furnished and installed.

B. Upon completion of the installation, the owner will review the functionality of the installed system and compare to the minimum performance standards as set forth in these specifications. Any installed system not meeting the minimum standards of performance as set forth in these specifications will be removed by the providing Vendor and replaced with a system referred to in these specifications as the “standard system of reference” at the expense of the Vendor responsible for this section of the specifications. Any additional expenses incurred to meet the owner’s interpretation of the “standard system of reference” will be the sole responsibility of the Vendor responsible for this section of the specifications. Any delays in the schedule shall also be subject to liquidated damages as required and/or described in other sections of these specifications.

1.4 PROGRAMMING

A. Coordinate and obtain a written approval of system functionality from the Owner prior to programming.

B. Perform a walk-through with the Owner and demonstrate the system functionality.

C. Make any adjustments to system functionality after initial programming if necessary to achieve the desired functionality requested by the Owner. Coordinate all required reprogramming with the Owner as required as part of this contract.

D. Obtain a written final letter of acceptance from the Owner upon completion of system functionality programming and demonstration.

1.5 SUBMITTALS

A. Comply with requirements specified in Division 01 and the following:

1. The vendor shall submit certification letter from the manufacturer of submitted equipment certifying that the installer is an authorized and certified installer of the submitted equipment.

2. The vendor shall make all connections at all field devices and at the head-end; and shall make all necessary field adjustments for a fully functional system.

B. Shop Drawings

1. Prior to assembling or installing the system, the Contractor shall provide complete shop drawings which include the following:

a. List the name of the manufacturer's local representative and his/her phone number.

b. Table of contents.

c. Manufacturer's parts lists

d. Product serial numbers

e. Catalog cut sheets

f. Installation instructions

g. Typical wiring diagrams

h. Drawings showing equipment locations

i. Manufacturer's warranty documents

2. All drawings shall be fully dimensioned.

3. Operating License: Submit evidence of application for FCC Radio Station Authorization prior to installing equipment when required for operation of the equipment.

C. As-Built Drawings

1. At the conclusion of the project, the Vendor shall provide "as built" drawings. The "as built" drawings shall be a continuation of the Contractors shop drawings as modified, augmented, and reviewed during the installation, check out and acceptance phases of the project. All drawings shall be fully dimensioned and prepared in DWG format using the latest version of AutoCAD.

2. The as-built drawings shall incorporate all updated system riser diagrams prepared in DWG format using the latest version of AutoCAD.

D. Manuals

1. At the conclusion of the project, the Vendor shall provide copies of the manuals as described herein. Each manual's contents shall be identified on the cover. The manual shall include names, addresses, and telephone numbers of each system integrator installing equipment and systems and the nearest service representatives for each item of equipment for each system. The manuals shall have a table of contents and labeled sections. The manuals shall include all modifications made during installation, checkout, and acceptance. The manuals shall contain the following:

a. Hardware Manual

1) The hardware manual shall describe all equipment furnished including:
2) General description and specifications
3) Installation and check out procedures
4) Equipment layout and electrical schematics to the component level
5) System layout drawings and schematics
6) Alignment and calibration procedures
7) Manufacturers repair parts list indicating sources of supply

b. Software Manual

1) The software manual shall describe the functions of all software and shall include all other information necessary to enable proper loading, testing, and operation. The manual shall include:
2) Definition of terms and functions
a) Use of system and applications software
b) Initialization, start up, and shut down
c) Alarm reports
d) Reports generation
e) Data base format and data entry requirements
f) Directory of all disk files

2. Operators Manual

a. The operator's manual shall fully explain all procedures and instructions for the operation of the system including:

1) Computers and peripherals
2) System start up and shut down procedures
3) Use of system, command, and applications software
4) Recovery and restart procedures
5) Use of report generator and generation of reports
6) Data entry
7) Operator commands
8) Alarm messages and reprinting formats
9) System access requirements

3. Maintenance Manual

a. The maintenance manual shall include descriptions of maintenance for all equipment including inspection, periodic preventive maintenance, fault diagnosis, and repair or replacement of defective components.

1.6 SYSTEM DESCRIPTION

A. Services: Upon commissioning, the In Building cellular amplification system shall provide coverage for the WSPs listed below on all frequencies currently being used by the designated WSPs in the given market that has an exterior signal level is -70db or stronger.

1. AT&T
2. Sprint
3. T-Mobile
4. Verizon
5. US Cellular

Service	Downlink
Cellular	870 - 894
PCS	1930 - 1995
AWS	2110 - 2155
700 LTE	728 - 756

B. WSP Notification: The Contractor shall register the amplifiers with the WSP's on their web sites that the amplifiers will be connected to the WSPs' macro networks.

1.7 CODES, STANDARDS AND CERTIFICATIONS

A. All work, including but not limited to: cabling, pathways, support structures, wiring, equipment, installation, workmanship, maintenance and testing shall comply with the latest editions of the National Electrical Code, National Electrical Safety Code, all applicable local rules and regulations, equipment manufacturer's instructions, and the National Electrical Contractors Association (NECA) Standard of Installation. In case of discrepancy or disagreement between the documents noted above, the contractor shall satisfy the most stringent requirements.

B. It is the Contractor's responsibility to ensure that the components comply with local code, ordinances or requirements established by the AHJ.

1.8 ABBREVIATIONS AND ACRONYMS

A. AHJ: Authority Having Jurisdiction

B. ATP: Acceptance Test Plan

C. AWS: Advanced Wireless Service

D. BDA: Bi-Direction Amplifier

E. BOM: Bill-of-Material

F. DAS: Distributed Antenna System

G. DAQ: Digital Audio Quality

H. ESMR: Enhanced Specialized Mobile Radio

I. FCC: Federal Communications Commission

J. iDEN: Integrated Enhanced Digital Network

K. LMR: Land Mobile Radio

L. LTE: Long Term Evolution

M. MTBF: Mean Time Between Failure

N. NFPA: National Fire Protection Association

O. NMS: Network Management System

P. PCS: Personal Communications System

Q. PSN: Public Safety Network

R. RoF: Radio-over-Fiber

S. RoHS: Restriction of Hazardous Substances

T. RSL: Received Signal Level

U. SISO: Single-Input, Single-Output

V. SMR: Specialized Mobile Radio

W. SMS: Short Message Service

X. SNMP: Simple Network Management Protocol

Y. SOW: Statement of Work

Z. VSWR: Voltage Standing Wave Ratio

AA. WSP: Wireless Service Provider

1.9 DEFINITIONS

A. Acceptance: Expressed approval by the customer

B. Active: Components that require AC/DC power for operation

C. Channel: A path for an RF transmission between two points

D. Component: A main system element of the Amplification system

E. Contractor: The prime contractor bidding the project

F. Delivered Audio Quality (DAQ): A measure of audio quality over a transmission medium used to quantify the quality of audio heard over a radio system. DAQ levels are defined by the following scale:

1. DAQ 1: Unusable. Speech present but not understandable.
2. DAQ 2: Speech understandable with considerable effort. Requires frequent repetition due to noise or distortion.
3. DAQ 3: Speech understandable with slight effort. Requires occasional repetition due to noise or distortion.
4. DAQ 3.4: Speech understandable without repetition. Some noise or distortion present.
5. DAQ 4: Speech easily understandable. Little noise or distortion.
6. DAQ 5: Perfect. No distortion or noise discernible.

G. Sub-contractor: A qualified and experienced integrator performing the deployment for the Contractor.

H. Head-End Equipment: The equipment that accepts the RF Source, and then typically amplifies the RF source to the interior antennas

I. Passive: Components that do not require AC/DC power for operation

1.10 PERFORMANCE REQUIREMENTS

A. WSP:

1. On a per channel basis, the downlink RSL for each frequency band shall meet or exceed the criteria in Table 1.

Table 1. System Parameters

Parameters	Unit	700 LTE	Cellular, PCS, AWS, Commercial 800 MHz
Minimum downlink receive signal level (RSL)	dBm	-75	-85

2. Contractor shall state the assumed channel loading and frequency bands for the proposed WSP in-building coverage. Prior to installation, contractors shall confirm the channel loading and frequency use in the serving area and shall guarantee coverage for these channels per the criteria in Table 1.

3. The system shall deliver coverage per the criteria in Table 1 throughout 95% of the building.

1.11 WARRANTY

A. Comply with Section 260001.

B. The Electrical Trade Contractor shall warranty that all materials furnished shall be free from defects of material for a period of one year from the date of Substantial Completion.

C. Provide a 3-year preventive maintenance plan. The plan shall include one site visit per year after the warranty period to verify that the system is working per the specifications and to proactively perform maintenance, repairs, and replacements to prevent failures before they occur.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Wilson Electronics

B. SureCall

C. HiBoost

D. Or approved equal

2.2 BASIS OF DESIGN

A. The system specified is based upon products by Wilson Electronics; and represents the performance standard upon which any equivalent solution shall be based.

PART NO.	DESCRIPTION
460231	WilsonPro Pro 4000R rack mounted, multi-amplifier cell booster
460237	WilsonPro Pro 1000R rack mounted, amplifier cell booster
304412	Indoor Dome Antenna
859981	4-Way Splitter
859980	3-Way Splitter
859957	2-Way Splitter
314411	Outdoor 50 Ohm Wide Band Directional Antenna
	N Male Connectors
	Plenum Rated 1/2" Heliax (or similar) Cable

2.3 GENERAL

A. The system shall be completed with all components and wiring required for compliance with all applicable codes and regulations, and for its operation as described hereinafter. No exclusion from or limitation in the symbolism used on the drawings or the language used in these specifications shall be interpreted as a reason for omitting any appurtenances or accessories required to enable the system to perform the specified functions.

B. Upon completion of the installation, the work shall include making all arrangements with the owner’s project manager and providing any assistance necessary for inspection and test as required for a fully functional system. In conjunction with the above, training as deemed necessary to instruct authorized building personnel in the proper operation of the system shall also form a part of the required work.

C. The site and the building shall be both pre and post tested for signal strength. This Contractor shall employ the services of an integrator to perform the signal strength. Any expense incurred by the test shall be the responsibility of this Contractor.

D. The integrator shall have experience in the design and installation of In-Building Cellular Amplification System and is expected to perform a site survey to determine the signal strength on and near the building grounds to ascertain the level of amplification necessary to provide clear and reliable cellular reception in all occupiable areas inside the building.

E. The test shall check the signal reception in several locations on the floor area. Signal strength shall be as required for clear reception throughout the building utilizing cellphones from various providers.

2.4 COMPONENTS

A. Cellular Amplifiers

B. Single Output Amplifier

C. Single Input Single Output (SISO) wall mount or rack mount cellular amplifier shall provide up to +15 dBm downlink power with maximum of 70dB gain that is compatible with all North American cell networks

D. The cellular amplifier shall incorporate eXtended Dynamic Range (XDR) ® technology to protect the amplifier from shutting down due to a strong outside signal (-40dBmor higher)or changes in the outside signals.

E. The cell amplifier shall auto-detect and prevent any cell tower interference.

F. The cell amplifier shall be procured in kits per FCC regulations. The minimum kit shall include (1) cell amplifier, (1) outside Directional Antenna, (1) Inside Dome Antenna, (1) Lightning surge protector (1) 2’ low loss LMR 400 cable, 75’ Low loss LMR 400 cable, (1) 100’ low loss LMR 400 cable

G. Frequencies:

1. Band 12 700MHz
2. Band 13 700MHz
3. Band 5 850MHz
4. Band 4 1700/2100MHz
5. Band 25/2 1900MHz

2.5 MULTIPLE OUTPUT AMPLIFIER

A. Single Input Multiple Output (SIMO) wall mount or rack mount cellular amplifier shall provide up to +12 dBm downlink power with maximum of 70dB gain from the input to each of (4) outputs and is compatible with all North American cell networks

B. The cellular amplifier shall incorporate eXtended Dynamic Range (XDR) ® technology to protect the amplifier from shutting down due to a strong outside signal or changes in the outside signals.

C. The cell amplifier shall auto-detect and prevent any cell tower interference.

D. The cell amplifier shall be procured in kits per FCC regulations. The minimum kit shall include (1) cell amplifier, (1) outside Directional Antenna, (1) Inside Dome Antenna, (1) Lightning surge protector (1) 2’ low loss LMR 400 cable, 75’ Low loss LMR 400 cable, (1) 100’ low loss LMR 400 cable

E. Frequencies:

1. Band 12 700MHz
2. Band 13 700MHz
3. Band 5 850MHz
4. Band 4 1700/2100MHz
5. Band 25/2 1900MHz

2.6 OUTSIDE ANTENNAS

A. Omni-Directional Outside Antennas: Omni-Directional outside antennas shall feature a multi-band design, accommodating multiple frequency bands in a single small antenna.

1. Electrical Band 1:
    a. Frequency Band: 698 – 800 MHz
    b. VSWR: < 1.8
    c. Gain: 2 dBi
    d. Maximum input power:100W
    e. Impedance: 50 Ω
    f. Beamwidth, Horizontal: 360° omnidirectional
    g. Beamwidth, Vertical: 60° nominal
2. Electrical Band 2:
    a. Frequency Band: 1710 – 2700 MHz and 800 – 960 MHz
    b. VSWR: 1.5:1
    c. Gain: 5 dBi
    d. Maximum input power: 100W
    e. Impedance: 50 Ω
    f. Beamwidth, Horizontal: 360° omnidirectional
    g. Beamwidth, Vertical: 60° nominal
3. Mechanical:
    a. Connector: 50 Ω N Type Female
    b. Mounting: Mast Mount
    c. Radome material: ABS, UV resistant
    d. Pigtail cable: KSR195, plenum rated
4. Environmental:
    a. Application: Outdoor
    b. Operating Temperature: 40 °C to +60 °C (40 °F to +140 °F)
    c. Relative Humidity: Up to 100%
5. Regulatory Compliance/Certifications: RoHS 2002/95/EC

B. Outside Directional Antennas (YAGI): Outside Directional antennas shall feature a multi-band design, accommodating multiple frequency bands in a single small antenna.

1. Electrical Band 1:
    a. Frequency Band: 698 – 800 MHz
    b. VSWR: < 1.8
    c. Gain: 2 dBi

d. Maximum input power:100W
e. Impedance: 50 Ω
f. Beamwidth, Horizontal: 360° omnidirectional
g. Beamwidth, Vertical: 60° nominal

2. Electrical Band 2:
a. Frequency Band: 1710 – 2700 MHz and 800 – 960 MHz
b. VSWR: <1.8
c. Gain: 4 dBi
d. Maximum input power: 100W
e. Impedance: 50 Ω
f. Beamwidth, Horizontal: 360° omnidirectional
g. Beamwidth, Vertical: 60° nominal

3. Mechanical:
a. Connector: 50 Ω N Type Female
b. Mounting: Thru-hole ceiling mount
c. Radome material: ABS, UV resistant
d. Pigtail cable: KSR195, plenum rated

4. Environmental:
a. Application: Indoor
b. Operating Temperature: 40 °C to +60 °C (40 °F to +140 °F)
c. Relative Humidity: Up to 100%

5. Regulatory Compliance/Certifications: RoHS 2002/95/EC

2.7 INSIDE ANTENNAS

A. Omni-Directional Coverage: Omni-Directional Coverage antennas shall feature a multi-band design, accommodating multiple frequency bands in a single small antenna.

1. Electrical Band 1:
a. Frequency Band: 698 – 800 MHz
b. VSWR: 1.5:1
c. Gain: 7 dBi
d. Maximum input power: 50 watts
e. Impedance: 50 Ω
f. Beamwidth, Horizontal: 360° omnidirectional
g. Beamwidth, Vertical: 60° nominal
h. Return Loss: 10.9 dB

2. Electrical Band 2:
a. Connector: 50 Ω N Type Female

b. Mounting: Thru-hole ceiling mount

c. Radome material: ABS, UV resistant

d. Pigtail cable: KSR195, plenum rated

3. Mechanical:

a. Connector: 50 Ω N Type Female

b. Mounting: Thru-hole ceiling mount

c. Radome material: ABS, UV resistant

d. Pigtail cable: KSR195, plenum rated

4. Environmental:

a. Application: Indoor

b. Operating Temperature: 40 °C to +60 °C (40 °F to +140 °F)

c. Relative Humidity: Up to 100%

5. Regulatory Compliance/Certifications: RoHS 2002/95/EC

B. Low Profile Omni-Directional Coverage: Omni-Directional Coverage antennas shall feature a multi-band design, accommodating multiple frequency bands in a single small antenna.

1. Electrical Band 1:

a. Frequency Band: 698 – 800 MHz

b. VSWR: 1.5:1

c. Gain: 7 dBi

d. Maximum input power: 50 watts

e. Impedance: 50 Ω

f. Beamwidth, Horizontal: 360° omnidirectional

g. Beamwidth, Vertical: 60° nominal

h. Return Loss: 10.9 dB

2. Electrical Band 2:

a. Frequency Band: 1710 – 2700 MHz and 800 – 960 MHz

b. VSWR: 1.5:1

c. Gain: 7 dBi

d. Maximum input power: 50 watts

e. Impedance: 50 Ω

f. Beamwidth, Horizontal: 360° omnidirectional

g. Beamwidth, Vertical: 65° nominal

h. Return Loss: ≤ 13.9 dB

3. Mechanical:

a. Connector: 50 Ω N Type Female

b. Mounting: Thru-hole ceiling mount

c. Radome material: ABS, UV resistant

d. Pigtail cable: KSR195, plenum rated

4. Environmental:
   a. Application: Indoor
   b. Operating Temperature: 40 °C to +60 °C (40 °F to +140 °F)
   c. Relative Humidity: Up to 100%
5. Regulatory Compliance/Certifications: RoHS 2002/95/EC

C. Directional Coverage Antennas: Directional coverage antennas shall feature a multi-band design, accommodating multiple frequency bands in a single small antenna.

1. Electrical Band 1:
   a. Frequency Band: 698 – 800 MHz
   b. VSWR: 1.5:1
   c. Gain: ≥ 5.0 dBi @ 698 – 800 MHz
   d. Maximum input power: 50W
   e. Impedance: 50 Ω
   f. Beamwidth, Horizontal: 70/60°
   g. Polarization: Vertical
   h. Return Loss: ≤ 10.9 dB
2. Electrical Band 2:
   a. Frequency Band: 1710 – 2700 MHz and 800 – 960 MHz
   b. VSWR: ≤ 1.5:1
   c. Gain: ≥ 5.0 dBi @ 800 – 960 MHz and ≥ 8.0 dBi @ 1710 – 2170 MHz
   d. Maximum input power: 50W
   e. Impedance: 50 Ω
   f. Beamwidth, Horizontal: 70/60°
   g. Return Loss: ≤ 13.9 dB
3. Mechanical:
   a. Connector: 50 Ω N Type Female
   b. Mounting: 4-hole wall mounting plate
   c. Radome material: ABS, UV resistant
   d. Pigtail cable: RG58, plenum rated
4. Environmental:
   a. Application: Indoor
   b. Operating Temperature: 40 °C to +60 °C (40 °F to +140 °F)
   c. Relative Humidity: Up to 100%
5. Regulatory Compliance/Certifications: RoHS 2002/95/EC

D. Air Dielectric, Plenum Rated Cable:

1. Material Characteristics:
   a. Jacket: Halogenated, Fire-Retardant
   b. Outer Conductor Material: Corrugated Aluminum or Corrugated Copper
   c. Inner Conductor Material: Copper-Clad Aluminum Wire
2. Electrical Characteristics:
   a. Impedance: 50 ± 2.0 Ω
   b. Frequency Band: 1 - 8800 MHz
   c. Peak Power Rating: ≥ 40.0 kW
3. Mechanical Characteristics:
   a. Diameter Over Jacket: ≤ .627 in
   b. Minimum Bending Radius: ≤ 5 in
   c. One Time Minimum Bending Radius: ≤ 3 in
4. Attenuation Characteristics:

Frequency (MHz)	Attenuation (dB/100ft)
150	≤ 0.848
450	≤ 1.53
800	≤ 2.105
2000	≤ 3.564

Standard Conditions: VSWR 1.0, ambient temperature 20 °C (68 °F)

E. Foam Dielectric Cable:
1. Material Characteristics:
   a. Jacket: Non-halogenated, Fire-Retardant Ployolefin
   b. Outer Conductor Material: Corrugated Copper
   c. Inner Conductor Material: Copper-Clad Aluminum Wire or Copper Tube
2. Electrical Characteristics:
   a. Impedance: 50 ± 1.0 Ω
   b. Frequency Band: 1/2” Nominal: 1 - 8800 MHz, 7/8” Nominal: 1 - 5000 MHz
   c. Peak Power Rating: ≥ 40.0 kW
3. Mechanical Characteristics:
   a. Diameter Over Jacket: 1/2” Nominal: ≤ .630 in, 7/8” Nominal: ≤ 1.1 in
   b. Minimum Bending Radius: 1/2” Nominal: ≤ 5 in, 7/8” Nominal: ≤ 10 in

c. One Time Minimum Bending Radius: 1/2” Nominal: ≤ 2 in, 7/8” Nominal: ≤ 5 in

4. Attenuation Characteristics: 1/2” Nominal

Frequency (MHz)	Attenuation (dB/100ft)
150	≤ 0.815
450	≤ 1.447
800	≤ 1.968
2000	≤ 3.251

Standard Conditions: VSWR 1.0, ambient temperature 20 °C (68 °F)

5. Attenuation Characteristics: 7/8” Nominal:

Frequency (MHz)	Attenuation (dB/100ft)
150	≤ 0.417
450	≤ .744
800	≤ 1.014
2000	≤ 1.683

Standard Conditions: VSWR 1.0, ambient temperature 20 °C (68 °F)

F. Splitters, Taps, Couplers, and Coax Jumpers:

1. Approved Manufacturer: Wilson Electronics

PART 3 - EXECUTION

3.1 INSTALLATION

A. The contractor shall install, commission and test the Cellular amplification system in accordance with the manufacturer’s instructions and recommendations.

B. The contractor shall install the Cellular amplification system in accordance with the accepted SOW.

C. The contractor shall adhere to all work and safety requirements while working at the job site.

D. The contractor shall have Cellular amplification system project foreman on site overseeing the installation.

E. The contractor shall have at a minimum one Project Manager on staff overseeing the project. The Project Manager will be responsible for the following:

1. Developing and maintaining a project plan consistent with the overall milestones of the project.
2. Overseeing and coordinating the activities of the Cellular amplification system project, including: initiating and holding weekly project conference calls, as well as maintaining and distributing meeting minutes.
3. Act as the point-of-contact interface for all Cellular amplification system project activities.
4. Provide weekly status updates regarding work performed, worked scheduled, open items, problems/issues and resolutions.

F. The contractor and Sub-contractor shall be prepared to deploy the Cellular amplification system in a phased approached as dictated by the building construction and/or work of other trades.

G. The contractor and Sub-contractor shall facilitate WSP registration and connection to their respective macro networks.

H. The contractor and Sub-contractor shall be prepared to connect to the WSP's network(s) in a phased approached as dictated by the construction schedules.

I. Install cabling designed for the environment the cable will be installed in.

J. Terminate and test all cabling with a sweep analyzer.

K. Label all cabling per the contract drawings to indicate the segment number from each amplifier.

L. Provide exterior cell measurements according to the manufacturers recommendations.

3.2 ACCEPTANCE TESTING

A. Acceptance testing will be performed confirming the requirements of Section 1.07 have been met.

B. The contractor shall complete the acceptance testing per the requirements and as prescribed in the approved Acceptance Test Plan (ATP) submittal.

C. Acceptance Testing

1. Acceptance Testing shall comply with the following:
   a. The Acceptance Test shall ensure that two-way coverage on each floor of the building meets the minimum coverage requirements detailed in Section 1.07.
   b. Tests shall be made using the frequencies listed in Section 1.02.A.
   c. Testing shall be coordinated with the Customer and AHJ to ensure no undue interference to any building operations.
   d. All testing shall be done on frequencies authorized by the FCC.
2. Test Procedures
   a. The test plan shall ensure testing throughout the building. Testing shall be performed on a grid system. A spot located approximately in the center of a grid area will be selected for the test. Once the spot has been selected,

prospecting for a better spot within the grid area will not be permitted. A grid is overlaid onto a floor area to provide 20 grid cells. Grid cells are provided with definite minimum and maximum dimensions. For most buildings, using a minimum grid dimension of 20 ft and a maximum grid dimension of 80 ft will suffice to encompass the entire floor area. A maximum of one area will be allowed to fail the test (95% coverage). Where a floor exceeds the sq ft, which is the floor area that can be covered by the system, the floor be subdivided into 40 equal sectors, with each sector being tested individually. A maximum of two non-adjacent areas will be allowed to fail the test (95% coverage). In addition to the above requirement, all critical areas, which include; the emergency command center(s), the fire pump room(s), exit stairs, exit passageways, elevator lobbies, standpipe cabinets, sprinkler sectional valve locations, and other areas deemed critical by the AHJ, shall be provided with 99 percent floor area radio coverage. Signal strength measurements shall be performed using standardized parameters as specified below.

3. Measurement Parameters

a. Signal levels shall be measured to ensure the system meets the criteria specified in the Technical Proposal. Downlink measurements shall be made with the following standardized parameters:

1) Measurements shall be recorded using a calibrated automatic signal-level measurement system measuring RSSI in each band with a dipole antenna positioned approximately 4’ above the surface.

2) Measurements will be recorded for the test pattern as described above.

3) System acceptance is achieved when 95% of the averaged data points meet or exceed the requirements specified here and in Section 1.07.

3.3 COMMISSIONING

A. Comply with requirements specified in Division 1.

B. Engage a factory-authorized service representative to supervise and assist with startup service. Complete installation and startup check according to the approved manufacturer's written instructions.

3.4 TRAINING AND SERVICE

A. Comply with Section 26 00 01.

B. Conduct two 4-hour training sessions. Train the Owner’s maintenance personnel on procedures and schedules related to start up and shutdown, troubleshooting, servicing, and preventive maintenance.

End of Section

Section 27 50 10

HANDHELD RADIO AMPLIFICATION SYSTEM

(TRADE CONTRACT REQUIRED AS PART OF SECTION 26 00 01)

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. PUBLICLY BID TRADE CONTRACT REQUIREMENTS: As provided under Section 26 00 01 - ELECTRICAL and supplemented under the Bidding Requirements, Contract Forms, and Conditions of the Contract, and applicable parts of Division 1 - GENERAL REQUIREMENTS.

1. Work of this Trade Contract includes all individual specification sections listed in Section 26 00 01.

1.2 RELATED DOCUMENTS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications

1.3 SCOPE OF WORK

A. It is the intent of these specifications that the Contractor, Manufacturer and/or its Authorized System Integrator expeditiously furnishes and installs a system complete in every respect and ready to operate. All miscellaneous items and accessories required for such installation, whether or not each such item or accessory as shown on the plans or mentioned in these specifications, shall be furnished and installed.

B. Upon completion of the installation, the owner will review the functionality of the installed system and compare to the minimum performance standards as set forth in these specifications. Any installed system not meeting the minimum standards of performance as set forth in these specifications will be removed by the providing Vendor and replaced with a system referred to in these specifications as the “standard system of reference” at the expense of the Vendor responsible for this section of the specifications. Any additional expenses incurred to meet the owner’s interpretation of the “standard system of reference” will be the sole responsibility of the Vendor responsible for this section of the specifications. Any delays in the schedule shall also be subject to liquidated damages as required and/or described in other sections of these specifications.

C. The school district has standardized on the Motorola 3500 handheld radios. This Contractor shall provide Motorola radio amplification infrastructure as shown on the contract documents and as specified herein.

1.4 PROGRAMMING

A. Coordinate and obtain a written approval of system functionality from the Owner prior to programming.

B. Perform a walk-through with the Owner and demonstrate the system functionality.

C. Make any adjustments to system functionality after initial programming if necessary to achieve the desired functionality requested by the Owner. Coordinate all required reprogramming with the Owner as required as part of this contract.

D. Obtain a written final letter of acceptance from the Owner upon completion of system functionality programming and demonstration.

1.5 SUBMITTALS

A. Comply with requirements specified in Division 01 and the following:

1. The vendor shall submit certification letter from the manufacturer of submitted equipment certifying that the installer is an authorized and certified installer of the submitted equipment.

2. The vendor shall make all connections at all field devices and at the head-end; and shall make all necessary field adjustments for a fully functional system.

B. Shop Drawings

1. Prior to assembling or installing the system, the Contractor shall provide complete shop drawings which include the following:

a. List the name of the manufacturer's local representative and his/her phone number.

b. Table of contents.

c. Manufacturer's parts lists

d. Product serial numbers

e. Catalog cut sheets

f. Installation instructions

g. Typical wiring diagrams

h. Drawings showing equipment locations

i. Manufacturer's warranty documents

2. All drawings shall be fully dimensioned.

3. Operating License: Submit evidence of application for FCC Radio Station Authorization prior to installing equipment when required for operation of the equipment.

C. As-Built Drawings

1. At the conclusion of the project, the Vendor shall provide "as built" drawings. The "as built" drawings shall be a continuation of the Contractors shop drawings as modified, augmented, and reviewed during the installation, check out and acceptance phases of the project. All drawings shall be fully dimensioned and prepared in DWG format using the latest version of AutoCAD.

2. The as-built drawings shall incorporate all updated system riser diagrams prepared in DWG format using the latest version of AutoCAD.

D. Manuals

1. At the conclusion of the project, the Vendor shall provide copies of the manuals as described herein. Each manual's contents shall be identified on the cover. The manual shall include names, addresses, and telephone numbers of each system integrator installing equipment and systems and the nearest service representatives for each item of equipment for each system. The manuals shall have a table of contents and labeled sections. The manuals shall include all modifications made

during installation, checkout, and acceptance. The manuals shall contain the following:

a. Hardware Manual

1) The hardware manual shall describe all equipment furnished including:

2) General description and specifications

3) Installation and check out procedures

4) Equipment layout and electrical schematics to the component level

5) System layout drawings and schematics

6) Alignment and calibration procedures

7) Manufacturers repair parts list indicating sources of supply

b. Software Manual

1) The software manual shall describe the functions of all software and shall include all other information necessary to enable proper loading, testing, and operation. The manual shall include:

2) Definition of terms and functions

a) Use of system and applications software

b) Initialization, start up, and shut down

c) Alarm reports

d) Reports generation

e) Data base format and data entry requirements

f) Directory of all disk files

2. Operators Manual

a. The operator's manual shall fully explain all procedures and instructions for the operation of the system including:

1) Computers and peripherals

2) System start up and shut down procedures

3) Use of system, command, and applications software

4) Recovery and restart procedures

5) Use of report generator and generation of reports

6) Data entry

7) Operator commands

8) Alarm messages and reprinting formats

9) System access requirements

3. Maintenance Manual

a. The maintenance manual shall include descriptions of maintenance for all equipment including inspection, periodic preventive maintenance, fault diagnosis, and repair or replacement of defective components.

1.6 SYSTEM DESCRIPTION

A. Services: Upon commissioning, the handheld radio amplification system shall provide coverage for the Worcester Public School's (WPS) Motorola 3500 hand held radios. The radios shall be procured by WPS.

1.7 CODES, STANDARDS AND CERTIFICATIONS

A. All work, including but not limited to: cabling, pathways, support structures, wiring, equipment, installation, workmanship, maintenance and testing shall comply with the latest editions of the National Electrical Code, National Electrical Safety Code, all applicable local rules and regulations, equipment manufacturer's instructions, and the National Electrical Contractors Association (NECA) Standard of Installation. In case of discrepancy or disagreement between the documents noted above, the contractor shall satisfy the most stringent requirements.

B. It is the Contractor's responsibility to ensure that the components comply with local code, ordinances or requirements established by the AHJ.

1.8 WARRANTY

A. Comply with Section 260001.

B. The Electrical Trade Contractor shall warranty that all materials furnished shall be free from defects of material for a period of one year from the date of Substantial Completion.

C. Provide a 3-year preventive maintenance plan. The plan shall include one site visit per year after the warranty period to verify that the system is working per the specifications and to proactively perform maintenance, repairs, and replacements to prevent failures before they occur.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Motorola

2.2 BASIS OF DESIGN

A. The system specified is based upon products by Motorola; and represents the performance standard upon which any equivalent solution shall be based

2.3 GENERAL

A. The system shall be completed with all components and wiring required for compliance with all applicable codes and regulations, and for its operation as described hereinafter. No exclusion from or limitation in the symbolism used on the drawings or the language used in these specifications shall be interpreted as a reason for omitting any appurtenances or accessories required to enable the system to perform the specified functions.

B. Upon completion of the installation, the work shall include making all arrangements with the owner's project manager and providing any assistance necessary for inspection and test as required for a fully functional system. In conjunction with the above, training as deemed necessary to instruct authorized building personnel in the proper operation of the system shall also form a part of the required work.

C. The site and the building shall be both pre and post tested for signal strength. This Contractor shall employ the services of an integrator to perform the signal strength. Any expense incurred by the test shall be the responsibility of this Contractor.

D. The integrator shall have experience in the design and installation of In-Building Cellular Amplification System and is expected to perform a site survey to determine the signal strength on and near the building grounds to ascertain the level of amplification necessary to provide clear and reliable radio reception inside as well as outside the building covering the entire site.

2.4 COMPONENTS

A. Furnish and install the following equipment to provide handheld radio amplification on the interior as well as the exterior of the building.

DESCRIPTION
Motorola SL5700 UHF 50W Digital Repeater Includes: 403-470 MHz Operation, Two Time Slot TDMA Operation, IP Site Connect Functionality, 100% Duty Cycle, Internal Power Supply, UHF Duplexer, Duplexer Cables, Two Year Warranty
BRKT, Wall MT, SL5700
UHF Antenna System: Includes UHF Antenna, Transmission line, connectors, jumpers, and mounting hardware.
Licensing & Coordination FCC Include: 10-year license for Repeater frequencies Construction Filing Application Documentation FCC FRN Set up Digital Emissions
Install SLR5700 Digital Repeater. Program Owner furnished radios for Repeater Operation.

PART 3 - EXECUTION

3.1 INSTALLATION

A. The contractor shall install, commission and test the handheld amplification system in accordance with the manufacturer's instructions and recommendations.

B. The contractor shall install the Cellular amplification system in accordance with the accepted SOW.

C. The contractor shall adhere to all work and safety requirements while working at the job site.

D. Install cabling designed for the environment the cable will be installed in.

E. Terminate and test all cabling with a sweep analyzer.

F. Label all cabling per the contract drawings to indicate the segment number from each amplifier.

3.2 ACCEPTANCE TESTING

A. Acceptance testing will be performed confirming the requirements of Section 1.07 have been met.

B. The contractor shall complete the acceptance testing per the requirements and as prescribed in the approved Acceptance Test Plan (ATP) submittal.

3.3 COMMISSIONING

A. Comply with requirements specified in Division 1.

B. Engage a factory-authorized service representative to supervise and assist with startup service. Complete installation and startup check according to the approved manufacturer's written instructions.

3.4 TRAINING AND SERVICE

A. Comply with Section 26 00 01.

B. Conduct two 4-hour training sessions. Train the Owner’s maintenance personnel on procedures and schedules related to start up and shutdown, troubleshooting, servicing, and preventive maintenance.

C. Conduct two 4-hour training sessions. Train the Owner’s personnel on procedures related operation of the system.

End of Section

Section 27 51 16

PUBLIC ADDRESS SYSTEM

(TRADE CONTRACT REQUIRED AS PART OF SECTION 26 00 01)

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. PUBLICLY BID TRADE CONTRACT REQUIREMENTS: As provided under Section 26 00 01 - ELECTRICAL and supplemented under the Bidding Requirements, Contract Forms, and Conditions of the Contract, and applicable parts of Division 1 - GENERAL REQUIREMENTS.

1. Work of this Trade Contract includes all individual specification sections listed in Section 26 00 01.

1.2 RELATED DOCUMENTS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications

1.3 SCOPE OF WORK

A. It is the intent of these specifications that the Contractor, Manufacturer and/or its Authorized System Integrator expeditiously furnishes and installs a system complete in every respect and ready to operate. All miscellaneous items and accessories required for such installation, whether or not each such item or accessory as shown on the plans or mentioned in these specifications, shall be furnished and installed.

B. Upon completion of the installation, the owner will review the functionality of the installed system and compare to the minimum performance standards as set forth in these specifications. Any installed system not meeting the minimum standards of performance as set forth in these specifications will be removed by the providing Vendor and replaced with a system referred to in these specifications as the “standard system of reference” at the expense of the Vendor responsible for this section of the specifications. Any additional expenses incurred to meet the owner’s interpretation of the “standard system of reference” will be the sole responsibility of the Vendor responsible for this section of the specifications. Any delays in the schedule shall also be subject to liquidated damages as required and/or described in other sections of these specifications.

C. The Contractor shall furnish and install all equipment including, but not limited to, outlet boxes, wiring, speakers, and all other necessary equipment to provide a complete operating system as indicated with the contract documents. Provide all necessary wall plates, specialty boxes, etc., not provided by others.

D. The intent of this specification is to maximize communications between the classroom and administrative areas while enhancing school safety and reducing maintenance and operational cost.

E. Under this specification, the system shall provide a complete Communication System for the entire school including the outdoor recreational areas.

F. The Communication System shall provide distribution of intercom, overhead paging, emergency paging, class change time tones, emergency tones, program material and on-board emergency messaging.

1.4 PROGRAMMING

A. Coordinate and obtain a written approval of system functionality from the Owner prior to programming.

B. Perform a walk-through with the Owner and demonstrate the system functionality.

C. Make any adjustments to system functionality after initial programming if necessary, to achieve the desired functionality requested by the Owner. Coordinate all required reprogramming with the Owner as required as part of this contract.

D. Obtain a written final letter of acceptance from the Owner upon completion of system functionality programming and demonstration.

1.5 SUBMITTALS

A. Comply with requirements specified in Division 01 and the following:

1. The vendor shall submit certification letter from the manufacturer of submitted equipment certifying that the installer is an authorized and certified installer of the submitted equipment.

2. The vendor shall make all connections at all field devices and at the head-end; and shall make all necessary field adjustments for a fully functional system.

B. Shop Drawings: Signed and sealed by a qualified professional engineer or an RCDD.

1. Prior to assembling or installing the system, the Contractor shall provide complete shop drawings which include the following:

a. List the name of the manufacturer’s local representative and his/her phone number.

b. Table of contents.

c. Manufacturer’s parts lists

d. Product serial numbers

e. Catalog cut sheets

f. Installation instructions

g. Equipment Details: Detail equipment assemblies and indicate dimensions, weights, required clearances, method of field assembly, components, and location of each field connection.

h. Station-Arrangement Details

i. Wiring Diagrams: Signal, and control wiring. Include the following:

1) Single-line diagram showing interconnection of components.

2) Cabling diagram showing cable routing.

j.

k. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved.

1) Ceiling-mounted items including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.

l. Manufacturer's warranty documents

2. All drawings shall be fully dimensioned.

3. Operating License: Submit evidence of application for FCC Radio Station Authorization prior to installing equipment when required for operation of the equipment.

C. As-Built Drawings

1. At the conclusion of the project, the Vendor shall provide "as built" drawings. The "as built" drawings shall be a continuation of the Contractors shop drawings as modified, augmented, and reviewed during the installation, check out and acceptance phases of the project. All drawings shall be fully dimensioned and prepared in DWG format using the latest version of AutoCAD.

2. The as-built drawings shall incorporate all updated system riser diagrams prepared in DWG format using the latest version of AutoCAD.

D. Manuals

1. At the conclusion of the project, the Vendor shall provide copies of the manuals as described herein. Each manual's contents shall be identified on the cover. The manual shall include names, addresses, and telephone numbers of each system integrator installing equipment and systems and the nearest service representatives for each item of equipment for each system. The manuals shall have a table of contents and labeled sections. The manuals shall include all modifications made during installation, checkout, and acceptance. The manuals shall contain the following:

a. Hardware Manual

1) The hardware manual shall describe all equipment furnished including:

2) General description and specifications

3) Installation and check out procedures

4) Equipment layout and electrical schematics to the component level

5) System layout drawings and schematics

6) Alignment and calibration procedures

7) Manufacturers repair parts list indicating sources of supply

b. Software Manual

1) The software manual shall describe the functions of all software and shall include all other information necessary to enable proper loading, testing, and operation. The manual shall include:

2) Definition of terms and functions

a) Use of system and applications software

b) Initialization, start up, and shut down

c) Alarm reports

d) Reports generation

e) Data base format and data entry requirements

f) Directory of all disk files

2. Operators Manual

a. The operator's manual shall fully explain all procedures and instructions for the operation of the system including:

1) Computers and peripherals

2) System start up and shut down procedures

3) Use of system, command, and applications software

4) Recovery and restart procedures

5) Use of report generator and generation of reports

6) Data entry

7) Operator commands

8) Alarm messages and reprinting formats

9) System access requirements

3. Maintenance Manual

a. The maintenance manual shall include descriptions of maintenance for all equipment including inspection, periodic preventive maintenance, fault diagnosis, and repair or replacement of defective components.

1.6 DEFINITIONS

A. Channels: Separate parallel signal paths, from sources to loudspeakers or loudspeaker zones, with separate amplification and switching that permit selection between paths for speaker alternative program signals.

B. VU: Volume unit.

C. Zone: Separate group of loudspeakers and associated supply wiring that may be arranged for selective switching between different channels.

1.7 PERFORMANCE REQUIREMENTS

A. Delegated Design: Design supports and seismic restraints for control consoles, equipment cabinets and racks, and components, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

B. Seismic Performance: Provide supports and seismic restraints for control consoles, equipment cabinets and racks, and components that withstand the effects of earthquake motions determined according to SEI/ASCE 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

1.8 WARRANTY

A. Comply with Section 260001.

B. The Electrical Trade Contractor shall warranty that all materials furnished shall be free from defects of material for a period of one year from the date of Substantial Completion.

C. Provide a 3-year preventive maintenance plan. The plan shall include one site visit per year after the warranty period to verify that the system is working per the specifications and to proactively perform maintenance, repairs, and replacements to prevent failures before they occur.

PART 2 - PRODUCTS

2.1 PUBLIC ADDRESS (PA) SYSTEM

A. Manufacturers

1. Valcom Class Connection™ IP6000 Communication System
2. Rauland Telecenter VoIP
3. Telecor IP
4. Or approved equal

2.2 BASIS OF DESIGN

A. The basis of design product shall be Valcom Class Connection™ IP6000 Communication System.

2.3 COMMUNICATION SYSTEM FEATURES

A. Direct dialed, hands-free, two-way communication from all administrative telephones to classroom locations equipped with a talkback speaker.

B. Call button initiated hands-free, two-way communication from all classroom locations equipped with a talkback speaker to an administrative telephone.

C. Microprocessor based PoE system capable of handling unlimited end-points. An end-point is defined as a device with an IP address. The system IP speakers must be SIP compliant.

D. System shall be a VoIP system compatible with 45 ohm 2-way speakers, 25v 2-way speakers, self-amplified one-way speakers and VoIP speakers. The system should also have 1, 2 and 4 zone one-way gateways for common area announcements.

E. System shall interface with any SIP capable VoIP telephone system, analog telephone system, or single line telephone, thus allowing the school(s) to upgrade or replace their telephone system without suffering a requirement to replace, or lose any feature of, their internal communications (intercom) system. Any system that limits system features based upon any selected telephone system, and/or is proprietary to one or only a few telephone systems shall not be acceptable.

F. System shall be capable of converting and loading WAV files used for bells, announcements or music.

G. System shall be capable of initiating emergency notifications by internet browser from anywhere on the network.

H. System shall be capable of increasing volume by event. An event is defined as any WAV file or tone.

I. System shall be capable of downloading a graph (site, building, etc.) and arranging icons on it to play emergency announcements, back to school announcements, message from the Superintendent, etc.; any WAV file.

J. System shall automatically sound a tone over any loudspeaker connected for two-way communication to alert the classroom teacher that this two-way call has been established. This is intended to prevent unauthorized monitoring. The privacy tone must repeat every 15 (fifteen) seconds.

K. System shall be capable of distribution of emergency or general announcement(s) by Administration functions or from any authorized telephone to all areas furnished with a loudspeaker. Emergency announcements shall have the highest system priority.

L. Classroom speakers shall be software assignable to an unlimited number of audio groups.

M. Provide the ability to define and archive unlimited time tone schedules with unlimited events per schedule. Each scheduled event shall be capable of controlling any internal tone, user selected custom WAV files, audio from any auxiliary source or up to 40 relays for building control. Each scheduled audio event shall be distributable to any of the audio groups. The system shall feature the ability to automatically initiate unlimited schedules per day, based upon the day of the week or calendar dates up to one year in advance. The system shall feature the ability to operate 25 or more schedules simultaneously. Schedule administration, modification and creation functions must be available through an Internet browser. Systems that do not allow the school to manage their own schedules with an Internet browser do not offer calendar-based scheduling up to one year in advance or require separate page and time groups shall not be acceptable.

N. Provide 1 to 11 digits numbering plan, thus allowing the classroom speaker and the classroom telephone to be the same architectural number.

O. Programmable features shall be stored in non-volatile memory and shall not be lost due to power failures.

P. Classroom initiated intercom calls must be able to be assigned to ring at specific administrative ports. These administrative ports shall have the flexibility to be forwarded to other administrative ports should a call go unanswered or should the assigned administrative port be busy.

Q. System functionality must include the capability to manually activate an unlimited number of chained events via browser-based device, pushbuttons, contact closure, or dial up tones from any administrative telephone. These events shall be customizable with respect to volume levels, cadence, priority, type and duration. Browser access must only be accessible by authorized users.

R. The system must be capable of providing an unlimited amount of ports to be connected to the telephone system via SIP or FXS Port integration from the intercom system. These ports shall provide built-in Enhanced Caller Line Identification which will visually announce the name of the teacher or location, the architectural classroom number. Systems that require integration to a specific telephone system or systems in order to offer this feature, or any system feature, shall not be acceptable.

S. The system shall have the ability to control all system relays. Relays shall be controlled through the browser, DTMF controlled, automatically cycle at a programmed time of day, or follow time schedule events. All relays must be software programmable with the flexibility to change as required.

T. The system shall provide at least three simultaneously operating, non-restrictive program distribution channels. The system administration shall be browser based allowing simple and easy changes.

U. The system shall have the ability to store up to 25000 seconds of WAV files directly onto the Application Server and shall not be lost due to power outage.

V. The WAV files shall be capable of being activated via any computer on the LAN/Wan, Telephone and/or Telephone system, and push buttons.

W. The WAV files shall be programmable as to what level of priority they can be broadcast. They shall be programmable as to override any class change tones, normal all call, music, and intercom in the event of an emergency.

X. The WAV files shall also have the ability to be broadcast into any and all of the audio groups.

Y. The WAV files shall have the ability to be broadcast via a schedule for any day of the week or time of the day. They shall also have the ability to be broadcast for any duration of time and repeat number of plays with the ability to select how long the duration is between each repeated broadcast.

Z. The WAV files shall be able to be broadcast via a pushbutton. When this pushbutton is activated it shall be programmable to select which WAV file is broadcast, the priority level, where it is broadcast, and how many times it shall play.

AA. The WAV files shall also have the ability to be a part of the class change tones within the system. These files shall be able to replace any tone within the class change schedules as to offer the flexibility of customizable tones and or phrases in this class change mode.

2.4 IP6000 COMMUNICATION SYSTEM

A. The Applications Server, Model VE6021, when used in a Class Connection IP6000 IP School Communications System shall provide scheduling, clock control and on demand distribution of WAV formatted audio to simultaneous groups of speakers per event.

B. The server shall feature simple browser-based interface to facilitate easy manipulation of custom audio files for use as class change tones or emergency notification.

C. Schedules shall be capable of automated initiation based upon day of the week, calendar date up to one year in advance and shall feature manual control capability.

D. The 1U server shall utilize web browser access for setup of schedules, and real-time control. The server shall be capable of simultaneously operating multiple schedules, events per schedule and simultaneously occurring events. The schedules shall feature one-second event resolution. Events shall be capable of controlling paging, relays, and/or streaming audio. The server shall allow cascading events from a single time trigger. Schedules shall be presented to the user in a calendar view showing school year and months with tabs for other options.

E. The server shall provide for default screen view after login and permissions per user. The Application Server shall provide on demand access of pre-loaded audio files via web browser or contact closure. Additionally, the Applications Server shall provide for “Quick Page” on demand triggers for easy origination of unscheduled events and shall import and convert audio files from many .wav formats with both an option to enhance audio files during import and an option to record page audio to a file. Events shall feature programmable pre/post page delays and volume control per event.

F. The server shall control Networked Page Zone Extender (VE8001AR/VE8002AR/VE8004Ars) to provide streaming audio to page group(s) and shall use VE8048 inputs to execute events from the Playlist. Controlling VE8048 relays from events shall be inherent. The server shall communicate with VIP-102B setup tool for setup and dial code and group information. Users shall have the ability to enter names for displaying dial codes, page groups, inputs, events, and schedules.

G. Shall seamlessly integrate to any VoIP/SIP or legacy phone system via SIP, FXO or Loop Start Trunk.

H. Contractor shall provide the required number of (1) VE8014AR at the head-end and connect (1) port to the telephone systems trunk port. System shall be able to add analog access talk paths in increments of 1 (one), 2 (two), or 4 (four) ports.

I. Enhanced Network Station Port Model VE801XAR will provide a single 10/100 Ethernet port and one to four FXS station ports. The Enhanced Network Station Port Model VE801XAR will provide all circuitry and software to convert network data to audio output and analog telephone control signals. The Enhanced Network Station Port Model VE801X will provide all circuitry and software to convert input audio and analog telephone events to zone page audio and control information suitable for transmission to other Class Connection IP Solutions products. The Enhanced Network Station Model VE801XAR shall be powered an 802.3af PoE Ethernet switch port.

J. The system shall seamlessly control relay contacts for building system control.

K. The VE8048/VE8048R IP Input/output Module allows operation of eight (8) contact closures which are software programmable as either form A or form B. Eight (8) contact closure activated inputs provide for various programmable relay functions. The VE8048/VE8048R allows initiation of VE6021 server events over an IP-based LAN/WAN. Multiple VE8048/VE8048R may be deployed on the same network. The VE8048R is designed for 19" mounting (1U). The VE8048R shall be powered via an 802.3af PoE Ethernet switch port.

L. Contractor shall provide a one or more Networked Page Zone Extenders at the MDF and each IDF. The purpose of this Networked Page Zone Extender is to provide streaming audio out to common area speakers (analog speakers). Connect the building’s common area speakers to the Networked Page Zone Extender channels are required

M. The Networked Page Zone Extenders shall provide a single 10/100 Ethernet port, audio input/output circuits and N.O. relay contact outputs. The unit shall be SIP compatible. The Networked Page Zone Extender shall provide all circuitry and software to convert network data to zone page audio output. The Networked Page Zone Extender shall also provide all circuitry and software to convert input audio to zone page audio and control information suitable for transmission to other Class Connection IP Solutions products over a data network. The Networked Page Zone Extender shall be powered via an 802.3af PoE Ethernet switch port.

N. The system shall capable of operating new 25V analog speakers in common areas such as hallways, outside, cafeteria, gymnasium, etc. via a networked zone expander.

O. The contractor shall provide an appropriate number of 25V rack mounted, amplifiers at the MDF and each IDF used to connect to any new common area 25V speakers. The 25V Amplifier shall be CC Model # V-6120.The common area paging zones shall be as follows:

1. Gymnasium
2. Auto/Diesel
3. Kitchen
4. Cafeteria
5. Culinary Arts
6. Media Center
7. Exterior Speakers
8. Corridors by building section

P. Class Connection IP Speakers

1. Programmable for one way or two-way operation
2. SIP and Multicast Addressable
3. Easy to Install Via RJ45
4. Powered Over Ethernet
5. Controlled and Set-Up via a software interface
6. Firmware Upgradeable
7. Fully Supervised
8. Compatible with Cisco, Nortel, Avaya, and most VoIP telephone systems
9. Capable of providing superior talkback quality
10. Able to accommodate a call-in button
11. Basis of design: Valcom Model # VE4020A (8” ceiling)

Q. Common Area Speakers

1. Ceiling Tile Installation (Round)
    a. Basis of design: Simplex 5120-9416 – 8" Dual cone 25/70V Speaker with frequency range of 30 Hz to 18KHz. 12-Watt power handling capacity with sensitivity of 94 dB tapped at 1 watt @ 1 meter. Ceramic 4.8 oz. Magnet.
    b. Basis of design: Simplex 5120-9420 - Round White Steel Baffle
    c. Basis of design: Simplex 5120-9491 - Back Box w/Tile Bridge
2. Wall Mount Installation (Square)
    a. Basis of design: Simplex 5120-9416 – 8" Dual cone 25/70V Speaker with frequency range of 30 Hz to 18KHz. 12-Watt power handling capacity with sensitivity of 94 dB tapped at 1 watt @ 1 meter. Ceramic 4.8 oz. Magnet.
    b. Basis of design: Simplex 5120-9430 - Square White Steel Baffle

c. Basis of design: Simplex 5120-9492 - Square Back Box

3. Surface Ceiling Installation (Square)

a. Basis of design: Simplex 5120-9416 – 8" Dual cone 25/70V Speaker with frequency range of 30 Hz to 18KHz. 12-Watt power handling capacity with sensitivity of 94 dB tapped at 1 watt @ 1 meter. Ceramic 4.8 oz. Magnet.

b. Basis of design: Simplex 5120-9430 - Square White Steel Baffle

c. Basis of design: Simplex 5120-9493 - Square Back Box

R. Weatherproof Speaker, Wall Mounted

1. Tamper and vandal-proof 16-watt speaker

a. Basis of design: Fourjay Industries, Inc. Model 416-TR with water-proof backbox.

b. The grille shall be 16-gauge stainless steel, 10"x10", and attach to the housing with four 8 x 1" stainless steel spanner head screws. The housing shall be 18-gauge, enameled steel, 8" x 8" x 6", with five combination 1/2"-3/4" conduit knockouts. The 25/70.7-volt line driver shall have a 1-1/2" voice coil with a frequency response of 500 to 7,000 Hz, and handle 16 watts RMS.

S. Exterior Speaker, Pole Mounted

1. IP PoE One-Way Horn

a. Basis of design: Valcom VE130AL. The VE130AL is a self-contained,

paging system which enables voice paging over an IP network. The VE130AL consists of a high efficiency horn and a Network Interface allowing stand-alone capability when used with a SIP telephone system or can be accessed from a variety of Valcom managed VoIP products.

b. RJ-45 network connection

c. Network Activity LEDs

d. Power over Ethernet (PoE) 802.3af compatible.

2. Components for Exterior Pole Mounted Speaker:

a. Furnish and install (1) heater and thermostat, (1) media converter, (1) 95W POE injector, and (1) surge protector in NEMA 4x rated heated enclosure sized to accommodate all components at each speaker.

b. Furnish and install 1.5kVA, 277V to 120V stepdown transformer and double duplex receptacle in a NEMA 4x enclosures at each speaker.

c. Furnish and install rack mounted media converter in the corresponding telecommunications room.

d. Basis of Design

1) Media Converter: Altronix NETWAYSP2P

2) Heater: Hoffman DAH301

3) Temperature Control Switch: Hoffman ATEMNC

4) POE Injector: Bosch NDP-600A1

5) Surge Protector: Ditek DTK-MRJPOE

6) Nema 4X Enclosure: Hoffman ELC404020 Enclosure (or larger to accommodate all components), EP4040AL Backplate and CPMK16 Pole Mount

7) Tamper Switch: interlogix 3025T-M

8) Transformer: Hammond Power 1.5kVA, 277V to 120V

T. Valcom IP Clocks shall be:

1. Controlled and Set-Up via a software interface
2. Easy to install via RJ45
3. Powered Over Ethernet
4. Accurate via updates from a network time server
5. Basis of design: IP 12” analog clock shall be Valcom Model # VIP-A12A
6. Basis of design: IP 16” analog clock shall be Valcom Model # VIP-A16A

2.5 OBSERVATION ROOM INTERCOM

A. The observation intercom shall be a standalone IP intercom system as shown on the drawings.

B. The system shall consist of a PoE ceiling speaker/microphone located in rooms being observed; and two button PoE intercom wall stations located in observation rooms. Each room being observed shall have an associated intercom station and a POE speaker in the room being observed.

C. The intercom wall station and the ceiling speaker shall be patched through the PoE security network data switch provided by the Owner. The speaker and the intercom station shall be linked via web based software.

D. Ceiling Speaker/Microphone

1. The Wahsega Labs WL-SPKR-22-INF-1 is a drop-in 2x2 ceiling tile speaker which supports dual registration with InformaCast® and SIP, powered via Power-over-Ethernet (PoE).

E. Intercom Wall Station

1. The Wahsega Labs WL-IC-FLMT-INF-I-W 2-button stations are network-based wall intercom stations used to establish communication between specific areas of a facility.
2. The stations feature a Push to Call, Push to Talk, and a Cancel. The stations shall be configured to listen into the classroom; conversations in the Observation room shall not be audible in the classroom unless the Push to Call button is pressed.

F. Wiring

1. Wiring to the ceiling speaker and the intercom wall station shall be a Category 6A data drop to each. The cables shall be terminated per the manufacturer’s instruction at the speaker and the wall station. In the telecommunications room the cables shall be terminated in a patch panel.

2.6 CONDUCTORS AND CABLES

A. Conductors: Jacketed, twisted pair and twisted multipair, untinned solid copper (West Penn # AQC 439 or equal). Sizes as recommended by system manufacturer, but not smaller than No. 22 AWG. – Us when cabling a 25/70V speaker.

B. Insulation: Thermoplastic, not less than 1/32 inch thick.

C. Shielding: For speaker-microphone leads and elsewhere where recommended by manufacturer; No. 34 AWG tinned, soft-copper strands formed into a braid or equivalent foil.

1. Minimum Shielding Coverage on Conductors: 60 percent.

D. Plenum Cable: Listed and labeled for plenum use.

E. Category 5E UTP – Use when connecting an IP device.

F. Provide all necessary hardware and software for a complete and operable system.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that surfaces are ready to receive work.

B. Verify that required utilities are available, in proper location, and ready for use.

3.2 INSTALLATION

A. Meet with the Owner prior to installation to determine and clarify all zoning requirements. Installation of the system will not begin until this meeting has occurred, and the Contractor has provided a zoning plan to and received written approval from the Owner and Architect. Confirm locations of all control consoles with Owner and Architect prior to installation.

B. Design Criteria:

1. Provide rooms with one speaker (as indicated on the drawings) with one circuit for intercom and a dedicated address.

2. Provide rooms with more than one speaker as indicated on the drawings (i.e. the Metal Fabrication Shop, Carpentry Wood Shop, and Automotive Tech Shop and others) with two circuits as follows:

a. Dedicate the speaker nearest the front of the room to a circuit to be used as intercom.

b. Install the additional speaker(s) on a separate circuit. Run these speaker's series, programmed to mimic the paging, time tone and program zones as the intercom circuit

3. Install corridor speakers on individual circuits.

4. Program exterior speaker circuits as one individual zone

C. Match input and output impedances and signal levels at signal interfaces. Provide matching networks where required.

D. Interior ceiling speakers shall be white, wall mounted speakers interior and exterior shall be provided with custom color selected by the architect. The following rooms that contain ceiling mounted speakers shall also have custom color selected by the architect:

1. Large Group instruction C205
2. Lecture Hall D336
3. Photo Dark Room A438.1
4. Film Room A438.2
5. Culinary Arts Restaurant A236
6. Auditorium

E. Identification of Conductors and Cables: Color-code conductors and apply wire and cable marking tape to designate wires and cables so they identify media in coordination with system wiring diagrams.

3.3 INTEGRATION WITH OTHER SYSTEMS

A. All equipment shall be installed and connected in strict accordance with the manufacturer’s recommended instructions.

B. Provide integration with Owner’s telephone system.

C. Provide integration with local sound systems and classroom speech reinforcement systems.

3.4 COMMISSIONING

A. Comply with requirements specified in Division 1.

B. Engage a factory-authorized service representative to supervise and assist with startup service. Complete installation and startup check according to the approved manufacturer's written instructions.

3.5 TRAINING AND SERVICE

A. Comply with Section 26 00 00.

B. Conduct two 4-hour training sessions. Train the Owner’s maintenance personnel on procedures and schedules related to start up and shutdown, troubleshooting, servicing, and preventive maintenance.

C. Conduct four 4-hour training sessions. Train teachers and administration personnel on system operation.

3.6 EXTRA MATERIALS

A. Furnish the following component at the end of the project to the Owner:

1. Classroom IP speaker: 10
2. Gym speaker: 2
3. Exterior speaker: 5
4. Corridor Speaker: 10

5. Analog Clock: 5
6. Emergency Call Station: 10
7. Observation Intercom Station: 2
8. Observation ceiling speaker: 2

End of Section

Section 27 51 29

DIGITAL SIGNAGE AND CLOCK SYSTEM

(TRADE CONTRACT REQUIRED AS PART OF SECTION 26 00 01)

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. PUBLICLY BID TRADE CONTRACT REQUIREMENTS: As provided under Section 26 00 01 - ELECTRICAL and supplemented under the Bidding Requirements, Contract Forms, and Conditions of the Contract, and applicable parts of Division 1 - GENERAL REQUIREMENTS.

1. Work of this Trade Contract includes all individual specification sections listed in Section 26 00 01.

1.2 RELATED DOCUMENTS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications

1.3 WORK INCLUDED

A. Furnish and install a complete Digital Signage and Clock System as described herein.

1.4 DEFINITIONS

A. A user-configurable messaging display and software platform that integrates with and supports emergency systems to deploy visual and audio alerts, synchronized content, messaging, audible tones, and clock images for:

1. Emergency notification/communication.
2. Routine digital signage and messaging.
3. Clock display.

B. Ethernet: A system to form a local area network with protocols to control the passing of information and provide time synchronization via SNTP (Simple Network Time Protocol).

C. Local Area Network (LAN): connects computers and devices in a limited geographical area.

D. Wi-Fi: A wireless networking technology that allows computers and other devices to communicate over a wireless signal. It describes network components that are based on one of the 802.11 standards developed by the IEEE and adopted by the Wi-Fi alliance.

E. Software Service Agreement (SSA): a software licensing and distribution model.

1. Software is licensed on a subscription basis for terms of one, two and three years.
2. It is centrally hosted and accessed by users over the Internet.

1.5 PROGRAMMING

A. Coordinate and obtain a written approval of system functionality from the Owner prior to programming.

B. Perform a walk-through with the Owner and demonstrate the system functionality.

C. Make any adjustments to system functionality after initial programming if necessary to achieve the desired functionality requested by the Owner. Coordinate all required reprogramming with the Owner as required as part of this contract.

D. Obtain a written final letter of acceptance from the Owner upon completion of system functionality programming and demonstration.

1.6 SUBMITTALS

A. Comply with requirements specified in Division 01 and the following:

1. The vendor shall submit certification letter from the manufacturer of submitted equipment certifying that the installer is an authorized and certified installer of the submitted equipment.

2. The vendor shall make all connections at all field devices and at the head-end; and shall make all necessary field adjustments for a fully functional system.

B. Shop Drawings

1. Prior to assembling or installing the system, the Contractor shall provide complete shop drawings which include the following:

a. List the name of the manufacturer’s local representative and his/her phone number.

b. Table of contents.

c. Manufacturer’s parts lists

d. Product serial numbers

e. Catalog cut sheets

f. Installation instructions

g. Typical wiring diagrams

h. Drawings showing equipment locations

i. Manufacturer’s warranty documents

2. All drawings shall be fully dimensioned.

3. Operating License: Submit evidence of application for FCC Radio Station Authorization prior to installing equipment when required for operation of the equipment.

C. As-Built Drawings

1. At the conclusion of the project, the Vendor shall provide “as built” drawings. The “as built” drawings shall be a continuation of the Contractors shop drawings as modified, augmented, and reviewed during the installation, check out and acceptance phases of the project. All drawings shall be fully dimensioned and prepared in DWG format using the latest version of AutoCAD.

2. The as-built drawings shall incorporate all updated system riser diagrams prepared in DWG format using the latest version of AutoCAD.

D. Manuals

1. At the conclusion of the project, the Vendor shall provide copies of the manuals as described herein. Each manual's contents shall be identified on the cover. The manual shall include names, addresses, and telephone numbers of each system integrator installing equipment and systems and the nearest service representatives for each item of equipment for each system. The manuals shall have a table of contents and labeled sections. The manuals shall include all modifications made during installation, checkout, and acceptance. The manuals shall contain the following:

a. Hardware Manual

1) The hardware manual shall describe all equipment furnished including:

2) General description and specifications

3) Installation and check out procedures

4) Equipment layout and electrical schematics to the component level

5) System layout drawings and schematics

6) Alignment and calibration procedures

7) Manufacturers repair parts list indicating sources of supply

b. Software Manual

1) The software manual shall describe the functions of all software and shall include all other information necessary to enable proper loading, testing, and operation. The manual shall include:

2) Definition of terms and functions

a) Use of system and applications software

b) Initialization, start up, and shut down

c) Alarm reports

d) Reports generation

e) Data base format and data entry requirements

f) Directory of all disk files

2. Operators Manual

a. The operator's manual shall fully explain all procedures and instructions for the operation of the system including:

1) Computers and peripherals

2) System start up and shut down procedures

3) Use of system, command, and applications software

4) Recovery and restart procedures

5) Use of report generator and generation of reports

6) Data entry

7) Operator commands

8) Alarm messages and reprinting formats

9) System access requirements

3. Maintenance Manual

a. The maintenance manual shall include descriptions of maintenance for all equipment including inspection, periodic preventive maintenance, fault diagnosis, and repair or replacement of defective components.

1.7 QUALITY ASSURANCE

A. Manufacturer must provide documentation of at least 10 continuous years of experience supplying networked systems in the education market.

B. Installer must be experienced in the installation of networked systems.

1.8 REGULATORY REQUIREMENTS

A. Equipment and components furnished shall be of manufacturer's latest model.

B. Refurbished equipment, upgraded to as-new condition, may be offered for product evaluation purposes and sold as such at discounted pricing.

C. System shall be installed in compliance with local and state authorities having jurisdiction.

1.9 DELIVERY, STORAGE AND HANDLING

A. Deliver all components to the site in the manufacturer's original packaging.

B. Packaging shall contain manufacturer's name and address, product identification number, and other related information.

C. Store equipment in finished building, unopened containers until ready for installation.

1.10 FIELD CONDITIONS

A. Displays shall not be installed until painting and other finish work in each room is complete.

B. Coordinate installation of 110 VAC outlets to all locations where a display shall be installed unless a suitable 110 VAC legacy power source already exists.

C. The display shall be installed within 4 feet of a 110 VAC outlet or within 12 inches of a legacy 110 VAC power source having a molex connector.

1.11 WARRANTY

A. Comply with Section 260001.

B. The Electrical Trade Contractor shall warranty that all materials furnished shall be free from defects of material for a period of one year from the date of Substantial Completion.

C. Provide a 3-year preventive maintenance plan. The plan shall include one site visit per year after the warranty period to verify that the system is working per the specifications and to proactively perform maintenance, repairs, and replacements to prevent failures before they occur.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. American Time, EverAlert Emergency Communication Platform

B. Visix

C. RiseVision

D. Or approved equal

2.2 BASIS OF DESIGN

A. The basis of design product shall be EverAlert™ by American Time.

2.3 SYSTEM FEATURE DESCRIPTION

A. Displays shall include the following features:

1. Smart 22” (minimum size) class HD screen with built-in speakers.
2. New construction installation where clocks are located in classrooms and hallways.
3. Screen display orientation can be either Landscape or Portrait mode.
4. Preloaded with operating system software.
5. Communicates to the online Management Portal through wired or Wi-Fi network.
6. Resumes normal operation after a temporary power interruption without intervention.
7. Operator adjustable or scheduled screen brightness to reduce distraction.
8. Scheduled sleep mode for energy conservation.

B. Wall Mounting Hardware shall include the following features

1. Display wall mounting bracket kits for retrofit installations and new installations.
2. Kits include tamper-resistant mounting brackets that allow tilting of the display in both portrait or landscape orientation, and integrated clip for the display power supply.
3. A clear guard for common area applications protects displays, provides ventilation, and accommodates full mounting bracket tilt.

C. Integrators shall include the following features

1. Integrators are wired to existing security system switches and create internet messages that automatically trigger alert displays upon change of switch status.
2. Each integrator supports physical wiring to monitor normally open (dry contact) security system switches, providing maximum reliability and fast response for automatically triggered alerts.
3. Integrators can be configured to monitor fire alarm panels, lockdown switches, or any other normally open switches used for emergency alarm purposes.

D. Software Service Agreement (SSA) shall include the following features

1. Provides access to the Management Portal and telephone technical support
2. Available for multi-year terms, renewable prior to expiration

3. Expiration of SSA will cause display to revert to synchronized clock function only: Emergency alert detection and notification, digital signage functions, including current weather, and technical support will no longer be available.

E. The Management Portal shall include the following features

1. General

   a. Three levels of user access-level rights, including Site Administrator/District, School, and Classroom.

   b. Capable of uploading audio files for playback through the displays, including bells, tones, sirens, music, and prerecorded voice messages.

   c. Supports automated email and/or text outbound notifications to a list of subscribers authorized by the site administrator upon alarm activation or loss of network connections between any display and the management portal.

2. Emergency Alerts

   a. Emergency alerts with audible tones and customized messages can be configured by the site administrator access level only: Fire drills and alerts, lockdown drills and alerts, severe weather drills and alerts, and custom alerts.

   b. Alerts override all other routine displays.

3. Routine digital signage

   a. Routine messages be configured and deployed by all access levels: Time-synchronized event reminders, and audio alerts, including scheduled tone activation for class change notification, school start and dismissal.

   b. Screen background customization.

   c. Quiet message type to prevent distraction: Alert and higher-level messages override quiet messages.

   d. Instant messaging with notification tone.

   e. Daily announcements, calendar events and scheduled activities.

   f. Tagging support for content delivery to individual classrooms or tagged groups.

   g. Weather advisories displayed as banners at the bottom of the screen.

4. Clock display

   a. Analog or digital synchronized clock time.

   b. 4-digit or 6-digit digital clock display.

   c. Classroom and hallway countdown timer support.

5. Management Portal user interface for mobile devices

   a. Password protected access, 4-character PIN.

   b. Accessible from any online smart mobile device.

   c. Streamlined, responsive-design version of the management portal full user interface.

   d. Trigger fire, lockdown and weather, and custom alerts directly from a smart phone.

   e. Send all clear message.

f. Send instant messages that override scheduled messages.

g. Automatically documents the mobile device user who has activated an alert.

2.4 EQUIPMENT SPECIFICATIONS

A. Display, American Time p/n EADV1 including:

1. Dimensions, master shipping carton, two displays: 38” L, 8-3/8” W, 18-1/2” H
2. Weight, master shipping carton, two displays: 37lbs
3. Weight, single display: 12lbs
4. Dimensions, single display: 21” L, 1-3/8” W, 12-29/32” H
5. Dimensions, display screen diagonal: 21.5”
6. Lighting, screen: LCD with LED backlight
7. Resolution, display screen: 1920 x 1080
8. Mounting formats: Portrait or Landscape modes
9. Internal speakers: 2 each at 2W
10. Operating system: Android
11. USB ports: 2
12. External speaker output jack: 3.5mm
13. Wired Ethernet connectivity: 10/100M, RJ45 connector
14. Wireless Ethernet connectivity: Wi-Fi - 802.11b/g/n (2.4GHz)
15. USB provisioning: USB drive with AES encryption
16. Wired provisioning: LAN/DHCP Web portal on network connection
17. Time synchronization support: 2 static IP address SNTP servers
18. Clock battery backup for power outages: CR1620 Lithium
19. Relative humidity: 85%
20. Operating temperature: 0deg C – 40deg C
21. Input voltage to power supply: 100-240VAC, 50/60Hz
22. Power supply output voltage: 12Vdc
23. Energy efficiency: Level VI
24. Power Consumption: 30W (average), 40W (maximum), 23W (sleep)
25. Certifications: ROHS, CE/FCC, PSU with UL

B. Wall Mounting Hardware kits for easy display installation:

1. Surface mount bracket kit, American Time p/n EASMB:
   a. Tilt bracket with standard VESA interface allows +/- 10 degrees of tilt.
   b. Integrated clip to hold display power supply
   c. Surface mount plate for new construction
2. Flush mount bracket kit, American Time p/n EAFMB:
   a. Tilt bracket with standard VESA interface allows for +/- 10 degrees of tilt.

b. Integrated clip to hold display power supply.

c. Back box cover-plate.

d. Power cord with molex connector for retrofit installations.

3. Display guard, American Time p/n GRP17X25X10:

a. Clear high-strength polycarbonate.

b. Allows full +/- 10 degrees display mounting bracket tilt.

C. Integrator, American Time p/n EAIV1:

1. Wired Ethernet connectivity: 10/100M, RJ45 connector
2. Monitored switch style: Normally open dry contact
3. Number of monitored switches: 2 switches per Integrator
4. Number of Integrators per EverAlert system: 5 Integrators per system
5. Input voltage to power supply: 100-240VAC, 50/60Hz
6. Power supply output voltage: 12Vdc

D. Software Service Agreement, American Time p/n's EASSA1V1, EASSA2V1, EASSA3V1.

1. Allows customer access to the Management Portal and technical support.
2. Available with one, two or three-year renewable Software Service Agreements (SSA).
3. Expiration of SSA will cause display to revert to synchronized clock function only: Emergency alert detection and notification, digital signage functions, including current weather, and technical support will no longer be available.

E. Management Portal, American Time (no p/n)

1. Server location: Cloud
2. Application updates: Daily at 2:00am
3. Update re-boot time: less than 5 minutes
4. Compatible browsers as of December, 2016: Internet Explorer, Chrome and Safari
5. Ethernet connectivity: HTTPS secure connection to all devices.
6. Maximum number of simultaneous active users per site: Up to 100
7. Maximum number of email and text message subscribers: Up to 100
8. Clock synchronization and daylight saving time support: Configurable SNTP server addresses/pool domain names
9. Network credentials: AES encrypted key creation
10. Number of automatically triggered weather alerts: Up to 15
11. Max size MP3 audio files: 4MB per file
12. Total storage for all media per site: 500MB

2.5 SYSTEM OPERATION AND STARTUP SEQUENCE

A. Provide all connections to data network.

B. Displays is configured/provisioned by one of two optional methods.

1. Display configuration using wired LAN on a DHCP Network (option 1).

a. Power-on device.

b. Connect Ethernet cable to display.

c. Display will automatically connect and provision to the correct site.

2. Display configuration using USB key (option 2)

a. Login to portal and create a USB key by selecting create key and saving to a USB.

b. Power-on Device.

c. Insert USB stick.

d. Display will automatically connect and provision to the correct site.

C. Integrator installation

1. Connect normally open contact closure switches of desired alarms to trigger on the Emergency Notification System integrator input 1 and/or input 2.

2. Login to portal and select new Emergency Notification System Integrator

a. In the Management Portal, document the title, serial number, and desired inputs.

b. Document instructions for display configuration when alarm is triggered for each Integrator input.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Construction must be complete, and rooms clean and dry where equipment is located.

B. Either a 110 VAC power outlet or legacy clock molex connector supplying 110 VAC power at the installation point is required for each display.

C. Wi-Fi or wired internet connectivity is required at each display location.

3.2 SYSTEM INSTALLATION

A. Install displays and integrators in accordance with manufacturer's installation manual furnished with the system, for proper installation of each system component.

B. Mounting brackets shall be securely attached to walls.

3.3 CLEANING

A. Prior to final acceptance, clean exposed surfaces of all system components, using cleaning methods recommended by the manufacturer.

B. Remove shipping packaging and other protective materials from the products.

3.4 FIELD INSPECTION

A. Prior to final acceptance, inspect each system component to function properly and replace parts that are found defective.

3.5 MANUFACTURERS SERVICES

A. Services are provided for the term of purchased Software Service Agreement.

B. Management portal software updates.

C. Remote technical assistance, on product start up, system setup, and system operation is provided via phone, fax, or e-mail.

3.6 COMMISSIONING

A. Comply with requirements specified in Division 1.

B. Engage a factory-authorized service representative to supervise and assist with startup service. Complete installation and startup checks according to the approved manufacturer's written instructions.

3.7 TRAINING AND SERVICE

A. Comply with Section 26 00 01.

B. Conduct two 4-hour training sessions. Train the Owner’s maintenance personnel on procedures and schedules related to start up and shutdown, troubleshooting, servicing, and preventive maintenance.

C. Conduct four 4-hour training sessions. Train teachers and administration personnel on system operation.

3.8 EXTRA MATERIALS

A. Furnish the following component at the end of the project to the Owner:

1. Smart 22” class HD screen with built-in speakers End of Section: 10

End of Section

Section 27 53 19

PUBLIC SAFETY RADIO DISTRIBUTED ANTENNA SYSTEM (DAS)

(TRADE CONTRACT REQUIRED AS PART OF SECTION 26 00 01)

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. PUBLICLY BID TRADE CONTRACT REQUIREMENTS: As provided under Section 26 00 01 - ELECTRICAL and supplemented under the Bidding Requirements, Contract Forms, and Conditions of the Contract, and applicable parts of Division 1 - GENERAL REQUIREMENTS.

1. Work of this Trade Contract includes all individual specification sections listed in Section 26 00 01.

1.2 RELATED DOCUMENTS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.

1.3 SCOPE OF WORK

A. It is the intent of these specifications that the Contractor, Manufacturer and/or it's Authorized System Integrator expeditiously furnishes and installs a system complete in every respect and ready to operate. All miscellaneous items and accessories required for such installation, whether or not each such item or accessory as shown on the plans or mentioned in these specifications, shall be furnished and installed.

B. This specification describes the criteria for deploying a Public Safety Radio Distributed Antenna System (DAS). The DAS components specified in this document include: Bi-Directional Amplifiers (BDA), Donor Antennas, Coverage Antennas, Coax Cable, Coax Connectors, Splitters, Combiners and Couplers. These devices shall be used as part of a system, by the DAS integrator, experienced with designing projects for in-building, public safety, 2-way radio systems.

C. It shall be the integrator's responsibility to base the design on the frequency ranges used by both Police and Fire departments and any proposal/submittal shall be reflective of advance investigation of this requirement. The system provided shall meet IFC 2009 and NFPA 1 2009 codes and shall be designed as such. It shall include a true, integrated battery backup unit which is serially connected to the main BDA system. Small UPS units not serially connected shall not be acceptable.

D. All the public safety agencies in the City of Worcester operate on the same frequency range. The frequency range is between 851-861. The City utilizes Astro P25 digital 800 trunked system. The proposed DAS system should be able to pass this range both analog and digital (Not channelized).

1.4 ABBREVIATIONS AND ACRONYMS

A. ACG: Automatic Gain Control

B. AHJ: Authority Having Jurisdiction

C. ATP: Acceptance Test Plan

D. BDA: Bi-Direction Amplifier

E. BOM: Bill-of-Material

F. DAS: Distributed Antenna System

G. EBS: Educational Broadband Service

H. ESMR: Enhanced Specialized Mobile Radio

I. FCC: Federal Communications Commission

J. GUI: Graphical User Interface

K. LMR: Land Mobile Radio

L. MTBF: Mean Time Between Failure

M. NFPA: National Fire Protection Association

N. NMS: Network Management System

O. PSN: Public Safety Network

P. RoF: Radio-over-Fiber

Q. RSL: Received Signal Level

R. SMR: Specialized Mobile Radio

S. SMS: Short Message Service

T. SNIR: Signal-to-Noise Interference Ratio

U. SOW: Statement of Work

V. VSWR: Voltage Standing Wave Ratio

1.5 DEFINITIONS

A. Acceptance: Expressed approval by the AHJ and owner's representative.

B. Specialty Trade Contractor: The Contractor experienced in the design installation and commissioning of 2-way Public Safety Radio In-Building Systems.

1.6 DESIGN SUBMISSIONS

A. The vendor will complete a Fire Alarm Permit Application acquired from the Fire Prevention Division stating a Bi-Directional Antenna "BDA" installation.

B. Plan Review: Provide one line, schematic and detail drawings of the proposed system architecture. Indicate proposed locations for system components. Provide specifications for procurement and installation of a complete system for review by the Fire Department and all other agencies and authorities having jurisdiction (included will be operational frequencies).

C. Testing and Commissioning: Coordinate the completion date of the Fire Department radio signal repeater system so as to permit a Certificate of Occupancy to be obtained in a timely manner, in accordance with a schedule established by the owner's project manager.

D. The entire system shall meet with the approval of the Fire Department and all other agencies and authorities having jurisdiction before a Certificate of Occupancy will be issued.

1.7 QUALITY ASSURANCE

A. Qualifications: The Integrator shall be an authorized reseller of the proposed system and shall employ NICET certified technicians.

1.8 CODES, STANDARDS AND CERTIFICATIONS

A. All work, including but not limited to: cabling, pathways, support structures, wiring, equipment, installation, workmanship, maintenance and testing shall comply with the latest editions of the National Fire Protection Association (NFPA), National Electrical Code, National Electrical Safety Code, all applicable local rules and regulations, equipment manufacturer's instructions, and the National Electrical Contractors Association (NECA) Standard of Installation. In case of discrepancy or disagreement between the documents noted above, the Contractor shall satisfy the most stringent requirements.

B. Requirements set forth by first-responder code, ordinance, or the AHJ shall supersede the requirements described herein and shall be met in their entirety. It is the Contractor's responsibility to ensure that the system complies with local code, ordinances or requirements established by the PSN AHJ.

1.9 SUBMITTALS

A. The Contractor, prior to beginning the on-site installation, is required to submit, for approval by the owner, a complete list of the proposed equipment with a system diagram showing how the various components are interconnected and their function. Included in the submittal shall be:

1. Prior to assembling or installing the system, the Contractor shall provide complete shop drawings which include the following:

a. List the name of the manufacturer's local representative and his/her phone number.

b. Table of contents.

c. Manufacturer's parts lists

d. Product serial numbers

e. Catalog cut sheets

f. Installation instructions

g. Typical wiring diagrams

h. Drawings showing equipment locations

i. Manufacturer's warranty documents

2. All drawings shall be fully dimensioned.

3. Operating License: Submit evidence of application for FCC Radio Station Authorization prior to installing equipment when required for operation of the equipment.

4. Product Data: Submit manufacturer datasheets for the following components:
    a. Bi-Directional Amplifiers (BDA)
    b. Donor and Coverage Antennas
    c. Coaxial Cable and Connectors
    d. Splitters, Combiners and Couplers
    e. Fiber-Optic Master Unit (if needed)
    f. Fiber-Optic Remote Units (if needed)
5. Shop Drawings: Submit the following items:
    a. RF site survey results
    b. System overview and riser diagram.
    c. Overlay of system components on floor plans.
    d. Donor Antenna lightning suppression and grounding details
6. Statement of Work (SOW): Submit a brief description of the DAS integrator role and responsibilities on this project. At a minimum, the services included shall be to perform the RF survey, systems design, test, optimization and commissioning of the DAS system
7. Acceptance Test Plan (ATP): Submit a proposed ATP including cable testing reports.

B. Submittal Requirements at Close Out
1. Drawings: Submit as-built drawings indicating:
    a. A final, signed copy of all previously submitted documents reflecting the final, as-built
    b. representation, equipment used and details
    c. Cable routing, splitters, couplers and coverage antenna final locations
    d. Active component locations, layout, configuration and programmed parameters
2. Test Reports
    a. Submit Accepted ATP reports.
3. Field Reports: Submit sweep-testing results for all cable runs.
4. Field Reports: Submit OTDR test results for all fiber runs.
5. Operation and Maintenance Data: Submit hardware and software manuals for all Active Components.
6. Warranty Documents:
    a. Submit for all manufactured components specified in this Section.
    b. Submit Contractor’s System Warranty.

1.10 WARRANTY

A. Comply with Section 260001.

B. The Electrical Trade Contractor shall warranty that all materials furnished shall be free from defects of material for a period of one year from the date of Substantial Completion.

C. Provide a 3-year preventive maintenance plan. The plan shall include one site visit per year after the warranty period to verify that the system is working per the specifications and to proactively perform maintenance, repairs, and replacements to prevent failures before they occur.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. TX/RX - Bird Electronics

B. CommScope/Andrew

C. Cellwave Inc

D. Or approved equal

2.2 BASIS OF DESIGN

A. The system specified is based upon TX/RX Systems Bird Technologies Group RescueLine Signal Booster and represents the performance standard upon which any equivalent solution shall be based.

2.1 APPROVED DAS SYSTEM INTEGRATORS

A. SimplexGrinnell

B. Worad, Inc

C. Comtronics

D. Or approved equal

2.2 GENERAL

A. The system shall be completed with all components and wiring required for compliance with all applicable codes and regulations, and for its operation as described hereinafter. No exclusion from or limitation in the symbolism used on the drawings or the language used in these specifications shall be interpreted as a reason for omitting any appurtenances or accessories required to enable the system to perform the specified functions.

B. Upon completion of the installation, the work shall include making all arrangements with the owner's project manager and providing any assistance necessary for inspection and test as required for approval by the Fire Department. Modifications, adjustments and/or corrective work necessary to obtain approval along with subsequent inspection and test resulting from the issuance of a "Notice of Defect" shall precede any consideration of formal acceptance by the building owner. In conjunction with the above, training as deemed necessary to instruct authorized building personnel in the proper operation of the system shall also form a part of the required work.

C. The building shall be both pre and post tested for fire and police department radio signal strength. At the request of this Contractor, a test shall be scheduled with the Fire Department. This Contractor shall employ the services of an integrator to perform the fire/police department radio signal strength. Any expense incurred by the test shall be the responsibility of this Contractor.

D. The integrator shall have experience in the design and installation of Public Safety Systems and is expected to perform a site survey to determine the RF signal strength on or near the building grounds to determine the level of amplification necessary to provide clear and reliable radio communications over 95% of the overall area inside the building.

E. The radio test shall check the signal reception in several locations on the floor area. Signal strength shall be as required for clear reception throughout the building utilizing the type of hand held radio unit that is used by the Fire and Police Departments. Quantity of test locations shall be determined and conducted by the local department representative. Each floor of the building shall be divided into a grid of approximately twenty (20) equal areas. A maximum of one (1) area will be allowed to fail the test per floor. A spot located approximately in the center of a grid area will be selected for the test. Once the spot has been selected, prospecting for a better spot within the grid area will not be permitted. Field strength testing instruments are to be recently calibrated (1 year) and of the frequency selective type incorporating a flexible antenna similar to the ones used on the hand held transceivers.

F. Required Signal Levels:

1. Signal strength shall be as required for clear reception throughout the building utilizing hand held radio units of the type(s), which are used by the fire and police department. Signal strength testing shall follow TSB-88 standards using delivered audio quality measurements (DAQ).
2. A minimum signal strength of –95 dBm (DAQ4) shall be available on over 95% of the floor area required to be covered when transmitted from the fire and police department.
3. A minimum signal strength of –95 dBm (DAQ4) shall be received at the fire and police department system from over 95% of the floor area required to be covered.

G. Required Broadcasting Frequency:

1. Frequency as required to be compatible with Fire and Police Department equipment.
2. The building owner will be responsible for keeping the operational frequencies of the BDA compatible with the Fire and Police Department radio system.

H. Should testing determine that a signal deficiency exists in the respective building and a signal repeater system becomes required, the fire and police department radio signal system shall be designed and installed. The bi-directional antenna type system shall consist of the following components:

1. Bi-directional radio amplifier
2. Plenum rated coaxial cable
3. Antennas (internal and external)
4. Terminators
5. Couplers
6. Other components and interconnecting circuitry as required
7. Battery Backup NFPA Compliant unit (not UPS system)

I. It is the intent of these specifications that where a BDA system is required, a complete fully functioning system will be designed, approved and tested before an Occupancy Permit is issued.

J. Areas requiring coverage include stairwells corridors, hallways, and other areas designated by the Fire Marshalls and/or the Authority Having Jurisdiction (AHJ).

K. The integrator shall propose, design and deploy a system capable of receiving approval of the AHJ. The Contractor shall coordinate with the Fire Marshall's office and Police Department Communications Division to obtain the correct frequencies and other similar information necessary to deploy a complete and fully operational system at this location.

L. Expansion: Without replacing or adding to the Infrastructure, the system shall have expansion capabilities to support the addition or changes of radio frequencies and future building renovations. Any additional Components required for system expansion shall comply with all specifications of this Section.

M. Alarming: The BDA shall include the following outputs which shall interface to the fire alarm system. The integrator shall coordinate the installation of this alarm with the fire alarm Contractor:

1. Signal booster malfunction alarm
2. Loss of AC Power Alarm
3. Low Battery Alarm
4. Antenna Circuit Malfunction
5. Charge Failure Alarm

N. If the Contractor elects to propose an active system, he will also be responsible for furnishing, installing, and testing of the fiber optic cable and components required to meet the needs of the proposed system.

O. Antenna locations as shown on the drawings are approximations. The Integrator is responsible for locating the in-building antennas and the donor antenna as required by the equipment selected, proposed design and the design criteria.

2.3 REQUIREMENTS

A. WSP DAS:

1. On a per channel basis, the downlink RSL for each frequency band shall meet or exceed Design Audio Quality (DAQ) testing criteria.
2. The DAS shall deliver coverage throughout 95% of the building, and 100% of areas designated as critical. Coverage areas shall include stairwells, elevators, and underground spaces.
3. The system shall be housed in a NEMA 4 cabinet and shall include 24 hour battery backup.
4. The system shall maintain maximum required output power while preventing excessive emissions per FCC requirements.

2.4 POWER SUPPLY

A. The central equipment shall be supplied with an emergency power unit including batteries and battery charging equipment that maintains this cabinet and all outlying equipment that requires power operation without any change in status for a minimum period of twenty-four (24) hours. The emergency power units(s) shall be sized to meet the following minimum requirements: operating in normal (supervisory) mode, twenty-four (24) hours, followed by twelve (12) hours of emergency operation. Batteries shall be of the sealed maintenance free type.

B. System design shall be such that neither the failure of the normal power source, the transfer to an emergency source, nor the retransfer to the normal source shall cause a change in system status.

C. Serially connected battery backup.

2.5 EQUIPMENT LOCATION AND PROTECTION

A. Secured Space: The bi-directional radio amplifiers shall be installed in 2-hour rated closet. They shall be located in a suitable non-finished space as approved by the engineer and/or where specifically shown on the drawings. The entrance to the secured space shall clearly identify the space as having the “Fire Department” radio signal repeater equipment, by the use of an attached engraved nameplate.

B. Unsecured Space: The bi-directional amplifiers shall be provided with NEMA 4 enclosures, hinged lockable doors, electric supervision against unauthorized access and the removal of any components, and shall each have an attached engraved nameplate identifying the unit.

C. The bi-directional amplifier shall be supplied with cavity style filtering in order to minimize unwanted frequencies from entering the amplifier. Cavities shall be tuned to the frequencies provided by the Fire Department. Cavity filters will be housed to allow access by technicians, but will be protected from tampering, or accidental damage.

D. The bi-directional amplifier shall contain automatic limiting control circuitry to avoid producing overdriven outputs from the amplifier.

2.6 MAINTENANCE

A. The bi-directional amplifier will be checked annually by the owner, with all functions tested and a report filed with the Fire Department.

B. Inspection and Test: Provide all material and labor to test system by verifying operation of the system throughout the building. Adjust as required to provide optimum system performance.

C. Parts and labor for repairs and/or replacements is excluded.

2.7 COMPONENTS

A. Yagi Donor (Outdoor) Antennas:

1. Electrical:

a. Frequency band: In accordance with Police/Fire Department requirements

b. Bandwidth > 1.5 VSWR: 20

c. Gain: ≥ 10 dB

d. Maximum input power: 250 watts

e. Vertical Beam width: 44 Deg.

f. Front-to-back ratio: ≥ 16 dB

g. Impedance: 50 Ω

h. Beam width, Horizontal, degrees: 60

i. Azimuth Pattern: As proposed by the manufacturer to meet the specifications in this Section.

2. Mechanical:
    a. Connector: 50 Ω N Type Female
    b. Mounting: Pole
3. 3. Environmental:
    a. Temperature: -40 °C to +60 °C
    b. Lighting protection: Direct ground
    c. Waterproof level: IP 66
    d. Wind Speed, maximum: 125 mph
    e. Wind Load: 0.45 sq. ft.

B. Bi-Directional Amplifier (BDA):
1. Characteristics
    a. Frequency: As determined by Police & Fire Department requirements
        1) All public safety agencies in the city utilize an 800 MHz trunked simulcast system.
        2) The frequency range is between 851-861.
        3) The City will be moving from analog to Astro P25 digital 800 trunked on the same frequencies in early 2016. The BDA should be able to pass this range both analog and digital (not channelized).
    b. Gain: +80dB maximum
    c. Programmable Gain adjustment attenuation, 0-30dB, 0.5 dB steps
    d. Maximum Output Power: + 32 dBm
    e. Noise Figure: 8 dB maximum
    f. Operating Temperature Range: -30 °C to +50 °C
    g. Chassis: Shall be capable of rack or wall mounting as required by the DAS integrators design.
    h. Filtering: Digital
    i. Separate Control: Each RF amplifier shall be capable of adjusting and controlling power levels for each WSP when multiple WSPs share a single amplifier.
    j. FCC Part 90.219 Type Classification: Class A
    k. Alarming: Dry contacts for remote alarms
    l. Mounting Options: shall support rack, wall and pole mounting
    m. Power Consumption: less than 100VA
2. Compliance:
    a. NFPA: The BDA shall comply with NFPA-1 2009 edition Annex O In-Building Public Safety Radio Enhancement Systems.
    b. FCC: Shall be FCC type certified.

C. Air Dielectric, Plenum Rated Cable:

1. Material Characteristics:
    a. Jacket: Halogenated, Fire-Retardant, Plenum rated
    b. Outer Conductor Material: Corrugated Aluminum or Corrugated Copper
    c. Inner Conductor Material: Copper-Clad Aluminum Wire
2. Electrical Characteristics:
    a. Impedance: 50 ± 2.0 Ω
    b. Frequency Band: 1 - 8800 MHz
    c. Peak Power Rating: ≥ 40.0 kW
3. Mechanical Characteristics:
    a. Diameter Over Jacket: ≤ .627 in
    b. Minimum Bending Radius: ≤ 5 in
    c. One Time Minimum Bending Radius: ≤ 3 in
    d. Standard Conditions: VSWR 1.0, ambient temperature 20 °C (68 °F)

D. Foam Dielectric Cable: To be used for donor antenna and outdoors.
1. Material Characteristics:
    a. Jacket: Non-halogenated, Fire-Retardant Ployolefin
    b. Outer Conductor Material: Corrugated Copper
    c. Inner Conductor Material: Copper-Clad Aluminum Wire or Copper Tube
2. Electrical Characteristics:
    a. Impedance: 50 ± 1.0 Ω
    b. Frequency Band: 1/2” Nominal: 1 - 8800 MHz, 7/8” Nominal: 1 - 5000 MHz
    c. Peak Power Rating: ≥ 40.0 kW
3. Mechanical Characteristics:
    a. Diameter Over Jacket: 1/2” Nominal: ≤ .630 in, 7/8” Nominal: ≤ 1.1 in
    b. Minimum Bending Radius: 1/2” Nominal: ≤ 5 in, 7/8” Nominal: ≤ 10 in
    c. One Time Minimum Bending Radius: 1/2” Nominal: ≤ 2 in, 7/8” Nominal: ≤ 5 in
4. Attenuation Characteristics: 1/2” Nominal
    a. Frequency (MHz) Attenuation (dB/100ft) 450 ≤ 1.447
    b. Standard Conditions: VSWR 1.0, ambient temperature 20 °C (68 °F)
5. Attenuation Characteristics: 7/8” Nominal:
    a. Frequency (MHz) Attenuation (dB/100ft) 450 ≤ .744
    b. Standard Conditions: VSWR 1.0, ambient temperature 20 °C (68 °F)

E. Fiber-Optic Master Unit: If the integrators design requires an Active fiber system, the Fiber-Optic Master Unit shall convert radio over coax to Radio-Over-Fiber (RoF) for distribution to Fiber-Optic Remote Units.
1. Characteristics
    a. Transmission Media: Single-mode fiber at 1310 nm

b. Operating Temperature Range: +5 °C to +40 °C

c. Impendence: 50 Ω

d. Chassis:

1) Shall be of modular design capable of supporting ≥ 32 Remote Units per 19", 4 RU chassis.

2) Shall support redundant power supplies.

3) Shall have the capability to remotely power the Remote Units via composite fiber-optic cable.

e. Automatic Gain Control (AGC): Shall provide AGC for optical loss compensation.

f. Optical Budget: Shall support ≤ 3 dB optical budget (~3 km or 2 miles)

g. Auxiliary Channel: Shall provide an input to support 400 to 2700 MHz for future expandability.

h. Interlink: Shall support one fiber or two fibers bi-directional optical link for distances up to 20 km with a 10 dB optical budget.

i. Remote Supervision:

1) Shall support the TCP/IP protocol, SNMPv2, FTP, HTTP, Telnet, and be fully compatible with general purpose SNMP managers.

2) Remote access shall be available via Point-to-Point Protocol (PPP), over circuit switched/packet data and wired/wireless modems.

3) Each Active device shall be manageable via a Web GUI.

4) Auto Mapping: Each board position shall be automatically mapped during system turn-up

2. Frequency Bands Supported: 800 MHz PSR

PART 3 - EXECUTION

3.1 INSTALLATION

A. The Contractor shall install the DAS in accordance with the integrator's instructions and recommendations.

B. Installation shall include the delivery, unloading, setting in place, fastening to walls, floors, ceiling, or other structures and where required, penetration fire-stop, interconnecting wiring of the system components, equipment alignment and adjustments, and all other work whether or not expressly required herein which is necessary to result in complete operational system.

C. All installation practices shall be in accordance with, but not limited to, these specifications and drawings. Installation shall be performed in accordance with the applicable standards, requirements and recommendations of National, State, and Local Authorities having jurisdiction.

D. All distributed antenna cables shall be installed such that the cables are straight as possible.

E. During the installation, and up to the date of final acceptance, the integrator shall be under obligation to protect his finished and unfinished work against damage and loss. In the event of such damage or loss, he shall replace or repair such work at no cost to the owner.

F. All equipment shall be properly mounted on equipment racks or walls and secured in place. Wall mounted equipment shall be mounted over a plywood securely attached to the wall.

G. Cables shall be properly supported with dedicated hangers or brackets. Cable trays shall be used only if they are dedicated low voltage trays and only with approval from the owner.

H. Fastenings and supports shall be adequate to support their loads with a safety factor of at least three.

I. All boxes, equipment, etc. shall be secured plumb, level and square.

J. In the installation of equipment and cable, consideration shall be given to operational efficiency and overall aesthetic factors. Antennas shall be centered and in-line with other ceiling mounted devices

K. All cables, regardless of length, shall be marked with cable markers reading “Public Safety Radio”, at regular intervals but not less than every 30 ft. There shall be no unmarked cables at any place in the system. In addition, markings codes at each end of the cables and patch panels shall correspond to codes shown on drawings and/or run sheets.

L. All cables the integrator installs must be handled in accordance with the manufacturers guidelines. Transmission line cables have minimum bending radius specifications that shall be followed. In the event a cable is kinked or bent excessively during installation that section of cable cannot be used, even if subsequently straightened. The damaged area of the cable shall be removed and a new section installed using correct splice methods. Ultimately the cable must pass the testing and meet the manufacturers requirements

M. Radio communications cabling shall not be grouped with electrical cabling. It can only share sleeves and raceways with other low voltage data and communications cables.

N. Connection between cables and other antenna components shall use N-Type premium connectors. No splicing is permitted.

O. All power dividers shall be securely mounted in place by bolting the mount to a solid surface or securing each by suspension on the cables within 4 inches of each connector termination at the power divider. The transmission lines connecting to the device shall be routed in the shortest possible path.

3.2 GROUNDING PROCEDURE

A. In order to minimize problems resulting from improper grounding, and to achieve maximum signal-to-noise ratios, the following grounding procedures shall be adhered to.

B. System Ground: A signal primary “system ground” shall be established for the system. All grounding conductors in that area shall connect to this primary system ground. The system ground shall consist of a copper bar of sufficient size to accommodate all secondary ground conductors. An extension of the ground shall connect to the buildings lightning protection system.

C. A copper conductor, having a maximum of 0.1 Ohms total resistance, shall connect the primary system ground bar to the primary system ground ring.

D. Secondary system grounding conductors shall be provided from all racks, radio consoles, and undergrounded radio equipment in each area, to the primary system grounding point for the area. Each of these grounding conductors shall have a maximum of 0.1 Ohms total resistance.

E. Under no conditions shall the AC neutral conductor, either in the power panel or in receptacle outlets, be used for a BDA system ground.

F. Radio cable Shields: All radio cable shields shall be grounded at both ends.

G. General: Because of the great number of possible variations in grounding systems, it shall be the responsibility of the installer to follow good engineering practice, as outlined above, and to deviate from these practices only when necessary to minimize crosstalk and to maximize signal to-noise ratios and reduce interference in the radio systems.

3.3 CABLE AND CONDUIT

A. Note the following circuitry requirements:

1. Conduit intended for use with the firefighter's communication bi-directional radio amplifier system shall be steel electric metallic tubing (EMT), except as follows:

   a. It shall be galvanized steel intermediate conduit where mounted within 8'-0" of the floor in mechanical spaces or otherwise exposed to mechanical damage, or where intended for embedment in concrete.

   b. It shall be galvanized steel intermediate conduit if local authorities prohibit use of EMT.

   c. It shall be rigid galvanized steel conduit for the power supply to the central equipment and to all outlying equipment cabinets requiring a 120-volt or 120/208-volt supply.

2. Where wires and cables are permitted to be run without conduit,

3. They shall be independently supported from the building structure or ceiling suspension systems at intervals not exceeding four feet on center, utilizing cable supports specifically approved for the purpose. Wires and cables shall not rest on or depend on support from suspended ceiling media (tiles, lath, plaster, as well as splines, runners or bars in the plane of the ceiling), nor shall they be supported from pipes, ducts or conduits. Bundling and/or supporting ties shall be of a type suitable for sue in a ceiling air handling plenum regardless of whether or not installed in a plenum.

4. Cables shall be tagged or labeled at each termination point and in each intermediate junction box, pull box or cabinet through which they pass, as well as intervals not exceeding 50 feet on centers where cables are run without conduit.

5. Comply with applicable building and electrical code requirements for locating and routing circuitry, for installing circuitry, and for fire stopping.

6. The covers of all dedicated junction, pull boxes shall be painted red and labeled "Fire Dept. Radio System". Junction and pull boxes will not be shared with other systems.

7. Cables other than radiating coaxial cables shall be run in conduit where indicated by the Engineer. Where not indicated, cable shall be installed per manufacturer's recommendation. Conduit shall be electric metallic or threaded conduit subject to the restrictions specified elsewhere for light and power circuitry.

8. Radiating coaxial cables shall be run without conduit. Where installed in a plenum type ceiling cable insulation shall be of a fire-resistant low-smoke producing type,

with a minimum rating of CATVR. This classification shall be clearly marked on the outer surface of the cable at regular intervals.

3.4 ACCEPTANCE TESTING

A. Submit certification that system is compatible with Fire Department radio systems prior to installation.

B. Verify proper operation of system by means of field test with:

C. Fire Department requirements, and include all adjustments and modifications to the system required for proper operation. Coverage of each floor of the building to a minimum of 95% is required for acceptance.

D. No activation, or power up of any RF equipment is permitted without first obtaining permission of the Fire Department. This includes any testing or calibration.

E. The Contractor shall complete the acceptance testing as prescribed in the approved Acceptance Test Plan (ATP) submittal.

F. Acceptance Test Procedure: Upon completion of installation, the building owner shall have the option to participate in the radio system tested to ensure that two-way radio coverage on each floor of the building is a minimum of 90 percent. and be tested as follows:

1. Each floor of the building shall be divided into a grid of 20 or more, approximately equal areas. No two test locations shall be greater than 50 ft apart

2. The test shall be conducted using a calibrated portable radio of the latest brand and model used by the agency talking through the agency's radio communications system.

3. No area designated as critical and no two adjacent areas shall be allowed to fail the test.

4. In the event that any three non-adjacent, non-critical areas fail the test, in order to be more statistically accurate, the floor may be divided into smaller areas. In the event that three noncritical, non-adjacent areas still fail the test, the Contractor shall reconfigure the system to meet the 90-percent coverage requirement with no three adjacent areas failing.

5. A test location approximately in the center of each grid area shall be selected for the test by the public safety or owner's representative, then the radio shall be enabled to verify two-way communications to and from the outside of the building through the public agency's radio communications system. Once the test location has been selected, that location shall represent the entire area. If the test fails in the selected test location, that grid area shall fail, and prospecting for a better spot within the grid area shall not be allowed.

6. The gain values of all amplifiers shall be measured and the test measurement results shall be noted on the as-built drawings and the O&M manuals so that the measurements can be verified during annual tests.

7. As part of the installation a spectrum analyzer or other suitable test equipment shall be utilized to insure spurious oscillations are not being generated by the subject signal booster. This test shall be conducted at time of system acceptance.

3.5 TRAINING AND SERVICE

A. Comply with Section 26 00 01.

B. Conduct two 4-hour training session. Train the Owner's maintenance personnel on procedures and schedules related to start up and shutdown, troubleshooting, servicing, and preventive maintenance.

C. Training shall include fire department personel.

End of Section

SECTION 28 08 00

COMMISSIONING OF ELECTRONIC SAFETY AND SECURITY

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this section.

B. The OPR and BOD documentation are included by reference for information only.

1.02 SUMMARY

A. This section includes commissioning process requirements for Electronic systems, assemblies, and equipment.

B. Related Sections:

1. Division 01 Section "General Commissioning Requirements" for general commissioning process requirements.

1.03 DESCRIPTION

A. Refer to Division 01 Section “General Commissioning Requirements” for the description of commissioning.

1.04 DEFINITIONS

A. Refer to Division 01 Section “General Commissioning Requirements” for definitions.

1.05 SUBMITTALS

A. Refer to Division 01 Section “General Commissioning Requirements” for CxA’s role.

B. Refer to Division 01 Section “Submittals” for specific requirements. In addition, provide the following:

C. Certificates of readiness

D. Certificates of completion of installation, prestart, and startup activities.

E. O&M manuals

F. Test reports

1.06 QUALITY ASSURANCE

A. Test Equipment Calibration Requirements: Contractors will comply with test manufacturer’s calibration procedures and intervals. Recalibrate test instruments immediately after instruments have been repaired resulting from being dropped or damaged. Affix calibration tags to test instruments. Furnish calibration records to CxA upon request.

1.07 COORDINATION

A. Refer to Division 01 Section “General Commissioning Requirements” for requirements pertaining to coordination during the commissioning process.

PART 2 - PRODUCTS

2.01 TEST EQUIPMENT

A. All standard testing equipment required to perform startup, initial checkout and functional performance testing shall be provided by the Electronic Safety and Security System Contractor for the equipment being tested. For example, the contractor of Division 28 shall ultimately be responsible for all standard testing equipment for the electronic systems in Division 28. A sufficient quantity of two-way radios shall be provided by each contractor.

B. Special equipment, tools and instruments (specific to a piece of equipment and only available from vendor) required for testing shall be included in the base bid price to the Owner and left on site, except for stand-alone data logging equipment that may be used by the CxA.

C. Proprietary test equipment and software required by any equipment manufacturer for programming and/or start-up, whether specified or not, shall be provided by the manufacturer of the equipment. Manufacturer shall provide the test equipment, demonstrate its use, and assist in the commissioning process as needed. Proprietary test equipment (and software) shall become the property of the Owner upon completion of the commissioning process.

D. All testing equipment shall be of sufficient quality and accuracy to test and/or measure system performance with the tolerances specified in the Specifications. If not otherwise noted, the following minimum requirements apply: Temperature sensors and digital thermometers shall have a certified calibration within the past year to an accuracy of 0.5°F and a resolution of + or - 0.1°F. Pressure sensors shall have an accuracy of + or - 2.0% of the value range being measured (not full range of meter) and have been calibrated within the last year.

PART 3 - EXECUTION

3.01 GENERAL DOCUMENTATION REQUIREMENTS

A. With assistance from the installing contractors, the CxA will prepare Pre-Functional Checklists for all commissioned components, equipment, and systems

B. **Red-lined Drawings:** The Electronic Safety and Security System contractor will verify all equipment, systems, instrumentation, wiring and components are shown correctly on red-lined drawings. Preliminary red-lined drawings must be made available to the Commissioning Team for use prior to the start of Functional Performance Testing. Changes, as a result of Functional Testing, must be incorporated into the final as-built drawings, which will be created from the red-lined drawings. The contracted party, as defined in the Contract Documents will create the as-built drawings.

C. **Operation and Maintenance Data:** Electronic Safety and Security System Contractor will provide a copy of O&M literature within 45 days of each submittal acceptance for use during the commissioning process for all commissioned equipment and systems. The CxA will review the O&M literature once for conformance to project requirements. The CxA will receive a copy of the final approved O&M literature once corrections have been made by the Contractor.

D. **Demonstration and Training:** Electronic Safety and Security System Contractor will provide demonstration and training as required by the specifications. A complete training plan and schedule must be submitted by the Electronic Safety and Security System Contractor to the CxA four weeks (4) prior to any training. A training agenda for each training session must be submitted to the CxA one (1) week prior the training session.

3.02 ELECTRONIC SAFETY and SECURITY SYSTEM CONTRACTOR'S RESPONSIBILITIES

A. Perform tests as required by Division 28.

B. Attend construction phase controls coordination meetings.

C. Participate in Electronic systems, assemblies, equipment, and component maintenance orientation and inspection as directed by the CA.

D. Provide information requested by the CxA for final commissioning documentation.

E. Include requirements for submittal data, operation and maintenance data, and training in each purchase order or sub-contract written.

F. Prepare preliminary schedule for Electronic system orientations and inspections, operation and maintenance manual submissions, training sessions, equipment start-up and task completion for owner. Distribute preliminary schedule to commissioning team members.

G. Update schedule as required throughout the construction period.

H. Assist the CxA in all verification and functional performance tests.

I. Provide measuring instruments and logging devices to record test data, and provide data acquisition equipment to record data for the complete range of testing for the required test period.

J. Gather operation and maintenance literature on all equipment, and assemble in binders as required by the specifications. Submit to CxA 45 days after submittal acceptance.

K. Coordinate with the CxA to provide 48-hour advance notice so that the witnessing of equipment and system start-up and testing can begin.

L. Notify the CxA a minimum of two weeks in advance of the time for start of the testing and balancing work. Attend the initial testing and balancing meeting for review of the official testing and balancing procedures.

M. Participate in, and schedule vendors and contractors to participate in the training sessions.
   1. Provide written notification to the CM/GC and CxA that the following work has been completed in accordance with the contract documents, and that the equipment, systems, and subsystem are operating as required.
   2. Security system.

N. The equipment supplier shall document the performance of his equipment.

O. Provide a complete set of red-lined drawings to the CxA prior to the start of Functional Performance Testing.

P. Equipment Suppliers
   1. Provide all requested submittal data, including detailed start-up procedures and specific responsibilities of the Owner, to keep warranties in force.
   2. Assist in equipment testing per agreements with contractors.
   3. Provide information requested by CxA regarding equipment sequence of operation and testing procedures.

Q. Refer to Division 01 Section “General Commissioning Requirements” for additional Contractor responsibilities.

3.03 CxA'S RESPONSIBILITIES

A. Refer to Division 01 Section “General Commissioning Requirements” for CxA’s Responsibilities.

3.04 TESTING PREPARATION

A. Certify in writing to the CxA that Electronic systems, subsystems, and equipment have been installed, calibrated, and started and are operating according to the Contract Documents.

B. Certify in writing to the CxA that Electronic instrumentation and controls have been completed and calibrated, that they are operating according to the Contract Documents, and that pretest set points have been recorded.

C. Certify in writing that testing procedures have been completed and that testing reports have been submitted, discrepancies corrected, and corrective work approved.

D. Place systems, subsystems, and equipment into operating mode to be tested (e.g., normal shut-down, normal auto position, normal manual position, unoccupied cycle, emergency power, and alarm conditions).

E. Inspect and verify the position of each device and interlock identified on checklists.

F. Check safety cutouts, alarms, and interlocks with building automation, smoke control and life-safety systems during each mode of operation.

G. Testing Instrumentation: Install measuring instruments and logging devices to record test data as directed by the CxA.

3.05 GENERAL TESTING REQUIREMENTS

A. Provide technicians, instrumentation, and tools to perform commissioning test at the direction of the CxA.

B. Scope of Electronic testing shall include the entire Electronic system installation, from the incoming power equipment throughout to each peripheral and end device. Testing shall include measuring, but not limited to resistance, voltage, and amperage of system(s) and devices.

C. Test all operating modes, interlocks, control responses, and responses to abnormal or emergency conditions, and verify proper response of building automation system controllers and sensors.

D. The CxA along with the Electronic Safety and Security System contractor and other contracted subcontractors, including the fire alarm Subcontractor shall prepare detailed testing plans, procedures, and checklists for Electronic systems, subsystems, and equipment.

E. Tests will be performed using design conditions whenever possible.

F. Simulated conditions may need to be imposed using an artificial load when it is not practical to test under design conditions. Before simulating conditions, calibrate testing instruments. Provide equipment to simulate loads. Set simulated conditions as directed by the CxA and document simulated conditions and methods of simulation. After tests, return settings to normal operating conditions.

G. The CxA may direct that set points be altered when simulating conditions is not practical.

H. The CxA may direct that sensor values be altered with a signal generator when design or simulating conditions and altering set points are not practical.

I. If tests cannot be completed because of a deficiency outside the scope of the Electronic system, document the deficiency and report it to the Owner. After deficiencies are resolved, reschedule tests.

J. If the testing plan indicates specific seasonal testing, complete appropriate initial performance tests and documentation and schedule seasonal tests.

3.06 SECURITY SYSTEMS, SUBSYSTEMS, AND EQUIPMENT TESTING PROCEDURES

A. **Equipment Testing and Acceptance Procedures:** Testing requirements are specified in individual Division 28 sections. Provide submittals, test data, inspector record, infrared camera or special equipment and certifications to the CA.

B. **Electronic Instrumentation and Control System Testing:** Field testing plans and testing requirements are specified in Division 28 Sections. Assist the CxA with preparation of testing plans.

C. **Electronic System Testing (Access Control, CCTV and/or Security):** Provide technicians, instrumentation, tools and equipment to test performance of designated systems and devices at the direction of the CxA. The CxA shall determine the sequence of testing and testing procedures for each equipment item to be tested.

D. The work included in the commissioning process involves a complete and thorough evaluation of the operation and performance of all components, systems and sub-systems. The following equipment and systems shall be evaluated:
   1. Coordination and functionality with the Building Automation System/Building Management Controls System
   2. Security System including switches, servers or routers

3.07 DEFICIENCIES/NON-CONFORMANCE, COST OF RETESTING, FAILURE DUE TO MANUFACTURER DEFECT

A. Refer to Division 01 Section “General Commissioning Requirements” for requirements pertaining to deficiencies/non-conformance, cost of retesting, or failure due to manufacturer defect.

3.08 APPROVAL

A. Refer to Division 01 Section “General Commissioning Requirements” for approval procedures.

3.09 DEFERRED TESTING

A. Refer to Division 01 Section “General Commissioning Requirements” for requirements pertaining to deferred testing.

3.10 OPERATION AND MAINTENANCE MANUALS

A. The Operation and Maintenance Manuals shall conform to Contract Documents requirements as stated in Division 01.

B. Refer to Division 01 Section “General Commissioning Requirements” for the AE and CxA roles in the Operation and Maintenance Manual contribution, review and approval process.

3.11 TRAINING OF OWNER PERSONNEL

A. Refer to Division 01 Section “General Commissioning Requirements” for requirements pertaining to training.

END OF SECTION

Section 28 10 00

UNIFIED SECURITY SYSTEM

(TRADE CONTRACT REQUIRED AS PART OF SECTION 26 00 01)

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. PUBLICLY BID TRADE CONTRACT REQUIREMENTS: As provided under Section 26 00 01 - ELECTRICAL and supplemented under the Bidding Requirements, Contract Forms, and Conditions of the Contract, and applicable parts of Division 1 - GENERAL REQUIREMENTS.

1. Work of this Trade Contract includes all individual specification sections listed in Section 26 00 01.

1.2 RELATED DOCUMENTS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications

1.3 SCOPE

A. It is the intent of these specifications that the Contractor, Manufacturer and/or it's Authorized System Integrator expeditiously furnishes and installs a system complete in every respect and ready to operate. All miscellaneous items and accessories required for such installation, whether or not each such item or accessory as shown on the plans or mentioned in these specifications, shall be furnished and installed.

B. The unified security system shall be installed as shown on the drawings and as specified herein. The work covered by this section of the specifications includes the furnishing of all labor, equipment, materials and performance of all operations associated with the video surveillance system for a fully functional system.

C. It is the intention of this specification that the Access Control System (ACS), Intrusion Detection System (IDS), and Video Surveillance System (VSS) all be integrated on a software level such that any workstation so designated will have operational and/or display capability of the three combined systems under one software platform.

D. The school district has standardized on the Genetec VMS, HID ACS, Bosch IDS, Axis cameras and video entry system. The district already has all the core services setup at the network operation center. The district's licensing vendor is Siemens Security.

1. This contractor shall procure all system licenses from Siemens Security to maintain the district's licensing agreements.

2. Siemens Security point of contact is: Jon Hipsh, telephone: 857-205-7598, email: jonathan.hipsh@siemens.com.

E. This contractor shall provide Genetec VSS, HID ACS, Bosch IDS, Axis cameras and video entry system as shown on the drawings and as specified herein.

F. The video surveillance system for South High School will integrate into the district's existing Genetec Security Center infrastructure. The Worcester Public Schools (WPS) currently has a centralized Genetec directory and this site will be an additional archive role in that directory.

G. The Vendor will provide server and workstation hardware specified as well as software licenses specified. The Vendor will provide man-hours to work with WPS Information Technology staff to load the necessary software and integrate the systems into the WPS core Genetec infrastructure.

1.4 CODES AND STANDARDS

A. Complete installation shall meet or exceed the latest edition of following standards:

1. TIA-568: Commercial building telecommunications wiring standard and all current addenda.
2. TIA-569: Commercial building standard for telecommunications pathways and spaces.
3. TIA-606: Administration standard for telecommunications infrastructure of commercial buildings.
4. TIA-607: Commercial building grounding and bonding requirements for telecommunications.
5. ANSI, ASTM, UL, NEMA, IEEE and FCC standards as applicable.
6. BICSI Telecommunications Distribution Methods Manual, current edition.

1.5 PROGRAMMING

A. Coordinate and obtain a written approval of system functionality from the Owner prior to programming.

B. Perform a walk-through with the Owner and demonstrate the system functionality.

C. Make any adjustments to system functionality after initial programming if necessary to achieve the desired functionality requested by the Owner. Coordinate all required reprogramming with the Owner as required as part of this contract.

D. Obtain a written final letter of acceptance from the Owner upon completion of system functionality programming and demonstration.

1.6 SUBMITTALS

A. Comply with requirements specified in Division 01 and the following:

1. The vendor shall submit certification letter from the manufacturer of submitted equipment certifying that the installer is an authorized and certified installer of the submitted equipment.
2. The vendor shall make all connections at all field devices and at the head-end; and shall make all necessary field adjustments for a fully functional system.

B. Shop Drawings

1. Prior to assembling or installing the system, the Contractor shall provide complete shop drawings which include the following:
    a. List the name of the manufacturer’s local representative and his/her phone number.
    b. Table of contents.
    c. Manufacturer’s parts lists
    d. Product serial numbers
    e. Catalog cut sheets

f. Installation instructions

g. Typical wiring diagrams

h. Drawings showing equipment locations

i. Manufacturer's warranty documents

2. All drawings shall be fully dimensioned.

3. Operating License: Submit evidence of application for FCC Radio Station Authorization prior to installing equipment when required for operation of the equipment.

C. As-Built Drawings

1. At the conclusion of the project, the Vendor shall provide "as built" drawings. The "as built" drawings shall be a continuation of the Contractors shop drawings as modified, augmented, and reviewed during the installation, check out and acceptance phases of the project. All drawings shall be fully dimensioned and prepared in DWG format using the latest version of AutoCAD.

2. The as-built drawings shall incorporate all updated system riser diagrams prepared in DWG format using the latest version of AutoCAD.

D. Manuals

1. At the conclusion of the project, the Vendor shall provide copies of the manuals as described herein. Each manual's contents shall be identified on the cover. The manual shall include names, addresses, and telephone numbers of each system integrator installing equipment and systems and the nearest service representatives for each item of equipment for each system. The manuals shall have a table of contents and labeled sections. The manuals shall include all modifications made during installation, checkout, and acceptance. The manuals shall contain the following:

a. Hardware Manual

1) The hardware manual shall describe all equipment furnished including:

2) General description and specifications

3) Installation and check out procedures

4) Equipment layout and electrical schematics to the component level

5) System layout drawings and schematics

6) Alignment and calibration procedures

7) Manufacturers repair parts list indicating sources of supply

b. Software Manual

1) The software manual shall describe the functions of all software and shall include all other information necessary to enable proper loading, testing, and operation. The manual shall include:

2) Definition of terms and functions

a) Use of system and applications software

b) Initialization, start up, and shut down

c) Alarm reports

d) Reports generation

e) Data base format and data entry requirements

f) Directory of all disk files

2. Operators Manual

a. The operator's manual shall fully explain all procedures and instructions for the operation of the system including:

1) Computers and peripherals

2) System start up and shut down procedures

3) Use of system, command, and applications software

4) Recovery and restart procedures

5) Use of report generator and generation of reports

6) Data entry

7) Operator commands

8) Alarm messages and reprinting formats

9) System access requirements

3. Maintenance Manual

a. The maintenance manual shall include descriptions of maintenance for all equipment including inspection, periodic preventive maintenance, fault diagnosis, and repair or replacement of defective components.

1.7 QUALITY ASSURANCE

A. The Contractor shall have successfully installed similar IP / NVR systems on a previous project of comparable size and complexity. The owner reserves the right to reject any control components for which evidence of a successful prior installation performed by the Contractor cannot be provided.

B. The Contractor shall have in-house engineering and project management capability consistent with the requirements of this project. Qualified and approved representatives of the system manufacturer shall perform the detailed engineering design of central and remote-control equipment. The Contractor is responsible for retaining qualified and approved representative(s) of those system manufacturers specified for detailed system design and documentation, coordination of system installation requirements, and final system testing and commissioning in accordance with these specifications.

C. The Vendors providing equipment installation services shall use adequate numbers of skilled workmen who are certified by the component manufacturer, thoroughly trained and experienced with the necessary technology and systems, and completely familiar with the specified requirements and methods needed for proper performance of work. The system head-end installation, start-up and commissioning shall be by the manufacturer certified vendor.

D. Each vendor is required to provide a letter from the manufacturer indicating that they hold a current certification for the specified system.

E. Use adequate numbers of skilled workers thoroughly trained and experienced on the necessary crafts and completely familiar with the specified requirements and methods needed for the proper performance of the work of this Section. Contractor is required to provide references of three similar installations completed in the last 12 months.

F. The Contractor must provide a project manager who has demonstrated the ability to supervise a project of this magnitude. The Project Manager must be available to attend meetings as required.

1.8 WARRANTY

A. Comply with Section 260001.

B. The Electrical Trade Contractor shall warranty that all materials furnished shall be free from defects of material for a period of one year from the date of Substantial Completion.

C. Provide a 3-year preventive maintenance plan. The plan shall include one site visit per year after the warranty period to verify that the system is working per the specifications and to proactively perform maintenance, repairs, and replacements to prevent failures before they occur.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Video Management System (VMS)

1. Genetec

B. Video Surveillance System (VSS) Cameras

1. Axis

C. Access Control System (ACS)

1. HID

D. Intrusion Detection System

1. Bosch

2.2 UNIFIED SECURITY SYSTEM

A. Overview

1. The Unified IP Security System consists of the following subsystems. All systems referenced below shall be connected to a standalone, dedicated security network as provided by the security Contractor.

a. Video Surveillance and Recording system

b. Access control platform

c. Security Peripherals

d. Servers and Workstations

e. Network Electronics

f. Preventative Maintenance and Service Agreement

2. The Security Contractor shall meet all qualifications as defined within this specification.

3. Integration between the IP Video and Access control system is defined as follows:

a. Each door contact, panic button, duress button shall be individually annunciated on the Unified Security Platform GUI.

b. The ACS shall support integration with the IP Video Surveillance System. Integration with the IP video surveillance system shall permit the user to view live and recorded video from one GUI and one single window. The same GUI shall be utilized for both the access control solution and the specified video surveillance solution. Switching from one application or GUI to another shall not be acceptable as well as utilizing two applications simultaneously to achieve the functionality specified is not allowed.

B. Unified Security Platform (USP)

1. General

a. The United Security Platform is defined as the Unified software package used for the IP Video, Access Control, Entry Intercom and Intrusion Alarm systems.

b. The Unified Security Platform (USP) shall be an enterprise class IP-enabled security and safety software solution.

c. The USP shall have the capacity to record and move video archives to the Azure Cloud. The archived video can be saved immediately or can be moved after a preset number of days.

d. The USP shall support the seamless unification of IP access control system (ACS), IP video management system (VMS), Intrusion detection system (IDS) and Entry Intercom system under a single platform. The USP user interface (UI) applications shall present a unified security interface for the management, configuration, monitoring, and reporting of embedded ACS, VMS, and IDS systems and associated edge devices.

e. Functionalities available with the USP shall include:

1) Configuration of embedded systems such as ACS, IDS, and VMS systems.

2) Live event monitoring.

3) Live video monitoring and playback of archived video.

4) Alarm management.

5) Reporting, including creating custom report templates and incident reports

6) Federation for global monitoring, reporting, and alarm management of multiple remote and independent ACS and/or VMS systems spread across multiple facilities and geographic areas.

7) Global cardholder management across multiple facilities and geographic areas each with their own independent ACS system.

8) Microsoft Active Directory integration for synchronizing USP user accounts and ACS cardholder accounts.

9) Intrusion device and panel integration (live monitoring, reporting, and arming/disarming).

10) SIP Intercom integration where both audio and video are annunciated on each client.

11) Integration to third party systems and databases via plug-ins (access control, video analytics, point of sale, and more).

12) Dynamic graphical map viewing.

13) Asset management system integration.

f. Licensing

1) Provide 4 x GSC-1U Genetec Security Desk client connection.

2) Provide 4 x GSC-1MobileU Genetec Security Mobile app connection Supported only with GSC Mobile

3) Provide licenses for access control connections.

4) Provide licenses for cameras.

2.3 SYSTEM FUNCTIONALITY

A. Unification of Video and Access Control

1. The Surveillance UI shall present a true Unified Security Interface for live monitoring and reporting of the ACS and VMS. Advanced live video viewing and playback of archived video shall be available through the Surveillance UI.

2. The Configuration UI shall present a true Unified Security Interface for configuration and management of the ACS and VMS.

3. User shall be able to associate one or more video cameras to the following entity types, among others: areas, doors, elevators, zones, alarms, and intrusion panels.

4. It shall be possible to view video associated to access control events when viewing a report.

5. It shall be possible to view video associated to intrusion panel events when viewing a report.

B. Third Party System Integration

1. The USP shall support multiple approaches to integrating third party systems. These shall include: Software Development Kits (SDKs), Driver Development Kits (DDKs), REST-based Web Service SDKs, and more.

2. The USP architecture shall support the addition of new connectors to integrate to third party system integration such as:

a. Video analytics.

b. Third party video systems.

c. Third party access control systems.

d. Point-of-sale (POS) systems.

e. Building management systems.

f. Human resource management systems (HRMS).

C. Alarm Management

1. The USP shall support the following Alarm Management functionality:

a. Create and modify user-defined alarms. An unrestricted number of user-defined alarms shall be supported.

b. Assign a time schedule or a coverage period to an alarm. An alarm shall be triggered only if it is a valid alarm for the current time period.

c. Set the priority level of an alarm and its reactivation threshold.

d. Define the time period after which the alarm is automatically acknowledged.

e. Define the recipients of an alarm. Alarm notifications shall be routed to one or more recipients. Recipients shall be assigned a priority level which prioritizes the order of reception of an alarm.

f. Define the alarm broadcast mode. Alarm notifications shall be sent using either a sequential or an all-at-once broadcast mode.

g. Define whether to display the source of the alarm, one or more entities, or an HTML page.

h. Specify whether an incident report is mandatory during acknowledgment.

2. The workflows to create, modify, add instructions and procedures, and acknowledge an alarm shall be consistent for access control, LPR, and video alarms.

3. Alarms shall be federated allowing global alarm management across multiple independent USP, ACS, and VMS systems.

4. The USP shall also support alarm notification to an email address or any device using the SMTP protocol.

5. The ability to create alarm-related instructions shall be supported through the display of one or more HTML pages following an alarm event. The HTML pages shall be user-defined and can be interlinked.

6. Alarm unpacking and packing shall be supported where all the entities associated to an alarm can be display in the Surveillance UI with the single click of button.

7. User shall have the ability to acknowledge alarms, create an incident upon alarm acknowledgement, and put an alarm to snooze.

8. The user shall be able to spontaneously trigger alarms based on something he or she sees in the system.

D. Health Monitoring

1. The USP shall monitor health of the system, log health-related events, and calculate statistics.

2. USP services, roles, agents, units, and client apps will trigger health events.

3. It shall populate the Windows Event Log with health events related to USP roles, services, and client apps.

4. A dedicated role, the Health Monitoring Role, shall perform the following actions:

a. Monitor health of the entire system and logs events

b. Calculate statistics within specified time frame (hours, days, months)

c. Calculates availability for clients, server, video/access/LPR units

5. A Health Monitoring task and Health History reporting task shall be available for live and historical reporting.

6. Health events shall be accessible via the SDK (can be used to create SNMP traps)

E. Advanced Task Management

1. The USP shall support an infrastructure for managing Surveillance UI tasks used for live monitoring, day to day activities, and reporting.

2. Administrators shall be able to assign tasks and lock the operator`s workspace. User management of their workspace shall be limited by their assigned privileges.

3. Operators shall be able save their tasks as either Public Tasks or Private Tasks and in a specific partition. Public tasks shall be available to all users. Private tasks shall only be available to the owner of the task.

4. Operators shall be able to share their tasks by sending them to one or more online use

F. Reporting

1. The USP shall support report generation (database reporting) for access control, LPR, video, and intrusion.
2. Each and every report in the system shall be a USP task, each associate with its own privilege. A user shall have access to a specific report task if he or she has the appropriate privilege.
3. The workflows to create, modify, and run a report shall be consistent for access control, LPR, and video reports.
4. Reports shall be federated allowing global consolidated reporting across multiple independent USP, ACS, and VMS systems.
5. Access control and LPR reports shall support cardholder pictures and license plate pictures, respectively.
6. The USP shall support the following types of reports:
    a. Alarm report
    b. Video-specific reports (archive, bookmark, motion, and more)
    c. Configuration reports (cardholders, credentials, units, access rules, readers/inputs/outputs, and more)
    d. Activity reports (Cardholder, cardholder group, visitor, credential, door, unit, area, zone, elevator, and more)
    e. LPR-specific reports (mobile LPR playback, hits, plate reads, reads/hits per day, reads/hits per LPR zone, and more)
    f. Health activity and health statistics reports
    g. Other types of reports include visitor reports, audit trail reports, incident reports, and time and attendance reports.
7. Generic Reports, Custom Reports and Reports Templates
    a. A user has the option of generating generic reports from an existing list, generating reports from a list of user-defined templates, or creating a new report or report template.
    b. The user shall be able to customize the predefined reports and save them as new report templates. There shall be no need for an external reporting tool to create custom reports and report templates. Customization options shall include setting filters, report lengths, and timeout period. The user shall also set which columns shall be visible in a report. The sorting of reported data shall be available by clicking on the appropriate column and selecting a sort order (ascending or descending).
    c. All report templates shall be created within the Surveillance UI.
    d. These templates can be used to generate reports on a schedule in PDF or Excel formats.
    e. An unrestricted number of custom reports and templates shall be supported.
8. A reporting task layout shall consist of panes with settings (report length, filters, go and reset commands, etc.), the actual report data in column format, and a pane with display tiles. The user shall be able to drag and drop individual records in a report onto one or more display tiles to view a cardholder’s picture ID, playback a video sequence, or both.
9. The USP shall support comprehensive data filtering for most reports based on entity type, event type, event timestamp, custom fields, and more.

10. The user shall be able to click on an entity within an existing report to generate additional reports from the Surveillance UI.

11. The USP shall support the following actions on a report: Print report, export report to a PDF/Microsoft Excel/CSV file, automatically email a report based on a schedule and a list of one or more recipients.

G. Federation: Monitoring of Remote Systems

1. The USP shall support the concept of a Federation for both access control and video.

2. Federation shall allow multiple independent USP systems (Federated systems) to be unified into a larger virtual system (the Federation). This shall facilitate global monitoring of multiple independent USP systems shall be possible.

3. The Federation shall support the unification of multiple independent video surveillance systems or VMS

4. The Federation shall support the unification of multiple independent access control systems or ACS.

5. Entities that shall be federated and monitored centrally from the Federation shall include: alarms, areas, cameras, cardholders and cardholder groups, credentials, doors, elevators, and zones (monitored inputs).

6. The Federation shall support Global Alarm Management from the Surveillance UI for both access control and video.

7. The Federation shall support Global Report Generation from the Surveillance UI for both access control and video.

8. The Federation shall support dozens of operator actions on remote (federated) entities from the Surveillance UI (e.g. generate a global report taking into account events from multiple independent sites or acknowledge remote alarms).

H. Microsoft Active Directory Integration

1. The USP shall support a direct connection to one or multiple Microsoft Active Directory server via the Active Directory Role(s). Active Directory integration shall enable the synchronization of information from the Active Directory server to the USP.

2. Active Directory integration shall permit the central management of the USP users, user groups, cardholders, and cardholder groups.

3. The USP shall be able to connect to and synchronize data from multiple Active Directory servers (up to 10).

4. When enabled, Active Directory shall manage user logon to the USP client applications through the user's Windows credentials. Logon to the USP shall utilize native Active Directory password management and authentication features.

5. It shall be possible to synchronize the following USP entities and their information from Active Directory to the USP:

a. Users (username, first and last names, email address, and more)

b. User groups (user group name, description, and group email address)

c. Cardholders (first and last names, description, email, and more)

d. Cardholder groups (cardholder group name, description, and group email address)

e. Active Directory attributes to USP custom fields.

6. When enabled, the addition, removal, or suspension of a user's Windows account in Active Directory shall result in the creation, deletion, or disabling of the equivalent user account in the USP.

7. When enabled, the addition, removal, or suspension of a user's Windows account in Active Directory shall result in the creation, deletion, or disabling of the equivalent cardholder account in the USP.

8. Supported synchronization methods for additions, modification, and deletions of synchronized entities shall include: on first logon (users only), manual synchronization, scheduled synchronization.

I. Zone Management

1. The USP shall support the configuration and management of zones for input point monitoring via the Zone Manager Role. A user shall be able to add, delete, or modify a zone if he has the appropriate privileges.

2. A zone shall monitor the status of one or more inputs points. Zone monitoring, or input point monitoring shall be possible through the use of a controller and one or more input modules. Inputs from video cameras or video encoders shall also be accessible via a zone.

3. Supervised inputs shall be supported depending on the hardware installed. Depending on the input module used, both 3-state and 4-state supervision shall be available.

4. A schedule shall be defined for a zone, indicating when the zone will be monitored.

5. Custom Events shall provide full flexibility in creating custom events tailored to a zone. Users shall be able to associate custom events to state changes in monitored inputs.

6. The ACS shall support one or more cameras per zone. Video shall then be associated to zone state changes.

7. Input/Output (IO) Linking

   a. Zone management shall support Input/Output (IO) Linking. IO linking shall allow one or more inputs to trigger one or more outputs.

   b. IO linking shall be available in offline mode when communication between the server and hardware is not available.

   c. Custom Output Behaviors shall provide full flexibility in creating a variety of complex output signal patterns: Simple pulses, periodic pulses, variable duty-cycle pulses, state changes.

   d. Through the "trigger an output" action, the ACS shall support the triggering of outputs with custom output behaviors.

J. Intrusion Device Integration

1. The USP shall integrate with third party intrusion panels and devices via an Intrusion DDK. The Intrusion Manager Role shall manage communications with the intrusion panels. Communications with intrusion devices shall be over serial communications and/or an IP network.

2. Integration with intrusion panels shall be possible outside the release cycle of the USP. It shall be possible to add new integrations at any point in time.

3. Functionality available via the USPs integration of intrusion devices shall include the following (where supported by the intrusion panel):

a. Arm and disarm intrusion devices (manually, on schedule, following a USP event).

b. Activate or trigger intrusion device outputs.

c. View intrusion events and alarms.

d. Monitor the status, including arming status, of the intrusion devices.

e. Video verification of intrusion events and alarms with video panels.

f. Create USP zones using intrusion device inputs.

K. User and User Group Security, Partitions, and Privileges Management

1. The USP shall support the configuration and management of users and user groups. A user shall be able to add, delete, or modify a user or user group if he has the appropriate privileges.

2. Common access rights and privileges shared by multiple users shall be defined as User Groups. Individual group members shall inherit the rights and privileges from their parent user groups. User group nesting shall be allowed.

3. User privileges shall be extensive in the USP. All configurable entities for the USP, including access control/video/video, shall have associated privileges.

4. Specific entities such as cardholders, cardholder groups, and credentials shall include a more granular set of privileges such as the right to access custom fields and change the activation or profile status of an entity.

5. Partitions

a. The USP shall limit what users can view in the configuration database via security partitions (database segments). The administrator, who has all rights and privileges, shall be allowed to segment a system into multiple security partitions.

b. All entities that are part of the USP can be assigned to one or more partitions.

c. A user who is given access to a specific partition shall only be able to view entities (components) within the partition he has been assigned. Access to a user is given by assigning the user as an accepted user to view the entities that are members of a particular partition.

d. A user or user group can be assigned administrator rights over the partition.

e. It shall be possible to specify user and user group privileges on a per partition basis.

f. Advanced logon options shall be available such as dual logon and more.

L. Schedules and Scheduled Tasks

1. Schedules

a. The USP shall support the configuration and management of complex schedules. A user shall be able to add, delete, or modify a schedule if he has the appropriate privileges.

b. The USP shall provide full flexibility and granularity in creating a schedule. The user shall be able to define a schedule in 1-minute or 15-minute increments.

c. Daily, weekly, ordinal, and specific schedules shall be supported.

2. Schedules Tasks

a. The USP shall support scheduled tasks for access control, LPR, and video.

b. Scheduled tasks shall be executed on a user-defined schedule at a specific day and time. Recurring or periodic scheduled tasks shall also be supported.

c. Scheduled tasks shall support all standard actions available within the USP such as sending an email or emailing a report.

M. Macros and Custom Scripts

1. The USP shall enable users to automate and extend the functionalities of the system through the use of macros or custom scripts for access control, LPR, and video.

2. Custom macros shall be created with the USP Software Development Kit (SDK).

3. A macro shall be executed either automatically or manually.

4. In the Surveillance UI, a macro shall be launched through hot actions.

N. Dynamic Graphical Maps

1. The USP shall support Mapping functionality for both access control and video.

2. Digital maps shall be used to represent the physical location of: cameras, doors, alarms, zones (monitored inputs), and output groups.

3. It shall be possible to add advanced functionality to dynamic maps using the SDK. Any functionality available through the SDK shall be available within maps.

4. Various actions shall be available within maps for execution through simple and intuitive double-click, right-click, or drag-and-drop functionality. Examples of actions available through maps shall include unlocking a door and acknowledging an alarm.

5. It shall be possible to create maps with hierarchies to facilitate navigation within and between various sites and buildings.

6. Mapping shall support the following drag-and-drop user actions:

a. Drag-and-drop a door from a map into a display tile for viewing

b. Drag-and-drop a camera from a map into a display tile for viewing

O. Audit Trails (Logs)

1. The USP shall support the generation of audit trails. Audit trails shall consist of logs of operator/administrator additions, deletions, and modifications.

2. Audit trails shall be generated as reports. They shall be able to track changes made within specific time periods. Querying on specific users, changes, affected entities, and time periods shall also be possible.

3. The ACS shall support the following actions on an audit trail report: print report, export report to a PDF/ Microsoft Excel/CSV file.

P. Incident Reports

1. Incident reports shall allow the security operator to create reports of incidents that occurred during a shift. Both video-related and access control-related incident reports shall be supported.

2. The operator shall be able to create standalone incident reports or incident reports tied to alarms.

3. Incident reports shall allow entities, events, and alarms to be added to support the report’s conclusions.

2.4 INTEGRATION TOOLKITS

A. Software Development Kit (SDK)

1. A USP SDK shall be available to support custom development for the platform.
2. The SDK shall include functionalities specific to the embedded license plate recognition (LPR), access control (ACS), and video (VMS) systems.
3. Integration with external applications and databases shall be possible with the SDK.
4. The SDK shall enable end-users to develop new functionality (user interface, standalone applications or services) to link the USP to third party business systems and applications such as Badging Systems, Human Resources Management Systems (HRMS), and Enterprise Resource Planning (ERP) systems.
5. The SDK shall be based on the .NET framework.
6. The SDK shall support dynamic or transactional updates to USP configuration. It shall also support change notification of USP entity configuration.
7. The SDK shall provide an extensive list of programming functions to view and/or configure core entities such as: users and user groups, alarms, custom events, and schedules, among others.
8. The SDK shall provide an extensive list of programming functions to view and configure ACS and VMS.
9. The SDK shall provide an extensive list of programming functions to view and configure most ACS entities such as: cardholders, cardholder groups, visitors, and credentials, access rules (modify only), and custom Fields.
10. The SDK shall be able to receive real time events from the USP entities: users and user groups, areas, zones, cameras, video units, doors, door controllers (units), elevators, cardholders, cardholder groups, and credentials.
11. The SDK shall be able to query the history of events for areas, cameras, zones, alarm, cardholders, credentials, visitors, doors, query license plate read events, license plate hit events, generate a license plate hits report, generate a license plate reads report.
12. The SDK shall support the following alarm functions: view alarms in real time, acknowledge alarms, change priority, change recipient

2.5 VIDEO SURVEILLANCE SYSTEM FUNCTIONALITY

A. General

1. The VMS shall be based on a true open architecture that shall allow for use of non-proprietary workstation and server hardware, non-proprietary network infrastructure and non-proprietary storage.
2. The VMS shall offer a complete and scalable video surveillance solution which allows cameras to be added on a unit-by-unit basis.
3. The VMS shall interface with analog-to-digital video encoders and IP cameras, hereafter referred to as digital video servers (DVS). The VMS shall support DVS from various manufacturers.
4. All video streams supplied from analog cameras or IP cameras shall be digitally encoded in MPEG-4, MPEG-2, MJPEG, H.264, Wavelet or JPEG2000 compression formats and recorded simultaneously in real time.
5. All audio streams supplied from IP video servers shall be digitally encoded in g711 (u-law), g721, g723 or AAC compression formats and recorded simultaneously in real time.
6. The VMS shall support a wide range of IP Video cameras. Consult with Genetec for current list.

7. The VMS shall support the following industry standards to interface to IP-based physical security products:
    a. ONVIF
8. Each camera's bit rate, frame rate and resolution will be set independently from other cameras in the system and altering these settings will not affect the recording and display settings of other cameras.
9. The VMS shall be able to use multiple CCTV keyboards to operate the entire set of cameras throughout the system, including cameras of various manufacturer's brands, including their PTZ functionalities (i.e.: Pelco keyboard controls Panasonic dome or vice-versa).
10. The VMS shall PTZ protocols independently of the PTZ protocols supported by the video server.
11. The VMS shall be able to retrieve and set the current position of PTZ cameras using XYZ coordinates.
12. The VMS shall support a wide range of PTZ camera protocols. Consult with Genetec for current list.
13. The VMS shall support a wide range of CCTV keyboard protocols. Consult with Genetec for current list.
14. The MVS shall support wide range of joysticks. Consult with Genetec for current list.
15. Audio and Video storage configuration for the SSM shall either be:
    a. Internal or external IDE/SATA organized or not in a RAID configuration;
    b. Internal or external SCSI/iSCSI/Fiber Channel organized or not in a RAID configuration;
    c. It shall be possible to include within the overall storage system disks located on external PCs on a LAN or WAN as well as;
    d. Network Attached Servers (NAS) on a LAN or WAN as well as;
    e. Storage Area Networks (SAN);
16. The SSM shall not limit the actual storage capacity configured per server

B. Configuration UI

1. The Configuration UI shall allow the administrator or users with appropriate privileges to change video configuration.
2. The Configuration UI shall provide the ability to change video quality, bandwidth and frame rate parameters on a per camera (stream) basis for both live and recorded video.
3. The Configuration UI shall provide the ability to configure brightness, contrast and hue settings for each camera on the same DVS.
4. The Configuration UI shall provide the capability to enable audio recording on DVS units that support audio
5. The Configuration UI shall provide the ability to change audio parameters, serial port and I/O configuration of individual DVS units
6. The Configuration UI shall provide the capability to rename all DVS units based on system topology and add descriptive information to each DVS

C. Archiving

1. The Archiver (role) shall use an event and timestamp database for advanced search of audio/video archives. This database shall be a Microsoft SQL 2005 or Microsoft SQL 2008.
2. The Archiver shall have the capacity to move video archives to the Azure Cloud. The archived video can be saved immediately or can be moved after a preset number of days.
3. The Archiver shall protect archived audio/video files and the system database against network access and non-administrative user access.
4. The Archiver shall digitally sign recorded video using 248-bit RSA public/private key cryptography.
5. The Archiver shall offer a plug and play type hardware discovery service with the following functionalities:
    a. Automatically discover DVS units as they are attached to the network.
    b. Discover DVS units on different network segments including the Internet and across routers with or without network address translation (NAT) capabilities.
6. The Archiver shall have the capacity to configure the key frame interval (I-frame) in seconds or number of frames.
7. The Archiver shall provide a pre-alarm and post-alarm recording option that can be set between one second and 5 minutes on a per camera basis.
8. Shall provide the functionality of storing of video and audio streams based on triggering events such as:
    a. Digital motion detection
    b. Digital input activation
    c. Macros
    d. Through SDK application recording
9. The Archiver shall perform video motion detection on each individual camera based on a grid of 1320 motion detection blocks. All of the video motion detection settings are configurable on schedule. A global sensitivity threshold is available to reduce motion detection sensitivity where video signal is noisy, or a lot of false hits are incurred. Video motion detection itself can be set into four different modes:
    a. Full Screen: All 1320 blocks on screen are activated, a general threshold for the overall motion in the entire image can be set and when reached it can trigger recording and a motion event or a custom event.
    b. Full Screen Unit: This is the same as the Full Screen, but the motion detection takes place in the DVS.
    c. Detection Zone: Six overlapping zones can be defined in the 1320 blocks on screen, each of these zones has its own threshold and when reached each one of them can trigger recording and a motion event or a custom event. Each zone triggering its own event allows for the configuration of directional motion detection events and other complex motion detection logic.
    d. Detection Zone Unit: This is the same as the Detection Zone, but the motion detection takes place in the DVS and only one zone is supported.
    e. Disabled: No motion detection is made on this camera.
10. The Archiver shall be able to detect motion in video within 200 milliseconds and not only on key frames.

11. The Archiver shall allow for multiple recording schedules to be assigned to a single camera, each schedule shall be created with the following parameters:
    a. Recording mode
    b. Continuous
    c. On Motion/Manual
    d. Manual
    e. Disabled
12. Time coverage
    a. All day
    b. Specific time range(s)
    c. Daytime or nighttime based on the times of sunrise and sunset, automatically calculated from the time of year and a geographical location. Provision shall be given to offset the calculated sunrise or sunset time by plus or minus 3 hours.
13. The Archiver shall allow each camera (video source) to be encoded multiple times in the same or different video formats (MPEG-4, MPEG-2, MJPEG, H.264, Wavelet or JPEG2000), limited only by the capabilities of each DVS.
14. Whenever multiple video streams are available from the same camera, users shall be free to use any one of them based on their assigned usage. The standard video stream usages are:
    a. Live
    b. Recording
    c. Remote
    d. Low resolution
    e. High resolution
15. The Archiver shall allow the video quality to vary according to predefined schedules. Such schedules shall have the same configuration flexibility as the recording schedules mentioned earlier. The video quality shall be based on, but not limited to, the following parameters:
    a. Maximum bit rate
    b. Maximum frame rate
    c. Image quality
    d. Key frame interval, etc.
16. The Archiver shall have the ability to dynamically boost the quality of the "recording stream" (see previous bullet) based on specific events:
    a. When recording is started manually by a user
    b. When recording is triggered by a macro, an alarm or detected motion
17. The Archiver shall have the capacity to communicate with DVS using 128 bits SSL encryption.
18. The Archiver shall have the capacity to communicate with DVS using HTTPS secure protocol.
19. The Archiver shall have the capacity to receive multicast UDP streams directly from the DVS.

20. For network topologies that restrict the DVS from sending multicast UDP streams, the Archiver shall redirect audio/video streams to active viewing clients on the network using multicast UDP.

21. The Archiver shall have the capacity to redirect audio/video stream to active viewing clients on the network using unicast UDP or TCP.

22. The Archiver shall allow the administrator to choose the disks to use for archiving and to set a maximum quota for each.

23. The Archiver shall allow the administrator to spread the archiving of different cameras on different disk groups (groups of disks controlled by the same controller) so that archiving could be carried out in parallel on multiple disks.

24. The Archiver shall have the capacity to down-sample video streams for storage saving purposes. The down-sampling options available are the following:

    a. For H.264 streams the down-sampling options are: all key frames, 1 fps, 2 sec./frame, 5 sec./frame, 10 sec./frame, 15 sec./frame, 30 sec./frame. 60 sec./frame 120 sec./frame

    b. For MPEG-4 streams the down-sampling options are: all key frames, 1 fps, 2 sec./frame, 5 sec./frame, 10 sec./frame, 15 sec./frame, 30 sec./frame. 60 sec./frame 120 sec./frame

    c. For MJPEG streams the down-sampling options are: 15 fps, 10 fps, 5 fps, 2 fps, 1 fps, 2 sec./frame, 5 sec./frame, 10 sec./frame, 15 sec./frame, 30 sec./frame, 60 sec./frame 120 sec./frame

25. The Archiver shall support DVS with edge recording capabilities and offer the following capacity:

    a. The ability to playback at different speeds the video recorded on the DVS

    b. The ability to offload (video trickling) on schedule, on event or manually the video recorded on the DVS to store it on the Archiver.

D. Video Streaming

1. The Media Router Role shall be responsible for routing video and audio streams across local and wide area networks from the source (e.g. DVS) to the destination (e.g. CSA).

2. The Media Router Role shall support multiple transport protocols such as unicast TCP, unicast UDP, and multicast UDP.

3. The Media Router shall support IGMP (Internet Group Management Protocol) to establish multicast group memberships.

    a. IGMP v3 including SSM (Source-Specific Multicast) shall be supported.

4. The Media Router Role using Redirector Agents shall be responsible to redirect a stream from a source IP endpoint to a destination IP endpoint.

5. The Redirector Agents shall be capable of converting a stream from and to any supported transport protocols, i.e.:

    a. Multicast UDP to Unicast TCP

    b. Multicast UDP to Unicast UDP

    c. Unicast TCP to Multicast UDP

    d. Unicast UDP to Multicast UDP

6. It shall be possible to protect the Media Router Role against hardware or software unavailability by configuring another Media Router Role acting as a hot standby server.

7. Multiple Redirector Agents shall be used on large VMS installation to increase the service availability and to provide automatic load balancing.

2.6 ACCESS CONTROL SYSTEM FUNCTIONALITY

A. General

1. The ACS shall be an enterprise class IP access control software solution. It shall be fully embedded within a Unified Security Platform (USP). The USP shall allow the seamless unification of the ACS with an IP video management system (VMS).

2. The ACS shall be highly scalable to support configurations consisting of thousands of doors with facilities spanning multiple geographic areas.

3. The ACS shall support an unrestricted number of logs and historical transactions (events and alarms) with the maximum allowed being limited by the amount of hard disk space available.

4. The ACS shall support a variety of access control functionality, including but not limited to:

a. Controller (Unit) management, door management, elevator management, and area management

b. Cardholder and cardholder group management, credential management, and access rule management

c. Badge printing and template creation.

d. Visitor Management.

e. People counting, area presence tracking, and mustering.

B. Access Management

1. The ACS shall be based on an open architecture able to support multiple access control hardware manufacturers. The ACS shall be able to integrate with multiple non-proprietary interface modules and controllers, access readers, and other third-party applications.

2. The ACS shall be an IP enabled solution. All communication between the ACS and hardware controllers shall be based on standard TCP/IP protocol.

3. Access Manager Role

a. The Access Manager Role shall be the server that synchronizes all access control hardware units under its control, such as door controllers and IO modules. It shall also be able to validate and log all access activities and events when the door controllers and IO modules are online.

b. The Access Manager Role shall maintain the communication link with the hardware controllers under its control. It shall also continuously monitor whether the controllers are online or offline.

c. Synchronization of hardware units shall be automated and transparent to users and shall occur in the background. It shall also be possible to manually synchronize units or on a schedule.

d. The Access Manager Role shall support doors and controllers located within one or more facilities. The Access Server shall support a minimum of 200 readers per computer.

4. The Access Server shall store all access events associated with the doors, areas, hardware zones (hardware input points), elevators, and controllers under its direct control.

C. Global Cardholder Management

1. The ACS shall support global cardholder management and synchronization between a central independent site and remote independent site, all of which can have their own Directory and databases.
2. It shall be possible to synchronize the following entities and their configuration data:
   a. Cardholders (incl. custom fields)
   b. Cardholder groups
   c. Credentials
   d. Badge templates
3. Cardholders and other synchronized entities can be added centrally and synchronized to remote sites for central cardholder management.
4. Cardholders and other synchronized entities can be added at remote sites and synchronized to the central site and other remote sites.
5. Shall support a single card per cardholder across all of an organization's sites.
6. Manual and scheduled synchronization shall be supported.

D. Hardware Compatibility List

1. The ACS shall have an open architecture that supports the integration of third-party IP-based door controllers and IO modules. The ACS shall simultaneously support mixed configurations of access control hardware from multiple vendors.
2. The ACS shall support multiple types of hardware devices: Single-reader controllers, 2-reader controllers, 1- to 64-reader controllers, integrated readers and door controllers, Power-over-Ethernet (PoE) enabled door controllers.
3. The ACS shall support most industry standard card readers that output card data using the Wiegand protocol and Clock-and-Data.
4. The ACS shall support the following IP-enabled controllers. For a description of the capabilities of the controller, refer to the specific controller's A&E specification.
5. Genetec Synergis Master Controller, which shall support the following downstream interface modules:
   a. VertX V100 reader interface module
   b. VertX V200 input module
   c. VertX V300 output module
   d. Mercury MR52 reader interface module
   e. Mercury MR16OUT output module
   f. Mercury MR16IN input module
6. HID Corporation
   a. VertX V2000 reader interface/network gateway
   b. iCLASS EdgeReader integrated reader and controller (PoE)
   c. iCLASS EdgePlus door controller (PoE)

d. VertX V1000 network gateway

e. VertX V100 reader interface module

f. VertX V200 input module

g. VertX V300 output module

7. Consult with Genetec on the compatible USB enrollment readers.

E. Software Functionality

1. Seamless Unification with IP Video Management System (VMS)

a. Through the USP (Unified Security Platform), the ACS shall support integration with an IP Video Surveillance System or MVS. Integration with an IP video surveillance system shall permit the user to view live and recorded video.

b. User shall be able to associate one or more video cameras to the following entity types, among others: doors, elevator, and hardware zone (input points).

c. The Surveillance UI shall present a true Unified Security Interface for access control and video surveillance. Advanced live video viewing and playback of archived video shall be available through the Surveillance UI.

d. It shall be possible to view video associated to access control events when viewing a report.

2. Controller (Unit) Management

a. The ACS shall support the discovery, configuration, and management of IP enabled controllers and IO modules (hardware units). A user shall be permitted to add, delete, or modify a controller if he has the appropriate privileges.

b. The ACS shall support automatic unit discovery. The user shall set the settings for discovery ports and types of unit discovery and the ACS shall automatically detect all connected devices.

c. Unit Swap Utility. The ACS shall support a unit swap utility to swap out an existing controller with a new controller. The unit swap utility shall avoid the reprogramming of the system whenever a unit is replaced. All logs and events from the old unit are maintained.

3. Cardholder and Cardholder Group Management

a. The ACS shall support the configuration and management of cardholders and cardholder groups. A user shall be able to add, delete, or modify a cardholder or cardholder group if he has the appropriate privileges.

b. Custom fields shall be supported for both cardholders and cardholder groups.

c. The ACS shall permit the following activation/expiration options for a cardholder’s profile: delayed activation of a cardholder’s profile, expiration based on the date of first use of credential, or expiration on a user-defined date

d. It shall be possible to associate a picture to the cardholder’s profile. The picture shall be imported from a file, captured with a digital camera, or captured from a video surveillance camera. When a cardholder event occurs, the picture of the cardholder shall be displayed in the Surveillance UI. The ACS shall support multiple standard picture formats.

e. Cardholder groups shall enable the grouping of cardholders to facilitate mass changes to system settings. It shall be possible to assign cardholder groups to access rules, thus avoiding the assignment of one cardholder at a time.

4. Credential Management

a. The ACS shall support the configuration and management of credentials, e.g. access cards and keypad PIN numbers. A user shall be able to add, delete, or modify a credential if he has the appropriate privileges.

b. User shall be able to add Custom Fields (user-defined fields) to credentials. Creating a new credential shall be accomplished either manually or automatically.

c. Automatic creation shall allow the user to create a credential entity by presenting a credential to a selected reader. The ACS shall read the card data and associate it to the credential entity. It shall be possible to automatically enroll any card format (128 bits or less).

d. The ACS shall support multiple credentials per cardholder, without necessitating duplicate cardholder information. The ACS shall automatically detect and prevent attempts to register an already-registered credential.

e. Batch enrollment of credentials shall be supported.

5. Custom Card Formats

a. A custom card format feature shall allow the administrator to add additional custom card formats using an intuitive tool within the Configuration UI. The custom card format tool shall be flexible in the following ways:

1) Once enrolled, new custom card formats shall appear in the card format lists for manual card enrollment.

2) An unrestricted number of additional custom card formats can be added.

b. The administrator shall be able to set the following options when defining a new format:

1) The order in which card fields appear in the user interface or CSA.

2) Whether a field is hidden from, or visible to an operator.

3) Whether a field is read only or modifiable by an operator.

4) Complex parity checking schemes.

5) The order and location of a field’s data. Location can be defined on a bit-by-bit basis

6. Badge Designer

a. The Badge designer shall be included in the base bid and provided at no cost to the owner.

b. The badge designer shall allow the creation of badge templates that define the content and presentation format of a cardholder badge to be printed.

c. Badge production shall consist of selecting the credential, the badge template, and clicking print.

d. Batch printing of cards shall be available.

e. The contents of a badge template can include: cardholder’s first name, last name, picture, custom fields, bitmap graphics, lines, ovals, rectangles,

dynamic text labels linked to custom fields and static text labels, barcodes (Interleaved 2 of 5, Extended Code 39).

f. Copy and paste of badge template objects shall be available.

g. It shall be possible to set the border thickness, border color, fill color of badge objects (content), and the color of text labels.

h. Settings such as object transparency, text orientation, and auto-sizing of text shall be available or transparent to the user.

i. Supported badge formats shall be (portrait and landscape): CR70 (2.875" x 2.125"), CR80 (3.37" x 2.125"), CR90 (3.63" x 2.37"), CR100 (3.88" x 2.63"), and custom card sizes.

j. Dual-sided badges shall be supported.

k. A badge template import and export function shall be available to allow the sharing of badge templates between distinct or independent ACS.

7. Door Management

a. The ACS shall support the configuration and management of doors. A user shall be able to add, delete, or modify a door if he has the appropriate privileges.

b. The ACS shall permit multiple access rules to be associated to a door.

c. The ACS shall support the following forms of authentication: Card Only, Card or Keypad (PIN), or Card and Keypad (PIN). It shall be possible to define a schedule for when Card Only or Card and Keypad authentication modes shall be required.

d. Extended Grant Time. It shall be possible to set an extended grant time on a per-door basis (in addition to the standard grant time). Cardholder properties shall include the option of using the extended grant time. When flagged cardholders are granted access, the door shall be unlocked for the duration of the extended grant time instead of the standard grant time.

e. The ACS shall support doors configured solely with a lock, a REX, and a door contact but without readers.

f. Implementation of a readerless door shall be possible with the use of standard access hardware IO modules. External hardware such as timers shall not be required.

g. Unlocking schedules shall be programmable for readerless doors.

h. Standard door activity reports shall also be possible with readerless doors.

i. Unlocking schedules and exceptions to unlocking schedules shall be associated to a door. An unlocking schedule shall determine when a door should be automatically unlocked. The ACS shall also support the use of a specific offline unlocking schedule. Exceptions to unlocking schedules shall be used to define time periods during which unlocking schedules shall not be applied, e.g. during statutory holidays.

j. The ACS shall support one or more cameras per door. Video shall then be associated to door access events, e.g. access grant or access denied.

8. Visitor Management

a. Visitor Management module shall be included in the base project and be available at no cost to the owner.

b. The ACS shall support the configuration and management of visitors. A user shall be able to enroll or remove a visitor if he has the appropriate privileges. The ACS shall support check-in and check-out of visitors from the Surveillance UI.

c. A visitor check-in wizard shall facilitate the enrollment process, allowing a user to specify the visitor's specific information.

d. The ACS shall permit the following credential options during visitor check-in:

1) Use an existing credential

2) Automatically create a new credential

3) Manually create a new credential

e. The ACS shall support the creation of a pool of visitor credentials in advance. Existing visitor credentials shall be assigned to visitors during the check-in process.

f. The ACS shall permit cardholder groups to be designated as "available for visitors". Users shall be able to define the access privileges for the cardholder groups (visitor cardholder groups) in advance. During visitor check-in, the user shall select the visitor cardholder group to associate with a visitor. All of the visitor cardholder group access privileges shall be automatically transferred to the visitor. This feature shall permit the creation of multiple types of visitor groups and associated privileges (for Contractors, VIPs, day visitors, etc.). Visitors added to visitor cardholder group in the Surveillance UI shall be automatically updated in the Configuration UI cardholder group screen.

g. A visitor's profile shall support the real-time modification of visitor information after a visitor has checked-in.

h. The ACS shall also provide comprehensive visitor tracking and visitor reporting. Through the real-time tracking feature, the ACS shall generate a real-time and historical visitor activity listing in the Surveillance UI. The ACS shall also generate visitor-specific reports that provide comprehensive listings of visitors as well as full details on their movement.

i. It shall be possible to exempt a visitor from any antipassback rules in effect.

j. The operator shall be able to print visitor badges during the check-in process. The printing of both paper badges (visitor without an assigned credential) and actual credentials shall be supported.

k. Visitor management and reporting shall be available through the Web Client as well.

l. It shall be possible to locate a visitor`s information or profile by swiping the visitor`s credential (card) at a USB reader.

9. People Counting & Area Presence Tracking (Mustering)

a. The ACS shall support people counting (or area presence tracking). The ACS shall be able to monitor and report the number of cardholders in an area in real-time and for all areas. Monitoring shall be based on the entire access control infrastructure, for both local areas and those in remote geographic locations. People Counting can also be used to perform mustering.

b. The ACS shall report area presence counts in the Surveillance UI. Area presence tracks shall dynamically track the total number of cardholders in an area. Displayed data shall be updated dynamically.

c. The ACS shall be able to generate an area presence report listing the cardholders located in one or more areas, accessible through the Surveillance

UI. It shall be possible to filter the report by area and time period. The report shall also include activity from sub-areas (nested areas).

d. Through people counting, the ACS shall be able to generate First Person In and Last Person Out events. The First Person In event shall detect when the first cardholder enters an empty area. The Last Person Out event shall detect when the last cardholder leaves an area. It shall be possible to trigger actions from both events such as sending a message or triggering an alarm.

10. Custom Fields (User-Defined Fields)

a. The ACS shall permit the creation of custom fields. Up to 1,000 custom fields shall be supported.

b. Custom fields shall be supported for the following entities: Cardholders, Cardholder groups, Credentials, and Visitors.

c. Supported custom fields include: Text, Integers, Decimal Numbers, Dates, Boolean, and Images (graphics).

d. User shall be able to define a default value for a custom field.

e. The creation of new custom field types shall be possible. New custom field types shall be based on the standard custom fields supported. They shall support user-defined values from which an operator must make a selection.

f. Administrators have the ability to define which users can view and modify specific custom fields. This shall limit the access to custom field data to users with pre-defined privileges. The ACS shall support querying and report generation using custom fields.

g. Custom fields can be grouped and ordered within these groups as defined by the user.

h. Values for custom fields can be imported using the Import Tool.

11. Import Tool

a. The ACS shall support an integrated Import Tool to facilitate the import of existing cardholder and credential data. The import of data shall be through the use the CSV file format. The tool shall be available from the Configuration UI.

b. The Import Tool shall also support the ability to manually import data that has been exported from a third-party database if it is in CSV format.

c. The import tool shall permit the import of the following data:

1) Cardholder name, descriptions, picture, email, and status

2) Cardholder group information

3) Credential name, status, format, and card number (including credentials with custom formats)

4) Partition information

5) Custom fields

d. Full flexibility in selecting the fields import during an import session shall be available.

e. The option to use a custom and unique cardholder key shall be specified during the import process to ensure that cardholders with duplicate names will not have their data overwritten. Cardholder key generation shall be automated. The end user shall have the option to select which fields will be

used to create this unique key, e.g. credential number, custom fields, cardholder name.

f. The ACS shall also support re-importing a CSV file containing new information to update existing information in the ACS database. Re-importing shall enable bulk amendments to existing access control data.

12. Web Client

a. The Web Client shall allow users to perform configuration, management, and reporting activities of the ACS.

b. The Web Client shall be accessible through Microsoft Internet Explorer. It shall be a truly thin client. It shall not require the download of any ACS-specific files or executable on the client workstation.

c. Functionality available through the web client includes:

1) Configuration and management of cardholders and cardholder groups

2) Configuration and management of credentials

3) Configuration and management of access rules

4) Badge printing over the network

5) Assignment of access rules to doors and areas

6) Visitor management including visitor check-in and check-out and reporting

7) Advanced reporting

2.7 VIDEO SURVEILANCE HARDWARE AND PERIPHERALS

A. Video Archiver Server: Furnish, install and configure two (2) video archiver server with the following specifications:

1. Server: PowerEdge R740XD2 Server

2. Motherboard: PowerEdge R740xd2 Motherboard

3. Trusted Platform Module (TPM): No Trusted Platform Module

4. Chassis Configuration: Chassis Config 0, 24x3.5" HDD, Single PERC, for Riser Config 1 or 4

5. SHIPPING: Power Edge R740XD2 Shipping

6. Shipping Material: PowerEdge R740XD2 Shipping Material

7. Processor: Intel® Xeon® Silver 4114 2.2G, 10C/20T, 9.6GT/s, 14M Cache, Turbo, HT (85W) DDR4-2400

8. Additional Processor: Intel® Xeon® Silver 4114 2.2G, 10C/20T, 9.6GT/s, 14M Cache, Turbo, HT (85W) DDR4-2400

9. Processor Thermal Configuration: CPU 1 Thermal for FH Riser

10. Memory DIMM Type and Speed: 2666MT/s RDIMMs

11. Memory Configuration Type: Performance Optimized

12. Memory Capacity: 64GB (4x16GB) RDIMM, 2666MT/s, Dual Rank

13. RAID Configuration: C4, RAID 5 for 3 or more HDDs or SSDs (Matching Type/Speed/Capacity)

14. RAID/Internal Storage Controllers: Dell PERC H730P RAID mezzanine, mini mono

15. Hard Drives: (12) 12TB 7.2K RPM NLSAS 12Gbps 512e 3.5in Hot-plug Hard Drive
16. Boot Optimized Storage Cards: BOSS controller card + with 2 M.2 Sticks 240G (RAID 1),LP
17. Operating System: No Operating System
18. OS Media Kits: No Media Required
19. Embedded Systems Management: iDRAC9,Enterprise
20. Group Manager: iDRAC Group Manager, Enabled
21. Password: iDRAC,Factory Generated Password,OEM
22. PCIe Riser: Riser Config 1, No Riser, 3xLP, Dual CPU, R740XD2
23. Additional Network Cards: On-Board Broadcom 5720 Dual Port 1Gb LOM; Intel XL710 Dual Port 40G, QSFP+, Low Profile
24. Optics & Cables for Network Cards: QSFP+ SR Optic, 40GbE, for Intel QSFP+ ports
25. Power Supply: Dual, Hot-plug, Redundant Power Supply (1+1), 1100W
26. Power Cords: (2) NEMA 5-15P to C13 Wall Plug, 125 Volt, 15 AMP, 10 Feet (3m), Power Cord, North America
27. Bezel: PowerEdge 2U Standard Bezel
28. BIOS and Advanced System Configuration Settings: Performance BIOS Setting
29. Advanced System Configurations: UEFI BIOS Boot Mode with GPT Partition
30. Rack Rails: PEC Static Rails
31. System Documentation: No Systems Documentation, No OpenManage DVD Kit
32. Service: 3 Years Basic Hardware Warranty Repair: 5x10 HW-Only, 5x10 NBD Onsite
33. Deployment Services: ProDeploy Dell Server R Series 1U/2U

B. Workstations (Large): Furnish, install and configure two (2) workstations with the following specifications:

1. Precision 5820 Tower: Precision 5820 Tower XCTO Base
2. Processor: Intel Xeon W-2125 (4.0GHz, 4.5GHz Turbo, 4C, 8.25MB Cache, HT, (120W)) DDR4-2666
3. Operating System: Windows 10 Pro for Workstation (up to 4 Cores) Multi - English, French, Spanish
4. Microsoft Office: Microsoft Office 30 Day Trial
5. Chassis Options: Precision 5820 Tower 950W PCIe FlexBay Chassis
6. Video Card: NVIDIA® Quadro® P4000, 8GB, 4 DP (5820T)
7. Memory: 16GB (2x8GB) 2666MHz RDIMM ECC
8. Systems Management: No Out-of-Band Systems Management
9. Wireless: No Wireless LAN
10. Operating System (Boot) Drive: NVMe PCIe SSD (Front PCIe FlexBay)
11. Hard Drive Controllers: Intel Integrated controller (RST-e) with 1-2 Front FlexBay NVMe PCIe Drives,v2
12. Hard Drive: M.2 256GB PCIe NVMe Class 40 Solid State Drive
13. 2nd Hard Drive: No Hard Drive

14. 3rd Hard Drive: No Hard Drive
15. 4th Hard Drive: No Hard Drive
16. Slimline Bay Options: Slim filler panel (no opt.)
17. 5.25" FlexBay: No Optical
18. 5th Hard Drive: No Hard Drive
19. 6th Hard Drive: No Hard Drive
20. RAID for HDD/SSD & Front M.2 NVMe SSDs: No RAID
21. Keyboard: Dell KB216 Wired Keyboard English Black
22. Mouse: Dell MS116 Wired Mouse Black
23. Teradici Remote Workstation Access Host Card: No Remote Access Host Card
24. Network Cards: Intel® X550-T2 10GbE NIC, Dual Port, Copper
25. PCIe I/O Cards: Not Selected in this Configuration
26. Power Cords: US 125V Power Cord
27. Placemat: Placemat 5820 Tower MUI DAO
28. Resource DVD: Resource DVD not Included
29. Operating System Recovery Options: OS-Windows Media Not Included
30. E-Star: No Energy Star
31. Optimizer: Dell Precision Optimizer
32. Optical Software: No Optical Software
33. Label: T5820 950W Regulatory Label (DAO)
34. Documentation/Disks: Safety/Environment and Regulatory Guide (English/French Multi-language)
35. Mounts and Monitor Stands: No Stand
36. Canada Ship Options: Non-Canada orders only
37. Storage Volume: Boot drive or boot volume is greater than 2 TB (select when 3TB/4TB HDD is ordered)
38. Cables and Dongles: No Accessories
39. TPM Security: TPM
40. Packaging: Ship Material Tower 5820,7820
41. Non-Microsoft Application Software: Windows 10
42. Driver: No Wireless LAN
43. Hardware Support Services: 3 Years ProSupport with Next Business Day Onsite Service
44. Dell 43 Ultra HD 4K Multi Client Monitor: (2) Dell 43 Ultra HD 4K Multi Client Monitor - P4317Q

C. Workstations (Small): Furnish, install and configure three (3) workstations with the following specifications:

1. Precision 3430 Small Form Factor: Precision 3430 Small Form Factor BTX BASE

2. Processor: Intel Xeon E-2124G, 4 Core, 8MB Cache, 3.4GHz, 4.5Ghz Turbo, HD Graphics 630
3. Operating System: Windows 10 Pro for Workstation (up to 4 Cores) Multi - English, French, Spanish
4. Microsoft Office: Microsoft Office 30 Day Trial
5. Chassis Options: Precision 3430 Small Form Factor w/ 260W up to 92% efficient PSU (80Plus Platinum)
6. Video Card: NVIDIA® Quadro® P1000, 4GB, 4 mDP
7. Memory: 16GB (2x8GB) DDR4 2666MHz UDIMM Non-ECC
8. Systems Management: Intel vPro Technology Enabled
9. Wireless: No Wireless LAN
10. Hard Drive Configuration: C3 M.2 PCIe Boot SSD
11. HDD Controller: Integrated Intel Sata Control
12. Hard Drive: M.2 512GB PCIe NVMe Class 40 Solid State Drive
13. Additional Hard Drive: No Additional Hard Drive
14. 3rd Hard Drive: No Additional Hard Drive
15. Optical or CAC/PIV reader: 8x DVD+/-RW 9.5mm Optical Disk Drive
16. Raid Connectivity: None
17. Keyboard: Black Dell KB216 Wired Keyboard
18. Mouse: Dell MS116 Wired Mouse
19. Teradici Remote Workstation Access Host Card: No Remote Access Host Card
20. Network Card: No Additional Network Card Selected (Integrated NIC included)
21. PCIe I/O Cards: Not selected in this configuration
22. Serial Port / Parallel Port: No Parallel or Serial Port
23. Power Cord: US Power Cord
24. Placemat: Quick Start Guide
25. Operating System Recovery Options: OS-Windows Media Not Included
26. Energy Star: Energy Star
27. Optimizer: Dell Precision Optimizer
28. Optical Software: Cyberlink Media Suite Essentials for Windows 10 and DVD drive (without Media)
29. FGA Module: 3430_CFL_2HFY19_007/US/BTS
30. TPM Security: Dell Precision TPM
31. Processor Branding: Intel Xeon CPU label
32. Documentation/Disks: Safety/Environment and Regulatory Guide (English/French Multi-language)
33. Driver: No Wireless LAN
34. Packaging: Shipping and Handling
35. Hard Drive Software: No Intel Rapid Start or Smart Connect

36. Canada Ship Options: US No Canada Ship Charge
37. Label: Precision 3430 Reg Label
38. SD Card Reader: SD Card Reader
39. Protect your new PC: No Security Software
40. Non-Microsoft Application Software: Dell Applications for Windows 10
41. Cables and Dongles: No Accessories
42. Dell Backup & Recovery: Dell Backup and Recovery
43. UPC Label: Print on Demand Label
44. Stands and Mounts: No Integrated Stand option
45. Optional Integrated Video or USB Ports: Additional HDMI 2.0b Video Port
46. Hardware Support Services: 3 Years Hardware Service with Onsite/In-Home Service After Remote Diagnosis
47. External Speakers: External Speaker Not Included
48. Dell 27 Monitor: (1) Dell UltraSharp 27 InifinityEdge Monitor - U2717D

D. Rackmount Accessories
1. KMM: (1) Dell Part #: A9165569 (Manufacturer Part #: DKMMLED185-G01-KIT3)
   a. Dell bundle includes 18.5 in 1U Rackmount LED KMM Console - English Language Keyboard with 1U KVM Mounting Bracket
2. KVM: (1) 8 port IP KVM Dell Part #: A7546773 (Manufacturer Part #: DMPU108E-G01)
3. SIM for KVM: (8) Dell Part #: A7547276 (Manufacturer Part #: DMPUIQ-VMCHS-G01)

E. Large Format Displays
1. (1) Samsung Q7FN QLED 55" large format display with mounting brackets to be installed in Gen. Office B101.
2. (1) Samsung Q7FN QLED 65" large format display with mounting brackets to be installed in Principal B102.
3. (1) Samsung Q7FN QLED 55" large format display with mounting brackets to be installed in SRO Office B103.

F. Cameras
1. Interior Corridor Camera: Axis P3227-LV
2. Interior 180 Degree Camera: Axis P3807-PVE
3. Interior/Exterior 360 Degree Camera: Axis P3717-PLE
4. Exterior Door Camera: Axis P3225-LVE MkII
5. Exterior 180 Degree Camera: Axis Q3709-PVE
6. Exterior 4K Camera: Axis P3228-LVE
7. Exterior PTZ Camera: Axis Q6128-E/Axis Q6125-LE (Covert IR)
8. Provide wall/corner mount brackets for all exterior cameras.

G. Components for Exterior Pole Mounted Cameras:

1. Furnish and install (1) heater and thermostat, (1) media converter, (1) 95W POE injector, and (1) lightning protection in NEMA 4x rated heated enclosure sized to accommodate all components at each camera.
2. Furnish and install 1.5kVA, 277V to 120V stepdown transformer and double duplex receptacle in a NEMA 4x enclosures at each camera.
3. Furnish and install rack mounted media converter in the corresponding telecommunications room.
4. Basis of Design
    a. Media Converter: Altronix NETWAYSP2P
    b. Heater: Hoffman DAH301
    c. Temperature Control Switch: Hoffman ATEMNC
    d. POE Injector: Bosch NDP-600A1
    e. Surge Protector: Ditek DTK-MRJPOE
    f. Nema 4X Enclosure: Hoffman ELC404020 Enclosure (or larger to accommodate all components), EP4040AL Backplate and CPMK16 Pole Mount
    g. Tamper Switch: interlogix 3025T-M
    h. Transformer: Hammond Power 1.5kVA, 277V to 120V

H. PoE Ethernet Extender

1. The PoE Ethernet Extender shall be a two-piece system, a Communications room located device and a device located in a NEMA 4X junction box near the CCTV Camera, that will be used to provide network access and power to the cameras specified on the Contract Drawings that are out of range of standard Ethernet.
2. The PoE Ethernet Extender will only be powered on the Communications room end and the matching device located in the NEMA 4X junction box near the camera shall receive its power over the CAT6 cable.
3. The PoE Ethernet Extender located in the Communications room shall be mounted on a new rack mount shelf in the Communications room.
4. The PoE Ethernet Extender shall provide PoE power to the IP Camera, shall be fully compatible with the Camera, and shall be completely transparent to the Ethernet protocol.
5. The PoE Ethernet Extender shall meet or exceed the following specifications:
    a. Ethernet Speed: 10Base-TX
    b. Data Connectors: RJ-45
    c. Power: 120VAC, only powered on Communications room end
    d. Dimensions: Approximately 3” x 1.5” x 2”
    e. Operating Temperature: -13ºF to 140ºF
    f. Transmission Distance: 900ft minimum

2.8 ACCESS CONTROL HARDWARE AND PERIPHERALS

A. Single Door Networked Access Controller Featuring Power Over Ethernet

1. General

a. The networked access controller shall be mounted above each door equipped with card access. Each controller shall be connected to the security network switch.

2. Features

a. Provides a complete and fully functional hardware/firmware infrastructure for IP access control software host systems.

b. Supports Power Over Ethernet (PoE), enabling cost-effective installation utilizing existing network infrastructure.

c. Stores a complete access control and configuration database for one door with one or two readers and 125,000 cardholders.

d. Provide access control processing, host functionality and power for a single door, including one or two readers, lock, door status, request-to-exit device and auxiliary sounder.

e. Utilizes on-board jumpers to select 12 or 24 VDC power to locks and AUX output when powering device over PoE or 24 VDC.

f. Provides encrypted door bus using Hi-O technology so that controller and Hi-O enabled readers and door components communicate securely.

g. Connects to the host and other devices on a TCP/IP network.

h. Receives and processes real-time commands from the host software application while reporting all activity to host. Buffers up to 99,999 transactions.

i. Provides fully functional offline operation when not actively communicating with the host access control software.

j. Interfaces with one or two Hi-O compliant readers and one Wiegand or Clock-and-Data reader (expandable to two).

k. UL 294 and UL 1076 recognized component.

3. Provide HID Edge EVO EH400-K networked controller for each door.

B. MultiClass Card Readers

1. Provide contactless multiClass readers as shown on the drawings.

2. Each reader shall operate on 125 KHz or 13.56 MHz transmit frequency.

3. The reader shall have a Weigand output.

4. The readers shall have both an audio and visual notification for access granted and access denied.

5. The reader shall be suitable for indoor and outdoor applications.

6. The reader shall operate up to 500ft on 22AWG cable.

7. The reader shall be able to communicate with either 125 kHz or 2K, 16K or 32K bit iClass cards.

8. Provide HID SE RP40 multiClass readers or approved equal for wall mount locations.

9. Provide HID SE RP15 multiClass readers or approved equal for mullion mount locations.

10. Provide HID SE RPK40 multiClass readers or approved equal for locations with keypad functionality.

C. Proximity key fob

1. The fob shall operate on 125kHz frequency.
2. The fob shall have an operating temperature of -50 to 160 degrees Fahrenheit.
3. Provide HID Proxkey III model 1346 or approved equal.
4. Provide 300.

D. Request-to-exit devices

1. Furnish and install motion request-to-exit sensors as shown on the drawings and as required. Devices shall mount directly above each door. Utilize doors that have hardware which have integral request-to-exit switches as required. Coordinate with door hardware.
2. Provide DS 150i or approved equal with trim plate.

E. Auxiliary Power Supply

1. Provide auxiliary power supply(s) for REX sensors as required. Provide Altronix or approved equal.

F. Locking device power supply

1. Furnish and install electric strikes and magnetic locks power supplies as needed and required.
2. 8 or 16 outputs, individually programmable for: Fail safe, Fail secure, Form "C' relay contact, Constant voltage for auxiliary devices, Fire Alarm Interface (FAI), Negative or open collector trip, Positive trip, Isolated trip.
3. Each output shall be fuse protected.
4. Provide coordination with door hardware Contractor on proper current draws.
5. Power supplies shall be interfaced to the fire alarm system.
6. Power supply shall be UL Listed.
7. Provide Altronix AL series or approved equal.

G. Locking Devices (Electric strike/Magnetic locks/Electric locks/Electric Hinges)

1. Furnished and installed by others. Wired by security Contractor.

H. Duress Stations

1. Provide remote duress red mushroom push button as shown on the drawings. The device shall be designed for high security applications and shall be vandal proof. Each duress button shall be wired to the security system for camera call-up and general alarm conditions. Each button shall report and be programmed independently of one another.
2. Provide Rauland HSS8 or approved equal.

2.9 INTRUSION DETECTION HARDWARE AND PERIPHERALS

A. Intrusion Alarm Control Panel

1. Provide an addressable intrusion alarm control panel complete with enclosure, power supply, door lock, etc.
2. The intrusion alarm panel shall be fully integrated to the USP.

3. Provide all labor, materials, equipment, and services to perform all operations required for the complete installation and related work as shown in all contract documents.
4. All motion detectors, roof hatches and exterior doors shall report and be individually annunciated on the intrusion alarm system. For locations that are exterior access control doors, each door contact shall be double pole, double throw. One pole shall be wired to the intrusion alarm system and the other shall be wired to the access control system and programmed in accordance with the access control specification. Each exterior door shall be wired and individually reported to the intrusion alarm system.
5. Keypads shall be able to arm and disarm the intrusion alarm system
6. Once armed, any motion detector, door contact, glass break, etc. shall both cause the audible sounder to sound and call the central station.
7. The control panel shall be capable of supporting Dynamic Host Communication Protocol (DHCP) Internet Protocol (IP) addressing.
8. The control panel shall be capable of two-way network communication using standard Ethernet 10BaseT in a LAN, WAN, or Internet configuration.
9. The panel must support up to 574 zones/points.
10. The panel must be able to support 32 independent partitions.
11. Provide with battery backup and battery harness for a minimum of 4 hours.

B. Intrusion Alarm Keypad

1. Provide 32-character intrusion keypads as shown on the drawings.
2. The keypads can be used to both arm and disarm the intrusion system.

C. PIR/Microwave Motion Detectors

1. Provide dual technology PIR and Microwave motion sensors. Sensors shall process their signals independently and shall have coverage patterns individually adjustable.
2. Each motion sensor shall be wired to the intrusion alarm system.
3. Provide long range detectors as shown on the plans and as required.
4. Wiring connections shall be made in equipment cabinets. Conductors other than that of detector will not be allowed at each device. Detectors shall not be wired in series or with door contacts. There shall be no exposed wiring leading to/from motion sensors.
5. Fields of view that are directed at heat sources such as fans, radiators and other areas that may cause false alarms shall be masked out.

D. Door Contacts/switches

1. Provide recessed door contacts/switches as shown on the drawings. Contacts shall be 3/4 inch and have wire leads of sufficient length for splices to be made in wiremold box or mud type box located adjacent to door. Provide GE model #1078C or approved equal for interior doors. Provide DPDT contacts for all exterior doors, GE model #1076-D or approved equal.
2. In event that circumstances prevent the use of recessed contacts in some locations, surface contacts may be used, subsequent to approval of Architect.
3. Wiring for door contacts shall be concealed.

4. Door contacts shall not be wired in series with exception of double doors which may be wired to panel as single door location.
5. There shall be no splices in door frames or jambs. Door contact connections shall be made in wiremold or mud switch box located adjacent to door.
6. Provide one (1) addressable input module per door contact.
7. Provide double pole double throw door switches for all doors equipped with electrified doors.

E. Overhead Door Contacts

1. Provide overhead door contacts as shown on the drawings.
2. Provide GE 2200 series or approved equal.
3. Provide double pole double throw door switches for all overhead doors.

F. Addressable Input Module

1. Provide single input module devices for all non-addressable inputs (motions, door contacts, glass break detectors, duress button, etc.).

G. Intrusion Alarm Panel Accessories and Modules

1. Interface Adapter Module. Provide one (1) loop adapter bus card per system.
2. Loop/Zone expansion interface card. Provide a minimum of two (2) expansion cards per system. Provide a sufficient amount of zone cards to handle 574 points as required.
3. Dual Phone Line Module. Provide one (1) per system.
4. Eight Input Module. Provide one per eight devices.
5. Zone Expansion Module. The individual zone expansion module shall be used to monitor door contacts, motion detectors, glass break detectors, and other monitor points. Provide as required.
6. Relay Output Module. Provide one (1) per system. Provide with four (4) relays.
7. Remote Software: Provide a software package for remote maintenance and service support.

H. Central Station Monitoring

1. Provide monitoring at a UL Listed central station for a period of one year

2.10 MAINTANANCE AGREEMENT

A. Unified Security Platform Software Maintenance Agreement

1. Provide a manufacturer approved software upgrade plan for the Unified Security Platform software for a period of one year after final completion. The plan should include:
   a. New USP software revisions for a period of one year from final completion at no cost to the owner.
   b. New USP software patches for a period of one year from final completion at no cost to the owner.
2. All labor associated with the software patches and upgrades shall be included.

B. Extended Service and Preventative Maintenance Agreement

1. General
    a. The Systems Integrator shall supply a one-year service and preventive maintenance agreement. The owner shall have the option to renew the agreement upon expiration.
    b. The agreement must be provided by the Systems Integrator which provided and installed the entire Integrated Security System.
    c. Equipment warranty shall be provided for a period of one year as described elsewhere within the specification.
    d. Access to 24/7/365 phone support. A technician will be
    e. dispatched the next day of when the service call was placed.
    f. A technician will be dispatched within 4 hours of when the call was placed for an emergency service call. Emergency service is defined as any one of the following: Video Server/ Video Workstation/Access Control Server/Access Control workstation fails, corridor camera/photo badge reader/card reader/intrusion panel or intrusion alarm keypad does not work.
    g. A technician will be dispatched within 24 hours of when the call was placed for a normal service call.
    h. Provide the client with 48 hours' notice of arriving for all preventative maintenance work. And provide a one-hour notice prior to arrival for all preventative maintenance work.
    i. Provide the client a written report explaining the scope of the service call within 48 hours after completing the service call.
2. Preventative Maintenance
    a. Upon a monthly basis:
        1) Reboot all Video servers. Verify all cameras are properly reporting and recording. Verify all workstations are reporting and working properly.
        2) Provide written report to end user stating the above is working properly.
    b. Upon a quarterly basis:
        1) Inspect CCTV Cameras. Verify Camera Field of View and Focus.
        2) Verify Cameras are viewing the desired image by the customer.
        3) Check System Alarm and Event Logs.
        4) Verify Camera Programming, Naming, Image Quality Settings and Recording Settings.
        5) Verify System is Recording and Note Retention Period.
        6) Verify Recording Hard Drive Configuration and Status. Check for Drive Failures or Bad Sectors.
        7) Verify Motion Detection Recording Settings. Verify all cameras are capturing the expected Motion Activity. Note any discrepancies.
        8) Verify PTZ Control of applicable Cameras. Check Presets, Tours and Home Position Settings.
        9) Verify all channels of the Video Encoder (s) are working properly.
        10) Provide Microsoft Window updates to each Security Workstation.
        11) Verify network switch utilization and network switch ports are functioning.

12) Check Access Control Panel / Controller Communications Status.

13) Check Access Control Panel / Controller Batteries. Note Battery Type, Voltage, Amp-Hour Rating and Date Code. Test and Note Battery Voltage.

14) Inspect Door Hardware for Operation, Damage & Mis-Alignment.

15) Inspect and Test Operation of Access Control Equipment at each Door [Card Readers, Door Contacts, REX & Door Release Push Buttons where applicable].

16) Test Operation of Ancillary Access Control Inputs and Outputs.

17) Check System Alarm and Event Logs. Attach a printed copy of the logs if applicable.

18) Verify Camera Call-Up upon Event / Alarm where applicable.

19) Verify Door Programming, Time Schedules, Access Levels and Door Unlock Schedules. Note programming operation.

20) Verify Photo Badge Reader and Workstation Photo-ID Call-up Operation.

21) Verify System Time of Day is configured and is synchronizing with a time server or consistent source.

22) Verify and Note Current Software Version and Device Firmware Versions.

23) Verify Client and Server Computer Hardware Specifications. Verify CPU, Memory & Network Utilization. Note Performance Stats. Perform Reboot of all Computers and verify system back-online and note any changes in performance stats.

24) Verify Access Control System Database is configured for a regular back-up.

25) Check each Intrusion motion detector, intrusion door contact, glass break device, duress button and keypad to verify its working properly.

26) Provide written report to end user stating the above is working properly.

2.11 HARDWARE SUPPORT

A. The Systems Integrator shall perform scheduled maintenance services on all systems and equipment as specified in this section.

B. Components and parts that are found to be defective, have failed operationally or which exhibit signs of near-term failure will be identified during each preventive maintenance inspection or test. If the component or part is covered under a current Systems Integrator or factory warranty, said part or component will be replaced at no charge to CUSTOMER including labor during normal business hours.

C. For any equipment requiring repair or replacement that is not covered, an estimate will be prepared and submitted for approval on a reimbursable basis and repair authorization shall be issued in writing by an authorized representative of the CUSTOMER before proceeding with the work.

2.12 RESPONSE TIME

A. Should an emergency arise, the Systems Integrator personnel will assess the situation either by phone or remote diagnostics, or both, and will determine the required course of action with the CUSTOMER.

B. On-Site Response Time: If it is determined that a site visit is required, the Systems Integrator personnel will arrive at the affected premises within four (4) hours of the request of the CUSTOMER.

C. If the resolution of the emergency service call requires the Systems Integrator to provide service for equipment that is not listed in this specification section, CUSTOMER will be liable for charges and expenses prevailing for such service.

D. Emergency Service will be provided during the following periods.

1. Provide Emergency Service Monday through Friday 8:00 AM – 5:00PM excluding evenings and weekends, city, state, federal and Systems Integrator observed holidays at no additional charge to the base annual service fee. Labor for travel time is included under this Agreement. The Systems Integrator will provide a response time as stated and agreed to above. Emergency Service requested by the CUSTOMER to be provided outside of the above stated times will be reimbursed by the CUSTOMER as shown below.

E. Emergency Service during the following periods is not included.

1. Emergency Service Monday through Friday 5:00PM – 8:00AM, weekends, city, state, federal and Systems Integrator observed holidays are not included. Emergency Services provided under this scope will be reimbursable by the CUSTOMER to the Systems Integrator at then current Systems Integrator published service labor rates and standard service charges (Minimum Labor Charge, Vehicle Charges, Round Trip Travel Time, Mileage, etc.

2.13 DOOR INTERCOM SYSTEM WITH VIDEO

A. Acceptable Manufacturer:

1. Axis

B. The system shall comprise desk video master stations (VMS) and remote weatherproof flush mounted exterior door video entry stations (VES).

C. Video Master Station (VMS):

1. Basis of design shall be GrandStream GXV3275 IPVideo Phone for Android. Furnish and install where shown on the drawings.

2. The phone combines a 6-line IP video phone with a multi-platform video conferencing solution and the functionality of an Android tablet to offer an all-in-one communications solution. The phone features dual Gigabit ports, HD audio and HD video, a built-in web browser, Bluetooth, integrated Wi-Fi (802.11b/g/n) for network flexibility, PoE/PoE+, and more.

3. Features:

a. Protocols/Standards: SIP RFC3261, TCP/IP/UDP, RTP/RTCP, HTTP/HTTPS, ARP, ICMP, DNS (A record, SRV, NAPTR), DHCP, PPPoE, SSH, TFTP, NTP, STUN, SIMPLE, LLDP-MED, LDAP, TR-069, 802.1x, TLS, SRTP.

b. Network Interface: Dual switched 10/ 100/ 1000 Mbps ports with integrated PoE/PoE+.

c. Graphic Display: 7-inch (1024×600) capacitive (5 points) touch screen TFT LCD.

d. Camera: Tiltable mega pixel CMOS camera with privacy shutter.

e. Bluetooth: Bluetooth 4.0 + EDR.

f. Wi-Fi: 802.11 b/g/n.

g. Auxiliary Ports: RJ9 headset jack (allowing EHS with Plantronics headsets), 3.5mm stereo headset with microphone, dual USB ports, SD, mini-HDMI

h. Feature Keys: 2 function keys VOLUME +/-, 3 dedicated Android keys for HOME, MENU, and BACK.

i. Voice Codecs: Support for G.711μ/a, G.722 (wide-band), G.726-32, iLBC, Opus, G.729, in-band and out-of-band DTMF (In audio, RFC2833, SIP INFO), VAD, CNG, AEC, PLC, AJB, AGC.

j. Video Codecs and Capabilities: H.264 BP/MP/HP, H.263 CIF/QCIF resolution, video resolution up to 720p, frame rate up to 30 fps, bit rate up to 2Mbps, 3-way video conference, anti-flickering, auto focus and auto exposure, PIP (Picture-in-Picture), on-screen-display, camera block, still picture capture/store, video recording, visual voice message indicator.

k. Telephony Features: Hold, transfer, forward (unconditional/no-answer/busy), call park/pickup, 6-way audio conference, shared-call-appearance (SCA) / bridged-line-appearance (BLA), virtual MPK, downloadable phone book (XML, LDAP), call waiting, call history, boss-secretary virtual button, flexible dial plan, hot desking, personalized music ringtones, server redundancy & fail-over.

l. Sample Applications: Skype, Google Hangouts, Microsoft Lync, Web browser, Adobe Flash, Facebook, Twitter, YouTube, news, weather, stock, Internet radio, Pandora, Last.fm, Yahoo Flickr, Photobucket, alarm clock, Google calendar, mobile phone data import/export via Bluetooth, etc. API/SDK available for advanced custom application development.

m. Applications Deployment: Allows Android OS version 4.2 compliant applications to be developed, downloaded and run in the embedded device with provisioning control.

n. HD Audio: both handset and speakerphone support HD (wide-band) audio.

o. Base Stand: GXV3275 uses flexible adjustable stand.

p. QoS: Layer 2 QoS (802.1Q, 802.1p) and Layer 3 (ToS, DifServ, MPLS) QoS .

q. Security: User and administrator level passwords, MD5 and MD5-sess based authentication, 256-bit AES encrypted configuration file, TLS, SRTP, HTTPS, 802.1x media access control.

r. Multi-language: English, German, Italian, French, Spanish, Portuguese, Russian, Croatian, Chinese, Korean, Japanese, and more.

s. Upgrade/Provisioning Firmware upgrade via TFTP / HTTP / HTTPS or local HTTP upload, mass provisioning using TR-069 or AES encrypted XML configuration file.

t. Power & Green Energy Efficiency: Universal power adapter included: Input 100-240VAC 50-60Hz; Output 12VDC, 1.5A (18W), Integrated PoE+ (Power-over-Ethernet)* 802.3at, Class 4. *When using with USB devices, must use PSU or PoE+ to power up phone. For other uses, PoE is enough.

u. Physical: Dimension: 252mm (W) x 211mm (L) x 84mm (H); Unit Weight: 1.08kg; Package Weight: 1.77kg

v. Temperature and Humidity: Operation: 0°C to 40°C, Storage: -10°C to 60°C, Humidity: 10% to 90% Non-condensing.

w. Package Content: GXV3275 phone, handset with cord, base stand, universal power supply, network cable, lens cleaning cloth, quick installation guide, brochure, GPL license

x. Compliance: FCC: Part 15 (CFR 47) Class B; UL 60950 (power adapter); Part 68 (HAC) CE : EN55022 Class B, EN55024, EN61000-3-2, EN61000-3-3, EN60950-1, EN62479, RoHS RCM: AS/ACIF S004; AS/NZS CISPR22/24; AS/NZS 60950; AS/NZS 4268

4. Integrate the VMS to the facility's IP phone system to make and receive calls as well as to the VES to open doors remotely.

5. Coordinate programming with the Owner.

D. Video Entry Station (VES):

1. Basis of design shall be Axis A8004-VE Network Video Door Station. Furnish and install where shown on the drawings.

2. Features:

a. Camera: Image sensor 1/3″ Progressive scan RGB CMOS

1) Lens: M12 mount, F2.8, Fixed iris, Megapixel resolution, 2.8 mm, 97° view

2) Light sensitivity: 0.4 - 100000 lux, F2.8, 0 lux with illumination LED on

3) Shutter time: Dynamic capture, 1/192 s to 1/37 s (50 Hz), 1/231 s to 1/44 s (60 Hz)

b. Video

1) Video compression: H.264 (MPEG-4 Part 10/AVC), Baseline Profile, Main Profile, Motion JPEG

2) Resolutions: 1280x960 (1.3 MP) to 160x90

3) Frame rate: HDTV 720p (1280x720), 25/30 fps (50/60 Hz)

4) Video streaming: Multiple individually configurable streams, H.264, Motion JPEG, Controllable frame rate and bandwidth, VBR/CBR H.264

5) Image settings: Compression, Color, Brightness, Sharpness, Contrast, White balance, Exposure control, Fine-tuning of behavior at low light, WDR - Dynamic Capture, Text and image overlay, Mirroring of images, Privacy mask

6) Pan/Tilt/Zoom: Digital PTZ

c. Audio

1) Audio streaming: Two-way, Full duplex

2) Audio compression: AAC LC 8/16 kHz, G.711 PCM 8 kHz, G.726 ADPCM 8kHz, Configurable bit rate

3) Audio output: 85 dB (at 0.5 m)

4) Audio input/output: Line output, Built-in microphone, Built-in speaker

5) Echo cancellation: Yes

6) Noise reduction: Yes

d. Network

1) Security: Password protection, IP address filtering, HTTPSb encryption, IEEE 802.1Xb network access control, Digest authentication, User access log

2) Supported protocols: IPv4/v6, HTTP, HTTPSb, SSL/TLSb, QoS Layer 3 DiffServ, FTP, CIFS/SMB, SMTP, Bonjour, UPnPTM, SNMP v1/v2c/v3 (MIB-II), DNS, DynDNS, NTP, RTSP, RTP, TCP, UDP, IGMP, RTCP, ICMP, DHCP, ARP, SOCKS, SIP

e. System Integration

1) Application Programming Interface: Open API for software integration including VAPIX® and AXIS Camera Application Platform; specifications at www.axis.com, AXIS Video Hosting System (AVHS) with One-click Connection, ONVIF Profile S; specification available at www.onvif.org

2) Software: Third-party video management software and mobile applications. See www.axis.com for compatibility

3) VoIP: SIP support for integration with VoIP, Peer-to-peer or integrated with SIP/PBX. Tested with various SIP softwares such as Cisco, Bria and Grandstream. Tested with various PBX softwares such as Cisco, Avaya and Asterisk.

4) Analytics: Video motion detection, Active tampering alarm, Audio detection, AXIS Camera Application Platform enabling installation of additional applications, External input, Edge storage events, Shock detection

5) Event triggers:

a) Call: DTMF, State, State changes

b) Detectors: Video motion detection, Audio detection, Live stream accessed, Shock detection, Tampering

c) Hardware: Casing open, Network

d) Input signal: Digital input port, Manuel trigger, Virtual input

e) PTZ: Moving, Preset reached

f) Storage: Disruption, Recording

g) System: System ready

h) Time: Use schedule

6) Event Actions:

a) Make call: SIP, API

b) File upload: FTP, HTTP, network share and email

c) Notification: email, HTTP and TCP

d) Video and audio recording to edge storage, Pre- and post-alarm video buffering, External output activation, Play audio clip, Overlay text, PTZ control, Status LED, WDR mode

7) Data streaming: Event data

8) Built-in installation aids: Pixel counter

3. Warranty: Axis 3-year warranty.

4. Integrate the video out put of the VES with the Genetec VMS to record all visitor interactions.

2.14 NETWORK SWITCHES

A. Furnished and installed under Section 272100.

B. Install and dress appropriate size fiber and Cat. 6A patch cords (provided by Electrical Trade Contractor under Division 271500) between all active switch ports and patch panel ports serving equipment.

PART 3 - EXECUTION

3.1 GENERAL

A. The ceiling cavity is being used as plenum return. Provide plenum rated cables, conduit, backboxes in all plenum rated ceilings, rated walls, penetrations though wall, floors and ceilings and where required by Local, State or Federal Codes.

3.2 EXAMINATION

A. Examine pathway elements intended for cables. Check raceways and other elements for compliance with space allocations, installation tolerance, hazards to camera installation, and other conditions affecting installation.

B. Examine roughing-in for LAN, WAN, and IP network before device installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.3 VIDEO SURVEILLANCE SYSTEM INSTALLATION

A. General

1. Comply with requirements in Division 26.

2. Video surveillance wiring color to be distinct and specific to the system. Contractor to coordinate cable colors with all other vendors to ensure color is not duplicated.

3. Wiring Method: Install cables in ‘J’ hooks or raceways unless otherwise indicated.

4. Except raceways are not required in accessible indoor ceiling spaces and attics.

5. Conceal raceways and wiring except in unfinished spaces.

6. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools.

7. Splices, Taps, and Terminations: For power and control wiring, use numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B.

8. Set pan unit and pan-and-tilt unit stops to suit final camera position and to obtain the field of view required for camera. Connect all controls and alarms and adjust.

9. Install power supplies and other auxiliary components at control stations unless otherwise indicated.

10. Provide suitable UPS for all network switch equipment, workstations, servers and storage arrays.

11. Avoid ground loops by making ground connections only at the control station.

B. Field Quality Control

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

2. Perform tests and inspections.

a. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

b. Include Manufacturer On-Site Field Engineering services for one day of system commissioning.

C. Adjusting

1. Check cable connections.

2. Check proper operation of cameras and lenses. Verify operation of auto-iris lenses and adjust back-focus as needed.

3. Adjust all preset positions; consult with appointed Owner's personnel.

4. Recommend changes to cameras, lenses, and associated equipment to improve Owner's use of video surveillance system.

5. Provide a written report of adjustments and recommendations.

D. Tests and Inspections:

1. Inspection: Verify that units and controls are properly installed, connected, and labeled, and that interconnecting wires and terminals are identified.

2. Pretesting: Align and adjust system and pretest components, wiring, and functions to verify that they comply with specified requirements. Conduct tests at varying lighting levels, including day and night scenes as applicable. Prepare video-surveillance equipment for acceptance and operational testing as follows:

a. Prepare equipment list described in "Submittals" Article.

b. Verify operation of auto-iris lenses.

c. Set back-focus of fixed focal length lenses. At focus set to infinity, simulate nighttime lighting conditions by using a dark glass filter of a density that produces a clear image. Adjust until image is in focus with and without the filter.

d. Set back-focus of zoom lenses. At focus set to infinity, simulate nighttime lighting conditions by using a dark glass filter of a density that produces a clear image. Additionally, set zoom to full wide angle and aim camera at an object 50 to 75 feet (17 to 23 m) away. Adjust until image is in focus from full wide angle to full telephoto, with the filter in place.

e. Set and name all preset positions; consult Owner's personnel.

f. Set sensitivity of motion detection.

g. Set sensitivity of motion detection.

h. Verify operation of control-station equipment.

3. Test Schedule: Schedule tests after pre-testing has been successfully completed and system has been in normal functional operation for at least 14 days. Provide a minimum of 10 days' notice of test schedule.

4. Operational Tests: Perform operational system tests to verify that system complies with specifications. Test equipment for proper operation in all functional modes.

E. Video surveillance system will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

3.4 ACCESS CONTROL SYSTEM INSTALLATION

A. Door Hardware Coordination

1. Doors shall not be locked in path of legal egress.

2. Refer to Section 08 71 00 for door hardware requirements and coordination. Contractor shall work directly with door hardware supplier to ensure the provision of specified mechanical and electronic functionality.

a. Coordinate the exact location of power supplies with the door hardware supplier prior to installation. Coordinate which power supplies shall be furnished by the door hardware supplier and installed by the Electrical Trade Contractor. Furnish and install any power supplies that are not being furnished by the door hardware supplier.

3. Request-To-Exit Activation: Contractor shall configure system such that Request-To-Exit devices and System Controllers will react quickly enough to bypass alarms before a fast-moving individual can reach and open the door. This bypass process shall be evaluated and verified by the Contractor on the fully configured and operational ACS system, prior to acceptance testing.

4. Fire Alarm Interface: Electrified locks and strikes which are part of this work and which may be locked in the path of legal exiting, shall be connected to the building Fire Alarm System in accordance with AHJ requirements such that they automatically unlock in the event of activation of the Fire Alarm System. This shall occur whether the activation is a result of a manual pull station, smoke detector or sprinkler flow switch.

a. A fire alarm "general/common alarm relay" shall be programmed at the fire alarm control panel to activate the ACS interface relays located in each Lock Power Supply cabinet.

b. This interface shall not depend on the ACS Host or Remote Controllers for its operation. Locate these interface relays electrically ahead of lock power distribution

B. Access Control and Lock Configuration

1. Secured Doors: Doors equipped with electric locks shall be individually programmed for locking and unlocking at specific times of the day. A valid credential presented at a reader will allow the portal to unlock for a programmed period of time.

2. Stairwell Door Locks

a. Stairwell doors which are locked from the stairwell side shall have the capability to be simultaneously unlocked upon a signal from the Fire Command Center, Fire Alarm Panel, or the Access Control Command Center.

b. Contractor shall provide clearly labeled switches, in the required locations, to unlock all stairwell doors simultaneously. Coordinate wall or desk mounted switch style, with the Owner and the Authority Having Jurisdiction.

c. This interface shall not depend on the ACS Host or Remote Controllers for its operation. Locate interface relays for each stairwell door electrically ahead of ACS lock control, to independently override ACS control.

3. Upon authorization by card reader or manual means, "door force" and "door held open" alarms associated with the portal shall be automatically bypassed (prevented from reporting an alarm) for a duration of time that is programmable on an individual door and individual cardholder basis.

4. The door shall re-lock immediately upon closing, after an authorized access, and the bypass duration shall be immediately truncated. A door position switch will be required at every door for this purpose. The same door position switch shall be used to sense the position of the door for "door forced" and "door held open" alarms.

5. Free Egress Authorization

a. Unless otherwise shown on the plans or described herein, the system shall detect the normal egress of a user at any individual portal and shall bypass any alarm associated with the portal for a duration of time that is programmable on an individual door and individual cardholder basis.

b. Timing shall be independently programmed for each portal during the initial enrollment process. This function allows extended timing for disabled persons to pass through a portal.

c. The timing function shall automatically truncate after an adjustable period (0 - 4 seconds) after a portal is closed. This feature allows a subsequent alarm at the portal to be detected and prevents the portal from being re-opened without an authorized request.

d. "Request-to-Exit" devices shall be used to signal the system that an individual is ready to exit the secured door. Request-to-Exit devices may include but not be limited to:

1) Integral Lock Handle Signal Switches

2) Touch Bars (Electro-mechanical or electronic)

3) Push Bars (Mechanical)

4) Push Buttons

e. On doors with integral electro-mechanical locking mechanisms (strikes, electrical panic hardware, or electrical mortise locks), the mechanical action of the door hardware shall enable egress without requiring release of the electrical mechanism. The Request-to-Exit device shall not unlock the door.

f. On doors with integral electro-mechanical locking mechanisms (magnetic locks), a Request-to-Exit device may have to unlock the door, releasing the electrical mechanism for the programmed duration. Refer to the drawings and details for direction.

g. On doors with Intercom system, Contractor shall interconnect the intercom system door release button to activate the Request to Exit function and unlock the door. The door release request contact shall be connected to an input on the ACS, such that an event shall be registered into the ACS system indicating this operation.

C. Sequences: Verify each door type sequence at each door with the Owner prior to programming.

1. Doors with Door Position Switch (DPS) and Request-to-Exit (REX) devices

a. DPS and REX contacts shall be wired to ACS auxiliary input. Configure the ACS to mask the associated DPS alarm for a minimum of 45 seconds. Coordinate the required masking duration with the Owner.

b. ACS shall report a "door forced" alarm when any time the door is opened without a valid REX request. The subsequent operation of an associated REX shall not abort a "door forced" alarm already sensed by the system.

c. ACS shall report a "door-held-open" alarm after the door has been opened and the masking duration has ended.

2. Doors with Electronic Locking (EL), DPS and REX devices

a. DPS and REX contacts shall be wired to ACS auxiliary input. Configure the ACS to mask the associated DPS alarm for a minimum of 45 seconds. Coordinate the required masking duration with the Owner

b. Electronic lock shall be wired to ACS auxiliary output. Configure the ACS to mask the associated DPS alarm during timed or commanded unlock

c. Electric lock shall be locked and unlocked based on preprogrammed schedules and conditions, and by manual control from the ACS client workstations.

d. ACS shall not cause an alarm event when door is unlocked.

e. ACS shall report a "door forced" alarm when any time the door is opened without a valid REX request. The subsequent operation of an associated REX shall not abort a "door forced" alarm already sensed by the system.

f. ACS shall report a "door-held-open" alarm after the door has been opened and the masking duration has ended during locked mode

g. REX device shall not unlock the door.

3. Doors with Card Access Control (CR), EL, DPS and REX devices

a. CR, EL, DPS and REX devices shall be wired to a door controller board.

b. Electronic lock shall be locked on command from the system at any time.

c. Electronic lock shall unlock during a preset time zone or from the system.

d. Electronic lock shall be unlocked and shall not require use of card reader during timed unlock mode.

e. ACS shall not report activity when door is unlocked.

f. During locked mode Card Reader shall unlock the door, mask DPS preventing alarm.

g. ACS shall report a "door-held-open" alarm after the door has been opened and the masking duration has ended.

h. ACS shall report a "door forced" alarm when any time the door is opened without a valid REX request. The subsequent operation of an associated REX shall not abort a "door forced" alarm already sensed by the system.

i. REX device shall not unlock door.

4. Doors with Auto-Operators, Proximity CR, EL, DPS and REX devices

a. Auto-Operator controls, CR, EL, DPS and REX devices shall be wired to a door controller board

b. Electronic lock shall be locked on command from the system at any time

c. Electronic lock shall unlock during a preset time zone

d. ACS shall not report alarm activity when door is unlocked

e. Day mode; proximity card reader shall activate the auto operator to open the door.

f. Secure mode:

1) Card reader, auto operator function, shall activate the auto door operator at all times.

2) Card Reader shall unlock the door, mask the DPS device preventing alarm and allow use of door open pushbuttons. Electronic lock to be unlocked prior to door open mechanism is engaged. The door open mechanism shall not engage until the electronic lock is unlocked. Where auto door equipment is not provided with door open pushbuttons, the door shall automatically open after unlocking.

g. ACS shall report a "door-held-open" alarm after the door has been opened and the masking duration has ended during locked mode

h. ACS shall report a "door forced" alarm when any time the door is opened without a valid REX request. The subsequent operation of an associated REX shall not abort a "door forced" alarm already sensed by the system.

i. Use of push plate shall activate the ACS REX, unlock the door and operate the auto door system

j. Door shall report a door held open time when REX (push plate or signal from the door operator) is activated, door is opened from the secured side and the system bypass time has expired during locked mode.

k. Verify interior push plate is operational in both locked and unlocked modes.

l. Verify exterior push plate is operational during unlocked mode.

m. Verify exterior push plate is non-operational until valid card read during locked mode.

n. Verify exterior push plate is operational after valid card read during locked mode.

o. Verify door can be manually opened during locked mode from secured side.

5. Doors with Auto-Operators, Dual CR, EL, DPS and REX devices

a. Auto-Operator controls, CR, EL, DPS and REX devices shall be wired to a door controller board.

b. Electric lock shall be locked on command from the system at any time.

c. Electric lock shall unlock during a preset time zone.

d. Door shall not report alarm activity when door is unlocked.

e. Secure mode

1) Card reader, auto operator function, shall activate the auto door operator at all times.

2) Card Reader shall unlock the door, mask the DPS device preventing alarm and allow use of door open pushbuttons. Electronic lock to be unlocked prior to door open mechanism is engaged. The door open mechanism shall not engage until the electronic lock is unlocked. Where auto door equipment is not provided with door open pushbuttons, the door shall automatically open after unlocking.

f. ACS shall report a "door-held-open" alarm after the door has been opened and the masking duration has ended during locked mode.

g. ACS shall report a "door forced" alarm when any time the door is opened without a valid REX request. The subsequent operation of an associated REX shall not abort a "door forced" alarm already sensed by the system.

h. Use of push plate shall activate the ACS REX, unlock the door and operate the auto door system.

i. Door shall report a door held open time when REX (push plate or signal from the door operator) is activated, door is opened from the secured side and the system bypass time has expired during locked mode.

j. Verify interior push plate is operational in both locked and unlocked modes.

k. Verify exterior push plate is operational during unlocked mode.

l. Verify exterior push plate is non-operational until valid card read during locked mode.

m. Verify exterior push plate is operational after valid card read during locked mode.

n. Verify door can be manually opened during locked mode from secured side.

6. Auto Sliding Doors shall operate similar to Doors with Auto-Operators.

a. Contractor to coordinate and confirm door hardware includes electronic remote door locking control capability.

b. Verify sliding door break a way feature is not disabled when door is in legal path of egress.

7. Roll Up Doors

a. Provide monitoring position switch with armored cable.

b. Provide keypad for local bypass of alarm with remote indicator (where shown on plans) to indicate bypass of alarm.

D. Tamper Devices

1. Terminal cabinets, equipment cabinets, enclosures, power supply cabinets, exposed wireways, and pull and junction boxes with wire connections or splices shall be equipped with tamper switches programmed to report an alarm.

2. Junction boxes requiring tamper switches that are associated with an individual alarmed device (such as a door position switch) may report to the respective device alarm point, if end-of-line resistors and the system are configured to support 6-state alarm reporting. Other cabinet and box tamper switches shall report as independent alarm points.

3. Power Supply/Battery Chargers: Power supply/battery chargers shall be connected to alarm monitoring points to provide an "Event" indication of tamper, power failures and other system troubles.

E. ACS Connectivity

1. Access Control Network: ACS Servers, Client Workstations and Controllers shall reside on the Owners' Local Area (LAN) and/or Wide Area Network (WAN) to allow global event activity and shared data interchange.

2. Provide and coordinate with Owner IT adequate network "firewalls" to maintain the security of ACS controls and information while connected to shared computer networks and transmission media. Contractor shall coordinate shared resource

usage with the Owner and develop network security schemes acceptable to the Owner to ensure the integrity of the ACS.

3. LAN Communications & Connectivity, (Integrated CPU's and Controller's)

   a. Provide LAN communications interfaces for the applicable ACS Server, Clients and Controllers to support multiple workstation and integration schemes that are part of this work.

   b. LAN Communications: Contractor shall utilize the facility's Local Area Network for ACS connections and interfaces, as shown on the drawings and described herein.

   c. Coordinate with ACS equipment and software manufacturers to provide network interface devices compatible with the established LAN/WAN network.

   d. Coordinate with the USC Information Systems Department to provide servers, ACS clients, network interface devices, bandwidth utilization, and appurtenances acceptable to the Owner.

4. Controller Communications

   a. Inter-Facility: Between facilities, buildings and controller "groups", the controller network shall be implemented utilizing the access control Owners infrastructure and connectivity, as shown on the drawings and described herein.

   b. Between controllers at an individual location, and between controllers located within the same building, the controller network may be implemented using standard, twisted, shielded copper conductors as approved by the system manufacturer. It is also acceptable for controllers to be LAN connected, regardless of location.

F. Emergency Standby Power

1. Servers, Computers, Clients, and Other 120VAC Equipment: Provide a UPS with sufficient time for power transfer where the respective buildings have an Emergency Power (EP) source. Where a building EP source is not available, provide sufficient UPS time to allow the system to run for a minimum of 1-Hour, plus (15) minutes to manage the shutdown process.

2. Low-Voltage Equipment: ACS Remote Controllers, peripheral devices and Lock Power Supplies shall also have their own 4-hour battery back-up systems.

   a. Power back-up may be in the form of direct DC battery power back-up or by 120VAC Uninterruptable Power Supplies (UPS), depending upon equipment requirements.

   b. Lock Power Supplies shall allow fail-secure locks to be operated by the system a minimum of 100 times-per-hour, during this time period. Fail-safe locks shall be maintained for the full 4-hours.

   c. Battery back-up systems may be distributed throughout the facility to provide the required emergency power to individual components.

   d. Battery back-up systems shall include battery chargers to keep storage batteries at their peak charge.

G. Card Reader Sensor

1. Install onto finished walls adjacent to door to be controlled, using concealed screws or bolts as required by wall construction and manufacturer's instruction. Where surface mount readers are required, mount on recessed conduit back box network.

Coordinate construction with general Contractor. Insure no metallic construction within 6" of the reader other than reader conduit and backbox.

2. Coordinate final placement and mounting of unit to assure placement is compatible with conduit and cable runs, device operation, and ADA requirements. Refer to Architect's interior elevations for exact placement requirements.
3. Wire electric lock "energize" circuit through card reader interface (CI) output relays to achieve activation of lock and/or shunting of local audible alarm.
4. Set energize relay adjustable timer to allow adequate time for passage through from access side location. Confer with Owner's representative and program time accordingly to allow passage but discourage tailgating.
5. Allow valid door exiting and assure detection of forced entry, by use of "request-to-exit" motion detector(s), and/or panic bar and/or mortised electric lock microswitches and programming of alarm shunt functions. REX to shunt contact only, not unlock lock. Review REX shunt timing with Owner's representative and program time accordingly to allow exiting but enforce "door forced" alarms.
6. Wire card readers to dedicated CI or FMP, using cable per manufacturer's recommendations with shield, and terminate shield on dedicated RF ground in CI or FMP enclosure, separate from 120VAC grounding.
7. Review reader mounting with General Contractor and manufacturer's instructions, paying special attention to related, adjacent construction material constraints. Review prior to reader rough-in to insure compliance with manufacturer's recommended mounting details and adequate physical blocking to insure strong and secure attachment, minimal interference with reading of proximity tags, and reliable operation of the access control system.
8. Ensure extra cable coils are not left in reader backbox where proximity readers are used.

H. Magnetic Switches

1. Install, at selected interior, perimeter doors, and roll-up doors and grilles per manufacturer's instructions and as shown on the Drawings.
2. At doors with card readers, contacts shall be installed. The contact shall be wired to the appropriate card reader field multiplex panel door open detect circuit.
3. Magnetic contact system to be fully supervised for circuit open, short, normal, and alarm. Provide required end-of-line resistors as required by Access Control System field multiplex panel manufacturer to achieve this supervision.
4. Switches to be recess/flush mounted to conceal all elements of switch and wiring wherever possible. Rolling doors and grilles only shall utilize surface mounted contacts.
5. One pair (magnetic switches) required per door leaf. See Security Drawings, for locations and details.
6. Coordinate all door, frame, or other preparation with the Construction Manager and the appropriate Contractors for general construction. Frames must be factory prepared to receive contacts by the Security System Contractor and shall be coordinated to achieve exact preparation details per manufacturer's installation instructions. Only under duress, if special conditions so require, field drill doors under the supervision of the Architect or his designee and the General Contractor.
7. Connect to field multiplex input panel module for device status signal transmission and provide one end ground of cable shield at the panel.

8. Prepare aluminum doors and frames to receive magnetic contacts to match recessed hollow metal locational details if material geometry allows.

9. Magnetic contacts shall be typically placed at the door head. Jamb mounting of contact on strike side of door is also acceptable, based on field conditions. Mounting of contacts of the hinge side is prohibited.

10. Door contact wiring shall be spliced to homerun signal wiring in door buck junction box, or through purchase of suitable length contact wire, in stainless steel sheathing, to adjacent junction box, based on field conditions associated with door contact mounting details. Purchase contacts with sufficient armor-clad wire and lead length to reach associated junction box with no intermediate splices. Mount associated junction box in or above ceiling or in wall in protected space as directed by the Architect or his designee. Wherever an accessible ceiling is provided, mount J-box above ceiling. Where drywall ceilings exist, mount J-box with flush, single gang cover at location agreed to by Owner. Use tamper proof screws where fasteners required and exposed.

11. Use suitable rubber bush compression fittings to secure miniature armor clad door contact cable entry to junction box if used, per Article 10 above.

12. Installation of contacts in special conditions at door frames shall be reviewed in the field and a sample installation of each typical condition shall be created in a working session between Construction Manager, Contractors, Engineer and the Architect or his designee, prior to final installation.

13. Silicone/RTV glue-in all flush mount where button-type contacts in hollow metal and aluminum frames are allowed. Insure adequate clearance exists between contact mounting, flanges and door and frame. Advise General Contractor, Architect and Engineer whenever inadequate clearances exist.

I. 12/24 VDC Security Device Low Voltage Power Supplies

1. Install in locations shown on Drawings at SDF's adjacent to other power supply panels, card access field multiplex panels, IDS remote input module enclosures, CCTV power supplies, etc., and connect to field multiplex panels and security devices, per floor plan notes and riser details, manufacturer recommendations and device installation specifications.

2. Hard wire into 120VAC source provided by Electrical Trade Contractor. Wire loss of "AC" power relay and low battery relay in panel enclosure and connect as separate alarm zones to intrusion detection field multiplex input panel module, using end-of-line resistors.

3. Wire from 12VDC individually fused terminals to 12VDC security device power circuits. Do not exceed 200 milliamps of connected load to any one fused circuit without the approval of the engineer. Do not exceed 50% of overall power supply power output rating.

4. Connect power supplies to CA/IDS field multiplex panels (if they require 12/24VDC input) to provide required normal and standby power for their operation. Do not connect more than 2 FMP's to any power supply, without FMP manufacturer and engineer's approval.

5. Check to assure charging circuits and power supply module is operating, producing proper "on-battery" current, proper output voltage at load, and does not exceed advertised ripple, and that power supervision relays change state. Battery back-up shall be 16 hours minimum at full load. Calculate number of 12 VDC powered devices per 12 VDC circuit, and number of circuits per power supply.

6. Assume all devices in normal state (largest current draw), and systems back up time capability present under this heaviest device load condition. Provide additional batteries in separate, externally protected, enclosure, if required.

7. Tag all 12VDC circuits with panel and 12VDC circuit number at both devices and at power supply fuse strip.

8. Wire out to 12 VDC devices using twisted, shielded, unique color-coded cable per specifications. Utilize wire gauge of adequate size to eliminate voltage drop outside of detector/device manufacturer's specification at furthest device from the panel. Increase size of wire from that shown on the drawings, based on actual run length used in the field.

9. Unit shall be UL listed, and come complete in enclosure with batteries, lock, tamper switch, loss of AC relay, low battery monitoring, fused output circuits, etc.

10. Activation of power kill switch shall initiate a "trouble" input to the IDS system field multiplex panel to indicate a protective circuit is temporarily disabled.

11. Provide an accessible power switch with a power "on" indicator between the 120V source and the 12VDC power supply load side connection.

J. System Software

1. Develop, install, and test software and databases for the complete and proper operation of systems involved. Assign software license to Owner.

K. Startup Service

1. Engage a factory-authorized service representative to supervise and assist with startup service. Complete installation and startup check according to approved procedures that were developed in "Preparation" Article and with manufacturer's written instructions.

2. Enroll and prepare badges and access cards for Owner's operators, management, and security personnel.

L. Testing

1. Prior to performing Preliminary Testing, inspection, and/or final testing procedures, Contractor shall insure the following:

a. Safe and proper operation of all components, devices or equipment, and the absence of extraneous or interfering signals.

b. Proper grounding of devices and equipment.

c. Integrity of signal and electrical system ground connections.

d. Proper powering of devices and equipment.

e. Integrity of all insulation, shield terminations and connections.

f. Integrity of soldered connections and absence of solder splatter, solder bridges, debris of any kind.

g. Proper dressing of wire and cable with labels matching as-build documents.

h. "Wire-checking" of all circuitry, including phase and continuity.

i. Preliminary targeting and setup of video camera assemblies.

j. Mechanical integrity of all support and positioning provisions, i.e.: as provided for video cameras, monitors and any other equipment.

k. Sequencing: If applicable, determine and record the sequence of energizing systems to minimize the risk of damage from improper startup.

l. Proper operation of devices and systems in accordance with specified performance requirements.

m. System is programmed for alarm reporting of each device and associated with the graphical maps.

n. Verify system programming is defined.

2. Testing Electronic Access Control Security Terminal Cabinets.

a. Test each equipment enclosure for tamper alarm.

b. Test each power supply battery for power loss alarm reporting.

c. Test each STC for 120VAC power loss alarm.

d. Test each STC for communication loss with server reporting.

3. Testing Electronic Access Control Doors

a. Doors with Door Position Switch (DPS) and Request to Exit device (REX) shall be tested for:

1) Door Forced Open alarm is generated when door is opened from unsecured side.

2) Door Held Open alarm is generated when door is held open past its preprogrammed duration after valid REX event.

3) REX shunts alarm on egress.

4) REX does not shunt forced door alarm.

b. Doors with Electrified Exit Device, DPS and REX

1) Door is locked in secure mode.

2) Door is unlocked by manual command from system workstation.

3) Door is unlocked by time zone.

4) Door Forced Open alarm is generated during secure mode only.

5) Door Held Open alarm is generated during secure mode only.

6) REX shunts alarm on egress during secure mode, for the preprogrammed duration.

7) Door relocks immediately when door closes after valid passage (does not wait for preprogrammed duration).

8) REX does not unlock door.

9) REX does not bypass forced door alarm.

10) Door relocks on time zone.

11) Door relocks during day mode on manual command from system workstation.

c. Doors with Automatic door operators

1) Door is locked in secure mode.

2) Door is unlocked by manual command from system workstation during secure mode.

3) Door is unlocked by time zone.

4) Door Forced Open alarm is generated during secure mode only.

5) Door Held Open to long alarm is generated during secure mode only.

6) REX shunts alarm on egress during secure mode.

7) REX does not unlock door.

8) Door relocks on time zone.

9) Door relocks during day mode on manual command from system workstation.

d. Doors or Gates with card reader

1) Door unlocks by use of the card reader for programmed unlock time and does not alarm when door is opened.

2) Door is locked in secure mode.

3) Door is unlocked by manual command from system workstation.

4) Door is unlocked by time zone.

5) Door Forced Open alarm is generated during secure mode.

6) Door Held Open alarm is generated during secure mode.

7) REX shunts alarm on egress during secure mode.

8) Door relocks immediately when door closes after valid passage (does not wait for preprogrammed duration).

9) REX for door does not unlock door.

10) REX for gates does not unlock gate.

11) Door relocks on time zone.

12) Door relocks during day mode on manual command from system workstation.

M. The Contractor shall maintain a complete log of all inspections and tests. Upon final completion of system tests, a copy of the log records shall be submitted as part of the as-built documentation.

3.5 INTRUSION DETECTION INSTALLATION

A. General

1. Provide lock-on device on all circuit breakers serving security equipment.

2. Main and remote security panels shall be placed only in telecommunications equipment rooms unless otherwise indicated on Drawings.

B. Motion Detectors

1. End of Line resistors shall be removed from all motion detectors.

2. Motion Detectors shall be "ON" at all times, unless noted otherwise. Main security keypad turns zone alarms Partitions on and off and reports to the monitoring station. Alarms are annunciated at all times in the Project site annunciator when the system is either in the "Armed" or "Disarmed" condition but will not report to the monitoring station when the system is in the "Disarmed" condition.

3. A 90-degree motion detector shall be installed in the corner of a room, facing away from sunlight, heating elements, HVAC outlets and any turbulent air movements. All 360-degree motion detectors shall be installed in the center of the room. All motion detectors shall be field adjusted for sensitivity and correct aim per manufacturer’s specifications.

C. Door Switches

1. Café refrigerators and Freezers: A J-box shall be installed 6" above each door switch facing inside of a room. Door switches to be installed at top of door, opposite the hinge side, 12 inches from outer edge of door. Special surface-mounted, watertight aluminum boxes shall be provided to accommodate surface mounted magnetic door switch on outside of walk-in freezer and refrigerator.

D. Main Security Controller

1. Controller shall be powered by a dedicated, unswitched 120 VAC power source. The circuit number shall be clearly identified and noted on both Electrical panel directory, record drawings, and on alarm panel.

E. LCD Keypad

1. The keypads shall be installed as shown on drawings. An additional service keypad shall be installed immediately adjacent to each Controller.

2. The location and distance from the main system panel along with the total quantity of keypads must be considered in the wiring capacitance calculations.

F. Zone Expansion Modules

1. All Expansion Modules shall be installed with 22AWG Wire across the “Tamper” terminals on the circuit board.

2. Zones shall not be doubled up without prior written approval from the Owner.

G. Batteries

1. Calculations shall be made and submitted to guarantee that the batteries in each panel location are sized for a minimum of 6 hours back-up protection for all modules powered at that location.

2. Battery installation date shall be clearly marked on each battery in a location easily read upon opening cabinet.

H. Lightning Suppression

1. The system shall include a lightning suppressor module that intercepts and directs lightning, transient, and RF interference to ground.

2. Basis of design shall be AMG1216 and ANG1217.

3.6 CLEANING

A. Clean installed items using methods and materials recommended in writing by manufacturer.

3.7 COMMISSIONING

A. Comply with requirements specified in Division 1.

B. Engage a factory-authorized service representative to supervise and assist with startup service. Complete installation and startup checks according to the approved manufacturer's written instructions.

3.8 TRAINING AND SERVICE

A. Comply with Section 26 00 01.

B. Conduct four 4-hour training sessions. Train the Owner's maintenance personnel on procedures and schedules related to start up and shutdown, troubleshooting, servicing, and preventive maintenance.

3.9 EXTRA MATERIALS

A. Furnish the following component at the end of the project to the Owner:

1. Interior Corridor Camera: Axis P3227-LV: 2
2. Interior 180 Degree Camera: Axis P3807-PVE: 2
3. Interior/Exterior 360 Degree Camera: Axis P3717-PLE: 2
4. Exterior Door Camera: Axis P3225-LVE MkII: 2
5. Exterior 180 Degree Camera: Axis Q3709-PVEL: 2
6. Exterior 4K Camera: Axis P3228-LVE: 2
7. Exterior PTZ Camera: Axis Q6128-E/Axis Q6125-LE (Covert IR): 2

End of Section

1. Section 28 31 11
ADDRESSABLE FIRE-ALARM SYSTEM

(TRADE CONTRACT REQUIRED AS PART OF SECTION 26 00 01)

PART 2 - GENERAL

2.1 GENERAL PROVISIONS

A. PUBLICLY BID TRADE CONTRACT REQUIREMENTS: As provided under Section 26 00 01 - ELECTRICAL and supplemented under the Bidding Requirements, Contract Forms, and Conditions of the Contract, and applicable parts of Division 1 - GENERAL REQUIREMENTS.

1. Work of this Trade Contract includes all individual specification sections listed in Section 26 00 01.

2.2 RELATED DOCUMENTS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.

2.3 SCOPE OF WORK

A. It is the intent of these specifications that the Contractor, Manufacturer and/or its Authorized System Integrator expeditiously furnishes and installs a system complete in every respect and ready to operate. All miscellaneous items and accessories required for such installation, whether or not each such item or accessory as shown on the plans or mentioned in these specifications, shall be furnished and installed.

B. Work covered by this section includes the furnishing of labor, equipment, and materials for installation of the fire alarm system as indicated on the drawings and specifications.

2.4 SUBMITTALS

A. General Submittal Requirements:

1. Submittals shall be approved by authorities having jurisdiction prior to submitting them to Architect.

2. Shop Drawings shall be prepared by persons with the following qualifications:

a. Trained and certified by manufacturer in fire-alarm system design.

b. NICET-certified fire-alarm technician, Level III minimum.

B. Product Data: For each type of product indicated.

C. Shop Drawings: For fire-alarm system. Include plans, elevations, sections, details, and attachments to other work.

1. Comply with recommendations in the "Documentation" Section of the "Fundamentals of Fire Alarm Systems" Chapter in NFPA 72.

2. Include voltage drop calculations for notification appliance circuits.

3. Include battery-size calculations.

4. Include performance parameters and installation details for each detector, verifying that each detector is listed for complete range of air velocity, temperature, and humidity possible when air-handling system is operating.

5. Include plans, sections, and elevations of heating, ventilating, and air-conditioning ducts, drawn to scale and coordinating installation of duct smoke detectors and access to them. Show critical dimensions that relate to placement and support of sampling tubes, detector housing, and remote status and alarm indicators. Locate detectors according to manufacturer's written recommendations.

6. Include floor plans to indicate final outlet locations showing address of each addressable device. Show size and route of cable and conduits.

D. Delegated-Design Submittal: For smoke and heat detectors indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Drawings showing the location of each smoke and heat detector, ratings of each, and installation details as needed to comply with listing conditions of the detector.

2. Design Calculations: Calculate requirements for selecting the spacing and sensitivity of detection, complying with NFPA 72.

E. Qualification Data: For qualified Installer.

F. Seismic Qualification Certificates: For fire-alarm control unit, accessories, and components, from manufacturer.

G. Field quality-control reports.

H. Operation and Maintenance Data: For fire-alarm systems and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 include the following:

1. Comply with the "Records" Section of the "Inspection, Testing and Maintenance" Chapter in NFPA 72.

2. Provide "Record of Completion Documents" according to NFPA 72 article "Permanent Records" in the "Records" Section of the "Inspection, Testing and Maintenance" Chapter.

3. Record copy of site-specific software.

4. Provide "Maintenance, Inspection and Testing Records" according to NFPA 72 article of the same name and include the following:

a. Frequency of testing of installed components.

b. Frequency of inspection of installed components.

c. Requirements and recommendations related to results of maintenance.

d. Manufacturer's user training manuals.

5. Manufacturer's required maintenance related to system warranty requirements.

6. Abbreviated operating instructions for mounting at fire-alarm control unit.

7. Copy of NFPA 25.

I. Software and Firmware Operational Documentation:

1. Software operating and upgrade manuals.

2. Program Software Backup: On magnetic media or compact disk, complete with data files.

3. Device address list.

4. Printout of software application and graphic screens.

2.5 AS-BUILT DRAWINGS

A. At the conclusion of the project, the Contractor shall provide “as built” drawings. The “as built” drawings shall be a continuation of the Contractors shop drawings as modified, augmented, and reviewed during the installation, check out and acceptance phases of the project. All drawings shall be fully dimensioned and prepared in DWG format using the latest version of AutoCAD.

B. The as-built drawings shall incorporate all updated system riser diagrams prepared in DWG format using the latest version of AutoCAD.

2.6 OPERATION AND MAINTANANCE MANUALS

A. Manuals

1. At the conclusion of the project, the contractor shall provide copies of the manuals as described herein. Each manual’s contents shall be identified on the cover. The manual shall include names, addresses, and telephone numbers of each system integrator installing equipment and systems and the nearest service representatives for each item of equipment for each system. The manuals shall have a table of contents and labeled sections. The manuals shall include all modifications made during installation, checkout, and acceptance. The manuals shall contain the following:

2. Operators Manual

a. The operator’s manual shall fully explain all procedures and instructions for the operation of the system including:

1) Computers and peripherals

2) System start up and shut down procedures

3) Use of system, command, and applications software

4) Recovery and restart procedures

5) Graphic alarm presentation

6) Use of report generator and generation of reports

7) Data entry

8) Operator commands

9) Alarm messages and reprinting formats

10) System access requirements

3. Maintenance Manual

a. The maintenance manual shall include descriptions of maintenance for all equipment including inspection, periodic preventive maintenance, fault diagnosis, and repair or replacement of defective components.

2.7 QUALITY ASSURANCE

A. Installer Qualifications: Personnel shall be trained and certified by manufacturer for installation of units required for this Project.

B. Installer Qualifications: Installation shall be by personnel certified by NICET as fire-alarm Level III technician.

C. Source Limitations for Fire-Alarm System and Components: Obtain fire-alarm system from single source from single manufacturer.

D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.8 SOFTWARE SERVICE AGREEMENT

A. Comply with UL 864.

B. Technical Support: Beginning with Substantial Completion, provide software support for two years.

C. Upgrade Service: Update software to latest version at Project completion. Install and program software upgrades that become available within two years from date of Substantial Completion. Upgrading software shall include operating system. Upgrade shall include new or revised licenses for use of software.

1. Provide 30 days' notice to Owner to allow scheduling and access to system and to allow Owner to upgrade computer equipment if necessary.

2.9 WARRANTY

A. Comply with Section 260001.

B. The Electrical Trade Contractor shall warranty that all materials furnished shall be free from defects of material for a period of one year from the date of Substantial Completion.

C. Provide a 3-year preventive maintenance plan. The plan shall include one site visit per year after the warranty period to verify that the system is working per the specifications and to proactively perform maintenance, repairs, and replacements to prevent failures before they occur.

D. Manufacturer’s Warranty

1. The manufacturer shall guarantee that the fire alarm panel technology and firmware is the latest available and shall be supported for at least 10 years.

2. The manufacturer shall guarantee that the system components shall be available for at least 10 years.

PART 3 - PRODUCTS

3.1 MANUFACTURERS

A. SimplexGrinnell - 4100ES.

B. NOTIFIER; a Honeywell company – NFS2-3030.

C. FCI – E3.

D. Or approved equal.

3.2 BASIS OF DESIGN

A. The basis of design system shall be Simplex 4100ES Digital Emergency Voice Evacuation System.

3.3 RELATED DOCUMENTS

A. The system and all associated operations shall be in accordance with the following:

1. Guidelines of the following Building Code: Massachusetts State Building Code 780 CMR, Latest edition.
2. 527 CMR 1.00: Massachusetts Comprehensive Fire Safety Code
3. NFPA 72, National Fire Alarm Code
4. NFPA 70, National Electrical Code
5. NFPA 101, Life Safety Code
6. NFPA 90A, Standard for the Installation of Air Conditioning and Ventilating Systems
7. Other applicable NFPA standards
8. Local Jurisdictional Adopted Codes and Standards
9. ADA Accessibility Guidelines

3.4 FIRE ALARM SYSTEM

A. Scope

1. This Section covers fire alarm systems, including initiating devices, notification appliances, controls, and supervisory devices.
2. Work covered by this section includes the furnishing of labor, equipment, and materials for installation of the fire alarm system as indicated on the drawings and specifications.
3. Fire alarm system specified shall have the ability to connect directly to the school's LAN and shall include this functionality. The school wishes to reduce service and maintenance costs by having this feature such that it is possible for them to obtain full analytical panel and system information. Include the ability to provide a one man walk test using smartphone technology integrated with the panel.
4. The Fire Alarm System shall consist of all necessary hardware equipment and software programming to perform the functions described herein.
5. Provide UL Listed and FM approved fire alarm Graphical Command Center computers and touchscreen monitors with full graphic layouts of the building floor plans and all fire alarm initiating and control devices where shown.
6. Provide an Internet interface in the fire alarm control panel that will send system events via email and text to selected individuals or groups of individuals.
7. Provide fire alarm and detection operations.
8. Provide control and monitoring of elevators, smoke control equipment, door hold-open devices, fire suppression systems, emergency power systems, and other equipment as indicated in the drawings and specifications.

9. Provide one-way supervised automatic voice alarm operations. The audio control at the fire alarm panel and annunciators shall be a push-to-talk microphone with select switches for all-call or selective paging per floor and on an All-Call basis. Microphone and amplifiers shall be built-in and integral to the main fire alarm panel and the annunciator panel.
10. Aside from devices connected to the main fire alarm panel, remote panels shown shall be full, local mode transponder panels. The remote transponder panels shall house all signal cards, addressable cards, amplifiers and communication network cards such that all devices in a specific area shall wire back to the specific transponder panel. Transponder panels shall then communicate all of their information back to the main panel. The entire system shall operate as a single entity.
11. Synchronize all visual devices.
12. Provide status indicators and controls for air-handling systems at the fire alarm panel.
13. The system shall be a microprocessor fire alarm system which will integrate peripheral devices onto the system via digital data communications.
14. Evacuation notification shall consist of audio evacuation tone, pre-recorded voice messaging, manual one-way paging, and visual (strobe) signaling.
15. Work in this section, as shown or specified, shall be in accordance with the related contract documents.
16. All exceptions, variances and substitutions of operating capabilities or equipment called for in these specifications shall be listed in writing and forwarded to the Engineer at the time of bid.
17. Provide automatic and manual, closed circuit, multiplex fire alarm communications according to the contract documents, wired, connected and left in first class operating condition.
18. Final connections, testing, and adjusting of the system shall be done by the system supplier. Provide NICET certified and factory trained technicians to demonstrate the system to the satisfaction and make all additional adjustments to the system operation as required by the Engineer.
19. The system design and installation shall conform to the following standards:
    a. All equipment shall be UL listed for its intended purpose.
    b. NFPA standards 70, 72, 90A, 92A, and 101.
    c. BOCA Basic Building Code - Latest Edition.
    d. Current State Building Code.
    e. The Americans with Disabilities Act (ADA).
    f. All requirements of all local authorities having jurisdiction.
20. Emergency Contact Closure Output
    a. Provide contact closure, interfaces, modules, cabling, programming, etc. to the network lighting controls system and dimming controls system to turn all zones to full output in the event of a fire alarm.
    b. Coordinate and facilitate integration and programming between the systems.

c. Provide contact closure, interfaces, modules, cabling, programming, etc. to audio-video systems in all classrooms, gymnasium, auditorium, cafeteria and all other locations where audio-video systems are provided to turn off/mute the audio-video systems in the event of a fire alarm.

d. Provide contact closure, interfaces, modules, cabling, programming, etc. to the public address (PA) system to mute the system in the event of a fire alarm.

e. A fire alarm "general/common alarm relay" shall be programmed at the fire alarm control panel to activate the access control system (ACS) interface relays located in each Lock Power Supply cabinet. The Fire Alarm Trade Contractor shall research and provide all necessary fire alarm system conduit, wire, hardware and programming to perform the required interface.

21. Provide contact closure, interfaces, modules, cabling, and programming to the kitchen Ansul system, access control system, video surveillance system, intrusion detection system, lighting control system, local sound systems in gymnasium, cafeteria and media center, etc. Provide all necessary materials, equipment and labor to facilitate interconnection with the specified systems.

B. Submit complete sets of shop drawings to include:

1. Complete building drawings showing all devices, addresses and circuits.

2. Complete point-to-point riser diagram showing all equipment and size, type and number of all conductors and devices.

3. Large scale drawings of each panel showing module placement and spare capacity allowances.

4. Address listing of all field devices shown on floor plans for coordination of LCD message text assignments. Coordinate and obtain a written approval of room names and numbers from the Architect prior to programming the fire alarm panel.

5. Original catalog data sheets for all items to assure compliance with these specifications. This equipment shall be subject to approval, and no equipment shall be ordered without prior approval.

6. Provide calculations to support the size of standby batteries, audible and visual notification circuits, amplifiers and power supplies submitted. Calculations shall demonstrate proper current draw, voltage drop, db loss, wire size considerations and spare capacity allowances.

7. Sequence of Operation, in the form of a program matrix as described in NFPA 72.

8. Confirmation that the equipment supplier will provide on-site project management and supervision during system installation, and perform system testing and instruction.

C. Conform to all UL and NFPA standards for testing of the completed installation by the equipment supplier.

D. The equipment supplier shall conduct the initial programming of the system and a complete rack/test of hardware panels prior to delivery to the installing Contractor.

E. Provide verification that all room names and numbers on the construction drawings will be coordinated with final room names and numbers as designated by the school. Update all risers and drawings accordingly for Operating & Maintenance manuals at the completion of the project. Addresses shall be programmed using final room names and numbers.

F. Provide copies of Operating & Maintenance manuals with the request for final inspection. O & M Manuals shall include the following:

1. All of the information submitted in the shop drawings.
2. As-built documentation which incorporates all modifications to the system, whether made as a field change or by a change order.
3. Include a copy of the final test report, Record of Completion and test contract.

3.5 SEQUENCE OF OPERATION

A. The operation of smoke, heat detector, sprinkler flow switch, or manual fire alarm station, shall automatically:

1. Initiate the-transmission of the alarm to the fire department via the radio masterbox.
2. Activate the audible-visual evacuation alarms on all floors throughout the building.
3. Operate prioritized outputs to release all magnetically held smoke doors and magnetically locked doors throughout the building.
4. Automatically shut down HVAC equipment as required in conformance with NFPA 90A.
5. Activate the exterior weatherproof beacon.
6. Sound alarm signal at FACP and illuminate system alarm LED. Alarm signal shall pulse until appropriate acknowledge switch is depressed which shall cause it to be silenced. System alarm LED shall remain lit until alarm condition has been corrected. Subsequent alarms shall re-initiate this sequence.
7. Display alarm condition at the FACP and annunciators.
8. Display Alarm condition on Graphical Command center(s).
9. Transmit alarm information to required recipients via Internet interface.
10. Record the alarm in the event history log and print a record of the alarm on the system printer where applicable.

B. The activation of a kitchen Ansul system shall immediately transmit an alarm signal to the fire department and initiate the sequence of operation described in A.1. to A.8. above.

C. The activation of a natural gas detector in the kitchen or boiler room shall immediately transmit an alarm signal to the fire department and initiate the sequence of operation described in A.1. to A.8. above.

D. The activation of a duct smoke detector shall immediately transmit a supervisory signal to the fire department via the radio masterbox and shut down the HVAC unit in alarm.

E. The activation of a carbon monoxide shall immediately transmit a supervisory signal to the fire department via the radio masterbox.

F. The activation of a sprinkler system pressure or tamper switch shall immediately transmit a supervisory signal to the fire department via the radio masterbox.

G. In the event of any System Trouble condition such as a device removed, loss of AC Power or wiring fault, a system Trouble condition shall occur as follows:

1. The activation of a trouble device shall immediately transmit a trouble signal to the fire department via the radio masterbox.

2. Flash a Trouble LED and sound an audible tone at the FACP and each system annunciator. Upon Acknowledgment, the LED shall light steadily and the audible shall silence. Subsequent Trouble conditions shall re initiate this sequence.

3. Visually indicate the alarm initiating device type, status and location via the LCD display located at the FACP and each system annunciator.

3.6 SYSTEM DESCRIPTION

A. General: Provide a complete, non-coded, addressable, microprocessor-based fire alarm system with initiating devices, notification appliances, and monitoring and control devices as indicated on the drawings and as specified herein.

B. Software: The fire alarm system shall allow for loading and editing instructions and operating sequences as necessary. The system shall be capable of on-site programming to accommodate system expansion and facilitate changes in operation. All software operations shall be stored in a non-volatile programmable memory within the fire alarm control unit. Loss of primary and secondary power shall not erase the instructions stored in memory. System shall be capable of storing dual configuration programs with one active and one in reserve. Panel shall be capable of full system operation during a new configuration download.

C. History Logs: The system shall provide a means to recall alarms and trouble conditions in chronological order for the purpose of recreating an event history. A separate alarm and trouble log shall be provided.

D. Recording of Events: Record all alarm, supervisory, and trouble events by means of system printer. The printout shall include the type of signal (alarm, supervisory, or trouble) the device identification, date and time of the occurrence. The printout differentiates alarm signals from all other printed indications.

E. Wiring/Signal Transmission:

1. Transmission shall be hard-wired, using separate individual circuits for each zone of alarm operation as required or addressable signal transmission, dedicated to fire alarm service only.

2. System connections shall be as follows:

a. Signaling Line Circuits: Class A.

b. Initiating device Circuits: Class A with spare capacity.

c. Notification Device Circuits: Class A with spare capacity.

d. Circuit Supervision: Circuit faults shall be indicated by a trouble signal at the FACP. Provide a distinctive indicating audible tone and alphanumeric annunciation.

e. Survivability: Level 0.

F. Remote Access:

1. FACP shall have the capability for remote access via the FACP LAN connection. Provide a LAN connector at the FACP and connect to the school local area network via data jack in the same room as FACP.

2. A personal computer or technician's laptop, configured with terminal emulation software shall have the ability to access the FACP for diagnostics, maintenance reporting and information gathering.

3. FACP shall include the capability to provide Remote Access through a listed Internet Interface via a standard web browser user interface.

G. Required Functions: The following are required system functions and operating features:

1. Priority of Signals: Alarm events have highest priority. Subsequent alarm events are queued in the order received and do not affect existing alarm conditions. Priority Two, Supervisory and Trouble events have second-, third-, and fourth-level priority respectively. Signals of a higher-level priority take precedence over signals of lower priority even though the lower-priority condition occurred first. Annunciate all events regardless of priority or order received.

2. Non-interfering: An event on one device does not prevent the receipt of signals from any other device. All devices are manually resettable from the FACP after the initiating device or devices are restored to normal. The activation of an addressable device does not prevent the receipt of signals from subsequent activations.

3. Transmission to Remote Central Station: Automatically route alarm, supervisory, and trouble signals to a remote central station service transmitter.

4. Annunciation: Operation of alarm and supervisory initiating devices shall be annunciated at the FACP and the remote annunciator, indicating the location and type of device.

5. General Alarm: A system general alarm shall include:

a. Indication of alarm condition at the FACP and annunciator(s).

b. Identification of the device or zone that is the source of the alarm at the FACP.

c. Operation of audible and visible notification devices throughout the building until silenced at FACP.

d. Closing doors normally held open by magnetic door holders.

e. Unlocking designated doors.

f. Shutting down supply and return fans serving zone where alarm is initiated.

g. Closing smoke dampers on system serving zone where alarm is initiated (if shown).

h. Notifying the local fire department.

i. Initiation of elevator recall in accordance with ASME/ANSI A17.1, when specified detectors or sensors are activated.

H. Supervisory Operations: Upon activation of a supervisory device such as fire pump power failure, low air pressure switch, and tamper switch, the system shall operate as follows:

1. Activate the system supervisory service audible signal and illuminate the LED at the control unit and the graphic annunciator.

2. Pressing the Supervisory Acknowledge Key will silence the supervisory audible signal while maintaining the Supervisory LED "on" indicating off-normal condition.

3. Record the event in the FACP historical log.

4. Transmission of supervisory signal to remote central station (if connected).

5. Restoring the condition shall cause the Supervisory LED to clear and restore the system to normal.

I. Alarm Silencing: If the "Alarm Silence" button is pressed, all audible alarm signals shall cease operation.

J. System Reset

1. The "System Reset" button shall be used to return the system to its normal state. Display messages shall provide operator assurance of the sequential steps ("IN PROGRESS", "RESET COMPLETED") as they occur. The system shall verify all circuits or devices are restored prior to resetting the system to avoid the potential for re-alarming the system. The display message shall indicate "ALARM PRESENT, SYSTEM RESET ABORTED."

2. Should an alarm condition continue, the system will remain in an alarmed state.

K. A manual evacuation (drill) switch shall be provided to operate the notification appliances without causing other control circuits to be activated.

L. WALKTEST: The system shall have the capacity of 8 programmable passcode protected one-person testing groups, such that only a portion of the system need be disabled during testing. The actuation of the "enable one-person test" program at the control unit shall activate the "One Person Testing" mode of the system as follows:

1. The city circuit connection and suppression release circuits shall be bypassed for the testing group.

2. Control relay functions associated to one of the 8 testing groups shall be bypassed.

3. The control unit shall indicate a trouble condition.

4. The alarm activation of any initiation device in the testing group shall cause the audible notification appliances to sound a voice announcement to identify the device or zone.

5. The unit shall automatically reset itself after signaling is complete.

6. Any momentary opening of an initiating or notification appliance circuit wiring shall cause the audible signals to voice announce the trouble condition.

M. Audible Alarm Notification: By voice evacuation and tone signals on loudspeakers in areas as indicated on drawings.

N. Automatic Voice Evacuation Sequence:

1. The audio alarm signal shall consist of an alarm tone for a maximum of five seconds followed by an automatic digital voice message. At the end of the voice message, the alarm tone shall resume. This sequence shall sound continuously until the "Alarm Silence" switch is activated.

2. All audio operations shall be activated by the system software so that any required future changes can be facilitated by authorized personnel without any component rewiring or hardware additions.

O. Manual Voice Paging

1. The system shall be configured to allow voice paging. Upon activation of any speaker manual control switch, the alarm tone shall be sounded over all speakers in that group.

2. The control panel operator shall be able to make announcements via the push-to-talk paging microphone over the pre-selected speakers.

3. Facility for total building paging shall be accomplished by the means of an "All Call" switch.

4. Provide a minimum of (10) custom messages including the ability to record messages in multiple languages.

P. Power Requirements

1. The control unit shall receive AC power via a dedicated fused disconnect circuit.

2. The system shall be provided with sufficient battery capacity to operate the entire system upon loss of normal AC power in a normal supervisory mode for a period of 24 hours with 15 minutes of alarm operation at the end of this period. The system shall automatically transfer to battery standby upon power failure. All battery charging and recharging operations shall be automatic.

3. All circuits requiring system-operating power shall be 24 VDC and shall be individually fused at the control unit.

4. The incoming power to the system shall be supervised so that any power failure will be indicated at the control unit. A green "power on" LED shall be displayed continuously while incoming power is present.

5. The system batteries shall be supervised so that a low battery or depleted battery condition or disconnection of the battery shall be indicated at the control unit and displayed for the specific fault type.

6. The system shall support NAC Lockout feature to prevent subsequent activation of Notification Appliance Circuits after a Depleted Battery condition occurs in order to make use of battery reserve for front panel annunciation and control.

7. The system shall support 100% of addressable devices in alarm or operated at the same time, under both primary(AC) and secondary (battery) power conditions.

8. Loss of primary power shall sound a trouble signal at the FACP. FACP shall indicate when the system is operating on an alternate power supply.

9. Provide 24 hours standby and 15 minutes alarm. Support with battery calculations and signal load calculations in submittal.

3.7 FIRE ALARM CONTROL PANEL (FACP)

A. General: Comply with UL 864, "Control Units for Fire-Protective Signaling Systems."

B. The system shall comply with the Fire Department requirements. Prior to installing and programming the system, the Electrical Trade Contractor shall coordinate all requirements with the Fire Department.

C. The system shall be capable of contact ID formatted reporting by zone as designated by the fire department.

D. The following FACP hardware shall be provided:

1. Power Limited base panel with red cabinet and door, 120 VAC input power.

2. 2,000 point capacity where (1) point equals (1) monitor (input) or (1) control (output).

3. 2,000 points of Network Annunciation at FACP Display when applied as a Network Node.

4. 2000 points of annunciation where one (1) point of annunciation equals:

a. 1 LED driver output on a graphic driver or 1 switch input on a graphic switch input module.

b. 1 LED on panel or 1 switch on panel.

5. From all battery charging circuits in the system provide battery voltage and ammeter readouts on the FCP LCD Display.

6. Municipal City Connection: Radio Masterbox.

7. One Auxiliary electronically resetable fused 2A @24VDC Output, with programmable disconnect operation for 4-wire detector reset.

8. One Auxiliary Relay, SPDT 2A @32VDC, programmable as a trouble relay, either as normally energized or de-energized, or as an auxiliary control.

9. Where required provide Intelligent Remote Battery Charger for charging up to 110Ah batteries.

10. Power Supplies with integral intelligent Notification Appliance Circuit Class A for system expansion.

11. Four (4) form "C" Auxiliary Relay Circuits (Form C contacts rated 2A @ 24VDC, resistive), operation is programmable for trouble, alarm, supervisory of other fire response functions. Relays shall be capable of switching up to ½ A @ 120VAC, inductive.

12. The FACP shall support (6) RS-232-C ports and one service port.

13. Remote Unit Interface: supervised serial communication channel for control and monitoring of remotely located annunciators and I/O panels.

14. Programmable Digital Dialer (DACT) for either Common Event Reporting or per Point Reporting. The digital dialer shall be a UL-listed device approved by the authority having jurisdiction which transmits coded point identification to the municipal DDI-7 receiver and shall report secondary to a reversing polarity connection.

15. Service Port Modem for dial in passcode access to all fire control panel information.

E. Cabinet: Lockable steel enclosure. Arrange unit so all operations required for testing or for normal care and maintenance of the system are performed from the front of the enclosure. If more than a single unit is required to form a complete control unit, provide exactly matching modular unit enclosures.

F. Display and System Controls: Display screen shall be a minimum resolution of 320 x 240 dot matrix (QVGA) and an active area of 4.53”w x 3.4”h displaying up to 854 characters using a standard ASCII character font to indicate alarm, supervisory, and component status messages and shall include a keypad for use in entering and executing control commands.

G. Internet Interface: Provide an Internet Interface to allow investigation of fire alarm control panel status using the familiar interface of an Internet browser.

1. Interface shall provide single user access for up to 20 different user accounts and be UL listed to Standard 864.

2. Selected status changes shall be able to be e-mailed automatically or through an established schedule. Information shall be alarm, supervisory, trouble or sensor service and status reports.

3. Compatible cell phones or personal hand held devices shall be able to receive direct e-mail messages or messages forwarded from a user account.

H. Voice Alarm: Provide an emergency communication system, integral with the FACP, including voice alarm system components, microphones, amplifiers, and tone generators. Features include:

1. Amplifiers comply with UL 1711, "Amplifiers for Fire Protective Signaling Systems." Amplifiers shall provide an onboard local mode temporal coded horn tone as a default backup tone. Test switches on the amplifier shall be provided to test and observe amplifier backup switchover. Each amplifier shall communicate to the host panel amplifier and NAC circuit voltage and current levels for display on the user interface.

2. All announcements are made over dedicated, supervised communication lines. All risers shall support Class A wiring for each audio channel.

3. Eight channel digitally multiplexed audio for systems that require more than two channels of simultaneous audio. Up to 8 channels of audio shall be multiplexed on either a style 4 or style 7 twisted pair.

4. Emergency voice communication audio controller module shall provide up to 8 minutes of message memory for digitally stored messages.

5. Status annunciator indicating the status of the various voice alarm speaker zones and the status of fire fighter telephone two-way communication zones.

6. System shall also support non-alarm audio (such as background music or paging) circuitry through the use of constant supervision modules.

I. Distributed Module Operation: FACP shall be capable of allowing remote location of the following modules; interface of such modules shall be through Class A supervised serial communications channel (SLC):

1. Amplifiers, voice and telephone control circuits

2. Addressable Signaling Line Circuits

3. Initiating Device Circuits

4. Notification Appliance Circuits

5. Auxiliary Control Circuits

6. Graphic Annunciator LED/Switch Control Modules

J. E-Mail Notifications/Pager Interface

1. Include hardware based upon SafeLinc feature in FACP which will provide:

a. Ability for facilities manager to log into fire alarm system to access system information

b. E-mail notification pertaining to system status changes

c. Interface to pagers for alarm, supervisory and trouble situations

K. Emergency Power Supply

1. General: Components include battery, charger, and an automatic transfer switch.

2. Battery: Sealed lead-acid type. Provide sufficient capacity to operate the complete alarm system in normal or supervisory (non-alarm) mode for a period of 24 hours. Following this period of operation on battery power, the battery shall have sufficient

capacity to operate all components of the system, including all notification appliances in alarm or supervisory mode for a period of 15 minutes.

3.8 GRAPHICAL COMMAND CENTER (AT REMOTE FACP LOCATIONS)

A. Provide a UL and FM approved Graphical Command center in a fire alarm locked panel enclosure which shall match the other fire alarm panels provided for the project and be an all-in-one package providing a touchscreen computer, monitor, hard drive, and required input/output connections in single assembly. Computer shall be pre-installed with Windows 10 Enterprise 64 Bit software and configured with RAID 1 mirroring. The all-in-one computer shall also be available for desktop applications. Functions shall include:

1. Connection to the Simplex fire alarm Network as a node allowing access to remote panel activity status, and for a Mass Notification System event or a fire alarm event, can take control of remote panel activity over the fire alarm network.
2. Available TCP/IP, LAN/WAN connections; up to 20 remote clients can be connected to the server for multiple remote users; with dedicated and listed Fire Alarm LAN equipment, listed remote clients can have control access.
3. Supports standard fire service annunciation icons to provide firefighter and first responders with critical fire response information.
4. Custom alarm and system messages guide emergency responders with important information.
5. Color graphical annunciation and control capacity for up to 100,000 points
6. Floatable and dockable windows allows windows to either be fixed (docked) or floatable.
7. Extensive historical logging; up to 500,000 events with operator notations.
8. Password Security supports 8 to 16 alphanumeric passwords with configurable lockout.
9. Optional interface to Digital Alarm Communicator Receiver (DACR) integrates multiple systems onto a single Incident Commander.
10. Backup Utility can be configured to automatically backup specified directories including TSW job data to the secondary hard drive. The backup utility is available to systems that do not use RAID.
11. Multiple password controlled operator levels.
12. 3rd Party Interface open-architecture solution provides enhanced information access for advanced users.
13. Available optional connections for printers or other compatible systems.
14. Dual monitor support allows the Alarm List Window to be on one monitor and the Graphics Window on the other.
15. Operating Systems; Server and clients shall be compatible with Windows 7 & 10 Professional or Enterprise, Clients also compatible with Windows 7 Home Premium and Windows 10 Home (32-bit and 64-bit for all options).
16. The command center shall have a mobile client capability allowing compatible iOS and Android devices to access system information.
17. Export to XML feature shall allow data to be easily exported for report generation and customization.

18. Test Mode allows unobtrusive testing of selective devices without nuisance interruptions.

19. Node Name allows a description of the specific building or area associated with a point in views and report*s.*

20. Vector information to supervised remote clients; select by point, event category, panel, or custom list.

21. System shall have email generation capability to send updates to individuals or to distribution lists with selectable content.

B. Graphic screens. Graphical customized floor plans showing initiating devices and all control functions shall be provided. Icons can be added to identify the location and type of the device of interest and the graphics control toolbar (located at the top of the graphic) can be used to pan and zoom for more precise detail. Programmable coverage zones can be added with selectable area and zoom level. A fixed area site plan (key plan) with action buttons and screen locator shall be included. Pan and zoom are tracked by a green rectangle in the key plan.

1. Graphic screens shall allow for pan-and –zoom capability for precise navigation.

2. Custom Banner and Main Screen Background. A custom banner shall be provided with a bitmap area of 2250 x 68 pixels. The main screen background can be customized with a bitmap of up to 1000 x 525 pixels.

3. Action Messages. In addition to screen text or graphic information, the operator shall be presented with specific action messages that provide emergency response information and directions. These action messages are easily field edited for local requirements. The fire alarm system installer shall work with the owner to create these messages.

4. Auto-Jump to Graphics or Alarm List. System shall allow a user to select whether activity should cause a jump to a list format or to the associated graphic screen.

5. Supported Graphics Formats:

a. DWG Import Formats: AutoCAD R9, 10, 11-12, 13,14, 2000-2002, 2004-2006, 2007-2009, 2010-2011.

b. DXF Import Formats: AutoCAD R14 and 2000

c. Export Formats: AutoCAD 2000 DWG/DXF format (allows editing in AutoCAD 2000 or later)

d. Import drawing files: DWG, WGS, IMS/GCC DOCfiles, WMF, BMP, GIF, and JPG

C. Network Annunciation**.** The graphical command center shall provide annunciation, status display, and control for Simplex fire alarm networks using a personal computer based graphical interface with a high resolution, color display. Response buttons with realistic icons provide control switches specific to the operation being performed.

D. Network Diagnostics**.** Automatic, built-in diagnostics are available to provide graphical views of Network topology and Network status. Missing communications links due to wiring breaks or shorts as well as inactive network nodes are indicated clearly to guide in returning the system to normal. Information screens are available to provide detail about each specific network node. Network level functions such as timekeeper node and monitor node are indicated as well as identification of the node being used for the diagnostic.

E. Remote Clients. For remote viewing of the graphical command information, remote clients shall be available and connected using TCP/IP LAN/WAN Ethernet communications.

F. Seismic Certification. The graphical commander shall be seismic tested and certified to IBC and CBC standards as well as to ASCE 7categories A-F.

3.9 REMOTE INFOALARM ANNUNCIATOR (ADMINISTRATIVE AREA)

A. Provide remote Infoalarm annunciator shall provide a large display with extended information content, dual language support including 2-byte character languages, and an intuitive control key interface to allow for the following:

1. Display screen shall be a minimum resolution of 320 x 240 dot matrix (QVGA) and an active area of 4.53” w x 3.4” h displaying up to 854 characters using a standard ASCII character font.

2. “Activity in System” primary display choices include: First and Most Recent, First 5 and Most Recent, First 8, Site Plan with activity status icons, General Alarm, or Direct to List; selectable individually by event type.

3. System reports are easily viewed; logs can be read with minimal scrolling required.

4. Up to six “softkeys” per screen provide functions that vary with the particular screen information aiding operators to determine how to proceed.

5. Up to 10 InfoAlarm annunciator shall be supported per control panel; able to allow one InfoAlarm annunciator to take-control and to designate access levels for interfaces not in-control; LEDs can be programmed for in-control status indications.

6. Menu-driven format conveniently prompts operators for the next action required.

7. Key controls are provided to select the highlighted entry, load next screen of information, or jump to top or bottom of activity lists.

8. Direct point callup displays individual points alphabetically and then homes in on the logical choice as more point information is entered.

9. A Site Plan bitmap can be displayed for reference; icons can be added to indicate system status.

10. Up to 50 custom point detail messages can be generated.

11. Date formats are either MM/DD/YY or DD/MM/YY.

12. Time formats are either 24 hour or 12 hour with AM/PM.

13. System Normal screen supports a gray scale bitmap (watermark) for location name, company logo, or site plan.

3.10 ISOLATION MODULES

A. Provide isolation modules to subdivide each signaling line circuit into groups of not more than 25 addressable devices between adjacent isolation modules.

3.11 ADDRESSABLE MANUAL PULL STATIONS

A. Description: Addressable double-action type, red LEXAN, with molded, raised-letter operating instructions of contrasting color. Station will mechanically latch upon operation and remain so until manually reset by opening with a key common with the control units.

B. Protective Shield: Provide a tamperproof, clear LEXAN shield and red frame that easily fits over manual pull stations. When shield is lifted to gain access to the station, a battery

powered piercing warning horn shall be activated. The horn shall be silenced by lowering and realigning the shield. The horn shall provide 85dB at 10 feet and shall be powered by a 9 VDC battery.

3.12 SMOKE SENSORS

A. General: Comply with UL 268, "Smoke Detectors for Fire Protective Signaling Systems." Include the following features:

1. Factory Nameplate: Serial number and type identification.

2. Operating Voltage: 24 VDC, nominal.

3. Self-Restoring: Detectors do not require resetting or readjustment after actuation to restore normal operation.

4. Plug-In Arrangement: Sensor and associated electronic components are mounted in a module that connects to a fixed base with a twist-locking plug connection. Base shall provide break-off plastic tab that can be removed to engage the head/base locking mechanism. No special tools shall be required to remove head once it has been locked. Removal of the detector head shall interrupt the supervisory circuit of the fire alarm detection loop and cause a trouble signal at the control unit.

5. Each sensor base shall contain an LED that will flash each time it is scanned by the Control Unit (once every 4 seconds). In alarm condition, the sensor base LED shall be on steady.

6. Each sensor base shall contain a magnetically actuated test switch to provide for easy alarm testing at the sensor location.

7. Each sensor shall be scanned by the Control Unit for its type identification to prevent inadvertent substitution of another sensor type. Upon detection of a "wrong device", the control unit shall operate with the installed device at the default alarm settings for that sensor; 2.5% obscuration for photoelectric sensor, 135-deg F and 15-deg F rate-of-rise for the heat sensor, but shall indicate a "Wrong Device" trouble condition.

8. The sensor's electronics shall be immune from false alarms caused by EMI and RFI.

9. Sensors include a communication transmitter and receiver in the mounting base having a unique identification and capability for status reporting to the FACP. Sensor address shall be located in base to eliminate false addressing when replacing sensors.

10. Panel shall have the ability to detect a sensor head that has been moved to another location.

B. Type: Smoke sensors shall be of the photoelectric type.

C. Bases: Provide standard bases but also provide isolator bases every 25 devices.

3.13 BEAM DETECTORS

A. Photoelectric projected beam detectors shall be individually addressable and consist of separate transmitter and receiver units capable of long-range coverage of up to 350 feet.

B. Beam detectors shall include alarm and trouble dry auxiliary contacts, and normal, alarm and trouble LED status indicators. Beam detectors shall include internal bore sights, automatic calibration, six sensitivity settings, automatic compensation for temperature and

lens contamination, and a trouble indication upon either a total obscuration or an obscuration of 50 percent of the alarm set point.

C. Beam detectors shall be suitable for four wire operation utilizing 24-volt DC power from the panel, and resettable by actuating the panel reset pushbutton.

3.14 DUCT SMOKE SENSOR

A. Photoelectric type, with sampling tube of design and dimensions as recommended by the manufacturer for the specific duct size and installation conditions where applied. Sensor shall include relays as required for fan shutdown.

B. Environmental compensation, programmable sensitivity settings, status testing, and monitoring of sensor dirt accumulation for the duct sensor shall be provided by the FACP.

C. The Duct Housing shall provide a supervised relay driver circuit for driving up to 15 relays with a single "Form C" contact rated at 7A@ 28VDC or 10A@ 120VAC. This auxiliary relay output shall be fully programmable. Relay shall be mounted within 3 feet of HVAC control circuit.

D. Duct Housing shall provide a relay control trouble indicator Yellow LED.

E. Compact Duct Housing shall have a transparent cover to monitor for the presence of smoke. Cover shall secure to housing by means of four (4) captive fastening screws.

F. Duct Housing shall provide two (2) Test Ports for measuring airflow and for testing. These ports will allow aerosol injection in order to test the activation of the duct smoke sensor.

G. Duct Housing shall provide a magnetic test area and Red sensor status LED.

H. For maintenance purposes, it shall be possible to clean the duct housing sampling tubes by accessing them through the duct housing front cover.

I. Each duct sensor shall have a Remote Test Station with an alarm LED and test switch.

J. Include remote test station and test tubes with each duct smoke detector.

K. Exterior Enclosure: A NEMA 4X weatherproof duct housing enclosure shall be provided for the circulation of conditioned air around the addressable duct sensor housing to maintain the sensor housing at its rated temperature range when the duct detector is mounted on the exterior of the building. The housing shall be UL Listed to Standard 268A.

L. Sequence of operation:

1. Upon sensing smoke, the duct smoke detector shall stop the fan(s) and de-energize controls through a direct circuit normally closed (NC) interlock contacts.

2. A set of normally open (NO) contacts will close, to signal the fire alarm system to initiate a supervisory alarm. The fire alarm system will report the alarm to the fire department via the radio masterbox.

3. A second set of NO contacts shall close and signal the building management system (BMS).

3.15 HEAT SENSORS

A. Thermal Sensor: Combination fixed-temperature and rate-of-rise unit with plug-in base and alarm indication lamp; 135-deg F fixed-temperature setting except as indicated.

B. Thermal sensor shall be of the epoxy encapsulated electronic design. It shall be thermistor-based, rate-compensated, self-restoring and shall not be affected by thermal lag.

C. Sensor fixed temperature sensing shall be independent of rate-of-rise sensing and] programmable to operate at 135-deg F or 155-deg F. Sensor rate-of-rise temperature detection shall be selectable at the FACP for either 15-deg F or 20-deg F per minute.

D. Sensor shall have the capability to be programmed as a utility monitoring device to monitor for temperature extremes in the range from 32-deg F to 155-deg F.

3.16 ADDRESSABLE CARBON MONOXIDE (CO) SENSOR

A. Detectors shall be electro-mechanical suitable for ceiling or wall mount.

B. Unit shall have Dual LED's. A green LED shall indicate normal operation, the red LED shall indicate alarm. Detector alarm and trouble conditions shall be reported to the fire alarm panel.

C. An internal 85dB sounder shall activate with a temporal 4 pattern to indicate alarm and also activates once per minute to signal end of CO sensor life.

D. Unit shall be UL listed to Standard 2075.

3.17 DUCT CARBON MONOXIDE (CO) SENSOR

A. Provide with sampling tube of design and dimensions as recommended by the manufacturer for the specific duct size and installation conditions where applied. Sensor to include relay as required for fan shutdown.

B. Environmental compensation, programmable sensitivity settings, status testing, and monitoring of sensor dirt accumulation for the duct sensor shall be provided by the FACP.

C. The Duct Housing shall provide a supervised relay driver circuit for driving up to 15 relays with a single "Form C" contact rated at 7A@ 28VDC or 10A@ 120VAC. This auxiliary relay output shall be fully programmable. Relay shall be mounted within 3 feet of HVAC control circuit.

D. Duct Housing shall provide a relay control trouble indicator Yellow LED.

E. Duct Housing shall provide two (2) Test Ports for measuring airflow and for testing.

F. Duct Housing shall provide a magnetic test area and Red sensor status LED.

G. For maintenance purposes, it shall be possible to clean the duct housing sampling tubes by accessing them through the duct housing front cover.

H. Each duct sensor shall have a Remote Test Station with an alarm LED and test switch.

I. A NEMA 4X weatherproof duct housing enclosure shall provide for the circulation of conditioned air around the internally mounted addressable duct sensor housing to maintain the sensor housing at its rated temperature range. The housing shall be UL Listed to Standard 268A.

J. Remote test switches with indicator LEDs shall be installed at the fire alarm control panel and located within the fire alarm control panel or in an enclosure similar to the fire alarm control panel next to the panel.

K. Indicator LEDs will be located on the ceiling or on the wall below the duct smoke detector so that it is visible to the responder.

L. This Trade Contractor shall verify the locations of the remote test switches and the LED indicator lights with the fire department prior to installation.

M. Exterior Enclosure: A NEMA 4X weatherproof duct housing enclosure shall be provided for the circulation of conditioned air around the addressable duct sensor housing to maintain the sensor housing at its rated temperature range when the duct detector is mounted on the exterior of the building. The housing shall be UL Listed to Standard 268A.

3.18 ADDRESSABLE CIRCUIT INTERFACE MODULES

A. Addressable Circuit Interface Modules: Arrange to monitor one or more system components that are not otherwise equipped for addressable communication. Modules shall be used for monitoring of waterflow, valve tamper, non-addressable devices, and for control of evacuation indicating appliances and AHU systems.

B. Addressable Circuit Interface Modules will be capable of mounting in a standard electric outlet box. Modules will include cover plates to allow surface or flush mounting. Modules will receive their operating power from the signaling line or a separate two wire pair running from an appropriate power supply as required.

C. There shall be the following types of modules:

1. Type 1: Monitor Circuit Interface Module

2. Type 2: Line Powered Control Circuit Interface Module

a. This module shall provide control and status tracking of a Form "C" contact. The two-wire signaling line circuit shall supply power and communications to the module.

3. All Circuit Interface Modules shall be supervised and uniquely identified by the control unit. Module identification shall be transmitted to the control unit for processing according to the program instructions. Modules shall have an on-board LED to provide an indication that the module is powered and communicating with the FACP. The LEDs shall provide a troubleshooting aid since the LED blinks on poll whenever the peripheral is powered and communicating.

3.19 MAGNETIC DOOR HOLDERS

A. Description: Units shall be listed to UL 228. Units are equipped for wall or floor mounting as indicated and are complete with matching door plate. Unit shall operate from a 120VAC, a 24VAC or a 24VDC source, and develops a minimum of 25 lbs. holding force.

3.20 STANDARD ALARM NOTIFICATION APPLIANCES

A. Visible/Only: Strobe shall be listed to UL 1971. The V/O shall consist of a xenon flash tube and associated lens/reflector system. The V/O enclosure shall mount directly to standard single gang, double gang or 4" square electrical box, without the use of special adapters or trim rings. V/O appliances shall be provided with different minimum flash intensities of 15cd, 75cd and 110cd. Provide a label inside the strobe lens to indicate the listed candela rating of the specific Visible/Only appliance.

B. Speaker/Visible: Combination Speaker/Visible (S/V) units combine the speaker and visible functions into a common housing. The S/V shall be listed to UL 1971 and UL 1480.

1. Twisted/shielded wire is required for speaker connections on a standard 25VRMS or 70.7VRMS NAC using and UTP conductors, having a minimum of 3 twists per foot is required for addressable strobe connections.
2. The following taps are available: 0.25W, 0.50W, 1.0W and 2.0W. At the 1.0W tap, the speaker has minimum UL rated sound pressure level of 84dBA at 10 feet.
3. The S/V shall have a frequency response of 400 to 4000 Hz for Fire Alarm and 125 to 12kHz for General Signaling.
4. The S/V installs directly to a 4" square, 1 1/2 in. deep electrical box with 1 1/2" extension.

C. All alarm notification appliances shall be white in color.

3.21 REMOTE ALARM INDICATORS

A. Furnish and install remote alarm indicators and permanently attached placard for all detectors that are installed behind locked doors and/or as indicated on the drawings.

B. The location of the detector and the area protected by the detector shall be prominently indicated at the remote alarm indicator by a permanently attached placard.

C. Remote alarm or supervisory indicators shall be installed in an accessible location and shall be clearly labeled to indicate both their function and any device or equipment associated with each detector.

3.22 FIRE ACCORDION DOOR

A. A switch is required to provide manual control of the fire accordion door. The switch is required to have “open – auto – close” positions labeled.

B. Annunciation

1. Status of the fire accordion door and components is required to be indicated on the Fire Alarm Control Panel. Status shall be indicated using LED. Acceptable LED colors are red, yellow, and green.

C. LED Operation

1. LED Legend: A legend of LED shall be provided. The legend LED shall continuously be lit. The legend shall indicate the following colors and labels:
   a. Red LED – Smoke Mode
   b. Yellow LED – Trouble
   c. Green LED – Normal
2. Red Only: Shall be illuminated when the FACP or the associated manual switch is activating the smoke control zone and/or components and all components required to activate have been monitored to be in the required position/operation for that scenario.
3. Green Only: Shall be illuminated to indicate normal mode when there is no initiation by the FACP or associated manual switch for the smoke zone and components and all required status for smoke control components indicate that the components are ready for operation.

4. Yellow Only: There shall be no situation where only a yellow LED is illuminated. The yellow LED shall only illuminate in conjunction with a blue LED, red LED or green LED.

5. Red and Yellow: A combination of the red and yellow LED shall illuminate to indicate that the smoke zone and/or component is being initiated by the FACP or the associated manual switch, and positive status indicating proper configuration of smoke zone components has not been received.

6. Green and Yellow: A combination of green and yellow LED shall illuminate when a smoke zone is not initiated, and the smoke control components do not report normal operating status. For instance, this may occur when a damper is closed due to loss of power, or there is a loss of power required for a smoke control fan.

7. Blue and Yellow: A combination of the blue and yellow LED shall illuminate to indicate that an auxiliary smoke control sequence is being initiated by the FACP or the associated manual switch, and positive status indicating proper configuration of components for the ancillary smoke control mode has not been received.

8. Sequence of Operations

   a. Smoke control sequences shall be programmed such that operation of fans and dampers associated with the smoke control system does not result in physical damage in any smoke control system components.

3.23 TEST TOOL

A. In order to expedite the installation process and ensure proper install of devices, include a manufacturer's certified technician test tool to be supplied to the installing Contractor that will identify opens and shorts in the addressable loop. The test tool shall also indicate errors in addressing of specific devices as well as condition of devices in the loop.

3.24 SAFE BOX

A. Furnish and install three (2) Supra safe boxes per the Fire Department requirements:

   1. Outside vestibule B001.

   2. Outside rear vestibule B100.1

B. Features:

   1. Box and lock are UL® Listed.

   2. Weather resistant door gasket.

   3. Hinged door allows single-handed operation.

   4. Colors: Black, Dark Bronze or Aluminum. Verify with the Architect.

   5. Coordinate mounting (surface or recessed) and color with the Architect.

   6. Provide monitor module to supervise the Knox box against tampering.

3.25 ALARM REPORTING

A. The installation shall comply with the requirements of the Fire Department. Refer to the rules and regulations provided by the fire department.

B. All master boxes shall be an AES 7788F radio transmitter type.

C. Master boxes shall be installed in accordance with NFPA 1221.

D. The radio master fire alarm box connected to the fire protection system must be compatible with the receiving equipment of the fire department. The Contractor shall coordinate the requirements with the fire department.

E. The master box shall be mounted on the inside of the building at the main entrance, next to the fire alarm panel or annunciator. Coordinate exact location with fire department prior to installation.

F. The Contractor shall provide all necessary connections, materials, contacts, relay cards, etc. in the existing fire alarm panel to facilitate interconnection to the masterbox.

3.26 EXTERIOR BEACON

A. Basis of design shall be Edwards Signaling 3000SD-EK Series 150,000 candle power strobe.

1. Red for fire alarm
2. White or blue for sprinkler flow alarm (if required)

PART 4 - EXECUTION

4.1 EQUIPMENT INSTALLATION

A. Wire notification Class A.

B. Wire initiation circuits Class A.

C. Smoke or Heat Detector Spacing:

1. Smooth ceiling spacing shall not exceed the rating of the detector.
2. Spacing of heat detectors shall be determined based on guidelines and recommendations in NFPA 72.

D. HVAC: Locate detectors not closer than 3 feet from air-supply diffuser or return-air opening.

E. Duct Smoke Detectors: Comply with NFPA 72 and NFPA 90A. Install sampling tubes so they extend the full width of the duct.

1. Photoelectric type, with sampling tube of design and dimensions as recommended by the manufacturer for the specific duct size and installation conditions where applied.
2. Duct smoke detectors listed for use in the air distribution systems shall be located downstream of the air filters and ahead of the branch connections in both the supply and return side of air systems of greater than 2000-cfm capacity.
3. In air systems having a capacity of over 15,000-cfm, the duct smoke detectors shall be located in both the supply and return side of the system.
4. In air system having a capacity of over 15,000-cfm and serving more than one story, an additional duct smoke detector shall be located at each story prior to the connection to a common return and prior to any circulation or fresh air inlet connection.
5. LED indicators marking the location of the detector shall be mounted directly below the device in areas where detectors are accessible via ceiling tiles. In areas where

detectors are not accessible through ceiling tiles, the fire department shall dictate the location of remote test switches and LED's. The Contractor shall coordinate the location of the remote test switches and the LED indicator lights with the fire department prior to installation. The remote test switches shall be mounted at the control panel inside the cabinet or in a cabinet next to the fire alarm control panel. The control panel shall enable the duct smoke detectors in the air handling systems to be tested from the panel. Provide wire guards for LED indicators in the gymnasium.

F. Manual Pull Stations: The manual stations shall be installed not less than 3½ ft. (42") and not more than 4½ ft. (54") above finished floor. All Manual Stations shall be in unobstructed locations. Mark the unit's address on the inside housing.

G. Smoke detectors: Mark the address and loop number on each detector's base. The location of detectors shown on the plans is schematic only. The detectors must be located according to code requirements.

H. Remote Status and Alarm Indicators: Install near each detector that is not readily visible from normal viewing position.

I. Audible/Visual Alarm-Indicating Devices: Install not less than 80 inches from the bottom of the strobe lens to the highest level of the finished floor or not less than 24" below finished ceiling, if the ceiling height is less.

J. Device Location-Indicating Lights: Locate in public space near the device they monitor.

4.2 WIRING INSTALLATION

A. Wiring within Enclosures: Separate power-limited and non-power-limited conductors as recommended by manufacturer to match existing conventions. Install conductors parallel with or at right angles to sides and back of the enclosure. Bundle, lace, and train conductors to terminal points with no excess. Connect conductors that are terminated, spliced, or interrupted in any enclosure associated with the fire alarm system to terminal blocks. Mark each terminal according to the system's wiring diagrams. Make all connections with approved crimp-on terminal spade lugs, pressure-type terminal blocks, or plug connectors.

B. Cable Taps: Use numbered terminal strips in junction, pull, and outlet boxes, cabinets, or equipment enclosures where circuit connections are made.

C. Color-Coding: Color-code fire alarm conductors differently from the normal building power wiring. Use one color-code for alarm circuit wiring and a different color-code for supervisory circuits. Color-code audible alarm-indicating circuits differently from alarm-initiating circuits. Use different colors for visible alarm-indicating devices. Paint fire alarm system junction boxes and covers red.

D. All wiring for the system shall be in accordance with Articles 760, 725, and 800 of the National Electrical Code and local electrical codes.

E. Provide complete wiring and conduit between all equipment. All devices shall be mounted upon and splices made in UL listed boxes. Wiring splices and transposing or changing of colors will not be permitted. Listed Type MC fire alarm cable may be used in lieu of conduit.

F. All junction boxes shall be painted red and labeled as 'Fire Alarm System' with decal or approved markings.

G. Fire Alarm control systems and equipment shall be connected to separate dedicated branch circuits, sized as required for proper service. Circuits shall be labeled 'FIRE ALARM'.

4.3 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals according to Division 16 Section "Electrical Identification."

B. Install instructions frame in a location visible from the FACP.

4.4 GROUNDING

A. Ground the FACP and associated circuits; comply with IEEE 1100. Install a ground wire from main service ground to the FACP.

4.5 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect test, and adjust field-assembled components and equipment installation, including connections and to assist in field testing. Report results in writing.

B. Perform the following field tests and inspections and prepare test reports:

1. Before requesting final approval of the installation, submit a written statement using the form for Record of Completion shown in NFPA 72.

2. Perform each electrical test and visual and mechanical inspection listed in NFPA 72. Certify compliance with test parameters. All tests shall be conducted under the direct supervision of a NICET technician certified under the Fire Alarm Systems program at Level III.

a. Include the existing system in tests and inspections.

b. Visual Inspection: Conduct a visual inspection before any testing. Use as-built drawings and system documentation for the inspection. Identify improperly located, damaged, or nonfunctional equipment, and correct before beginning tests.

c. Testing: Follow procedure and record results complying with requirements in NFPA 72.

3. Detectors that are outside their marked sensitivity range shall be replaced.

4. Speakers shall calculated at 1 watt each, and sound levels shall be measured and recorded in each space. All necessary adjustments shall be made to installed speakers to ensure proper sound levels and performance is achieved.

a. Test and Inspection Records: Prepare according to NFPA 72, including demonstration of sequences of operation by using the matrix-style form in provided in the approved shop drawing submittals.

4.6 TESTING AND ACCEPTANCE

A. The Contractor is responsible for giving all notices, filing all plans, obtaining all permits, fire alarm system testing and obtaining necessary approvals from authorities having jurisdiction.

B. The authority having jurisdiction, the Fire Department., requests periodic inspection of the fire alarm system during the installation period. The Contractor shall contact the Fire Dept. to schedule these inspections.

C. The Contractor shall schedule all fire alarm tests a minimum of 2 weeks in advance. Coordinate testing times with the Owner, Designers, and authorities having jurisdiction. Fire Alarm Testing will be performed before or after normal business hours or on weekends and holidays. Additional compensation will not be provided to the Contractor for non-business hours testing.

4.7 FINAL ACCEPTANCE TEST

A. This test is required for issuance of the Certificate of Occupancy by the Fire Department. The Electrical Trade Contractor shall submit to the Fire Department the following documentation prior to requesting the final fire alarm system acceptance test:

1. Affidavit from the fire alarm system designer letter certifying the system has been installed according to plans and specifications and the system is 100% operational and ready for the final testing.
2. Affidavit from the Electrical Trade Contractor letter certifying the fire alarm system has been installed according to the plans and specifications and is ready for final testing.
3. Fire alarm manufacturer completed and signed NFPA Record of Completion form.
4. Copy of the approved Fire Alarm Narrative, Matrix and English language device list.
5. Copy of the fire alarm manufacturer’s program notes and approved shop drawings.
6. Copy of the stamped fire alarm drawings (as-built drawings if available).

B. The Contractor shall schedule the final fire alarm test with the Fire Department, the Owner and other required participants.

C. Required participants at the final acceptance test to include:

1. Fire Department
2. General Contractor’s site Superintendent
3. Electrical Trade Contractor
4. Owner’s Representative
5. If the final acceptance fire alarm test is successful, the Fire Department will issue a letter of acceptance. If the fire alarm test is not successful the Contractor shall immediately provide the required changes and reschedule the fire alarm test.

4.8 TRAINING AND SERVICE

A. Comply with Section 26 00 01.

B. Conduct four 4-hour training sessions. Train the Owner’s maintenance personnel on procedures and schedules related to start up and shutdown, troubleshooting, servicing, and preventive maintenance.

C. Training shall include fire department personnel.

4.9 EXTRA MATERIALS

A. Furnish the following component at the end of the project to the Owner:

1. Pull stations and covers: 5
2. Smoke detectors: 10
3. Duct smoke detectors: 2
4. Carbon monoxide detectors: 5
5. Duct carbon monoxide detectors: 2
6. Emergency call station: 10
7. Heat detectors: 5
8. Notification appliances
    a. Multi-candela ceiling mounted audiovisual devices: 10
    b. Multi-candela ceiling mounted visual devices: 10
    c. Multi-candela wall mounted audiovisual devices: 10
    d. Multi-candela wall mounted visual devices: 10

End of Section

Section 31 10 00
SITE CLEARING

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.

1.2 DESCRIPTION OF WORK

A. Work Included: Provide labor, materials, and equipment necessary to complete the work of this Section, including but not limited to the following:

1. Protecting existing trees and vegetation to remain, including temporary fencing for trees in close proximity to construction operations.
2. Removing existing trees and vegetation indicated to be removed.
3. Clearing and grubbing.
4. Stripping and stockpiling topsoil.
5. Removing above and below grade site improvements.
6. Protection of Existing Utilities.
7. Utility Demolition as required to accommodate new construction.
8. Protection and Abandonment of Utilities.
9. Disconnecting, capping or sealing of utilities as required.

B. Alternates: Not Applicable.

C. Items to Be Installed Only: Not Applicable.

D. Items to Be Furnished Only: Not Applicable.

E. Related Work: The following items are not included in this Section and will be performed under the designated Sections:

1. Section 31 20 00 – EARTH MOVING for soil materials, excavating, backfilling, and site grading and removal of site utilities.
2. Section 31 25 00 – EROSION AND SEDIMENTATION CONTROLS for required erosion and sedimentation control measures.

1.3 DEFINITIONS

A. Topsoil: Natural or cultivated surface-soil layer containing organic matter and sand, silt, and clay particles; friable, pervious, and black or a darker shade of brown, gray, or red than underlying subsoil; reasonably free of subsoil, clay lumps, gravel, and other objects more than 2 inches in diameter; and free of subsoil and weeds, roots, toxic materials, or other nonsoil materials.

B. Tree Protection Zone: Area surrounding individual trees or groups of trees to be protected during construction and defined by the drip line of individual trees or the perimeter drip line of groups of trees, unless otherwise indicated.

1.4 MATERIAL OWNERSHIP

A. Except for stripped topsoil or other materials indicated to remain the Owner's property, cleared materials shall become Contractor's property and shall be removed from Project site.

1.5 SUBMITTALS

A. Refer to SECTION 01 33 00 – SUBMITTALS for submittal provisions and procedures.

1. Schedule indicating proposed sequence of operations for demolition work for review prior to start of work. Include coordination for shutoff, capping, and continuation of utility services as required, together with details for dust and noise protection.

a. Provide detailed sequence of demolition and removal work to ensure uninterrupted progress of Owner's on-site operations.
b. Coordinate with Owner's continuing occupation of portions of existing building, adjacent buildings, and with Owner's partial occupancy of completed portions of proposed building or additions.

2. Preconstruction survey photographs sufficiently detailed, of existing conditions of existing buildings, trees and plantings, adjoining construction, and site improvements that might be misconstrued as damage caused by site clearing.

B. Record drawings, according to Section 01 77 00 - CONTRACT CLOSEOUT identifying and accurately locating capped utilities and other subsurface structural, electrical, and mechanical conditions.

1.6 PROJECT CONDITIONS

A. Traffic: Minimize interference with adjoining roads, streets, walks, and other adjacent occupied or used facilities during site-clearing operations.

1. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from the Owner's Representative and authorities having jurisdiction.
2. Provide alternate routes around closed or obstructed traffic ways if required by authorities having jurisdiction.

B. Salvable Improvements: Carefully remove items indicated to be salvaged and store on the Owner's premises where indicated.

C. Utility Locator Service: Notify utility locator service for area where Project is located before site clearing.

D. Do not commence site clearing operations until erosion and sedimentation control measures are in place.

E. Protection of Existing Improvements: Provide protection necessary to prevent damage to existing improvements indicated to remain in place or outside of the limit of work. Protect improvements on adjoining properties and on the Owner's property.

1. Restore improvements damaged by Contractor's clearing activities to their original condition, at no additional expense to the Owner.

1.7 EXAMINATION OF SITE AND DOCUMENTS

A. It is hereby understood that the Contractor has carefully examined the site and all conditions affecting work under this Section. No claim for additional costs will be allowed because of a lack of knowledge of existing conditions as indicated in the Construction Documents, or obvious from observation of the site.

B. Plans, surveys, measurements, and dimensions under which the work is to be performed are believed to be correct, but the Contractor shall have examined them for himself during the bidding period and formed his own conclusions as to the full requirements of the work involved.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 PREPARATION

A. Protect and maintain benchmarks and survey control points from disturbance during construction.

B. Locate and clearly flag trees and vegetation to remain or to be relocated.

C. Protect existing site improvements to remain from damage during construction.

1. Restore damaged improvements to their original condition, as acceptable to the Owner's Representative.

3.2 TREE PROTECTION

A. Refer to the Landscape Architect's specifications for all tree protection requirements.

3.3 UTILITIES

A. Locate, identify, disconnect, and seal or cap off utilities indicated to be removed.

1. Arrange with utility companies to shut off indicated utilities. The Contractor is responsible for coordinating and scheduling with the authorities having jurisdiction the removal and/or abandonment of existing utilities as required to complete the work.

B. Existing Utilities: Do not interrupt utilities serving facilities occupied by the Owner's Representative or others unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated:

1. Notify the Owner's Representative not less than two days in advance of proposed utility interruptions.
2. Do not proceed with utility interruptions without the Owner's Representative's written permission.

C. Utility pipes designated to be abandoned in place shall be plugged at their ends with watertight brick masonry or cement mortar with a minimum thickness of 8 inches.

D. Utility pipes designated to be removed shall consist of the complete removal and disposal of the entire length of pipe and backfill and compaction of the void with ordinary borrow. When

the void is within the footprint of the new building, gravel borrow shall be used to backfill the void.

E. Utility structures designated to be abandoned in place shall have their cast iron castings removed and disposed, inlet and outlet pipes plugged, the bottom of the structures shall be broken, the void of the structure shall be backfilled and compacted with ordinary borrow, and the top of the structure shall be removed so that it is at least 36 inches below finished grade.

F. Utility structures designated to be removed shall consist of the removal and disposal of cast iron castings, plugging of inlet and outlet pipes, removal of the structure, and backfill and compaction of the void with ordinary borrow. When the void is within the footprint of the new building, gravel borrow shall be used to backfill the void.

3.4 CLEARING AND GRUBBING

A. Remove obstructions, trees, shrubs, grass, and other vegetation to permit installation of new construction.

1. Do not remove trees, shrubs, and other vegetation indicated to remain or to be relocated.
2. Cut minor roots and branches of trees indicated to remain in a clean and careful manner where such roots and branches obstruct installation of new construction.
3. Grind stumps and remove roots, obstructions, and debris extending to a depth of 18 inches below exposed subgrade.
4. Use only hand methods for grubbing within tree protection zone.
5. Chip removed tree branches and dispose of off-site.

B. Fill depressions caused by clearing and grubbing operations with satisfactory soil material unless further excavation or earthwork is indicated.

1. Place fill material in horizontal layers not exceeding a loose depth of 8 inches and compact each layer to a density equal to adjacent original ground.

3.5 TOPSOIL STRIPPING

A. Remove sod and grass before stripping topsoil.

B. Strip topsoil to whatever depths are encountered in a manner to prevent intermingling with underlying subsoil or other waste materials.

1. Remove subsoil and nonsoil materials from topsoil, including trash, debris, weeds, roots, and other waste materials.

C. Stockpile topsoil materials away from edge of excavations without intermixing with subsoil. Grade and shape stockpiles to drain surface water. Cover to prevent windblown dust or contamination by airborne weed seed.

1. Limit height of topsoil stockpiles to 72 inches.
2. Do not stockpile topsoil within tree protection zones.

3.6 EXCESS TOPSOIL

A. Topsoil that has been stripped and stockpiled, but is not needed after the completion of all final topsoil spreading and grassing, shall be removed and legally disposed of off-site by the Contractor per local, state, and federal standards.

3.7 SITE IMPROVEMENTS

A. Remove existing above- and below-grade improvements as indicated and as necessary to facilitate new construction.

B. Remove slabs, paving, curbs, gutters, and aggregate base as indicated.

1. Unless existing full-depth joints coincide with line of demolition, neatly saw-cut length of existing pavement to remain before removing existing pavement. Saw-cut faces vertically.
2. Paint cut ends of steel reinforcement in concrete to remain to prevent corrosion.

3.8 DISPOSAL

A. Disposal: Remove surplus soil material, unsuitable topsoil, obstructions, demolished materials, and waste materials including trash and debris, and legally dispose of them off the Owner's property.

1. Burning on site is prohibited.
2. Separate recyclable materials produced during site clearing from other nonrecyclable materials. Store or stockpile without intermixing with other materials and transport them to recycling facilities.

3.9 CLEANUP AND REPAIR

A. General: Upon completion of demolition work, remove tools, equipment, and demolished materials from site.

B. Repair demolition performed in excess of that required. Return elements of construction and surfaces to remain to condition existing prior to start operations. Repair adjacent construction or surfaces soiled or damaged by site demolition work.

End of Section

Section 31 20 00

EARTH MOVING

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.

1.2 SPECIAL INSTRUCTIONS

A. The Contractor shall become familiar with other Sections of the Specifications to determine the type and extent of work there under which affects the work of this section whether or not such work is specifically mentioned.

B. The conditions of the Order of Conditions, issues by the City of Worcester Conservation Commission for this project, shall be met by the Contractor.

1.3 DESCRIPTION OF WORK

A. Work Included: Provide labor, materials, services, and equipment, including all items incidental thereto, necessary to complete the work as specified in this Section and as shown in the drawings, including but not limited to the following:

1. Control of surface water runoff, dust control and clean up during construction.
2. Site excavation, loam striping, site preparation, shoring and bracing at the existing school, and material stockpiling was completed under the Site Enabling Bid Package #1. This work is a continuation of the site package.
3. Excavating all types of materials to limits indicated or required, including soil, rock, and other materials for new, below-grade construction and other site improvements as shown on the Drawings. All topsoil, subsoil, root balls, organic soil, existing fill, and other deleterious matter should be entirely removed from within the proposed building footprint. All topsoil, subsoil, organic material, root balls, and other deleterious material shall be entirely removed from within the paved areas. The existing fill shall be improved under the subbase of paved areas.
4. Stone and earthen material stockpiled on site from Site Enabling Bid Package #1 must be sampled and a sieve analysis performed and paid for by the Contractor. Material that does not meet gradation specifications must be amended to meet specifications. Excavation of all unsuitable material encountered below indicated subgrade elevation shall be performed as directed on the Drawings.
5. Prepare and protect subgrades as indicated on the Drawings and as specified herein. Any new fill materials for building, roadway or landscape work that cannot be taken from existing onsite stockpiles shall be quantified by the Contractor based on the survey and Drawings.
6. Excavation, covering, and backfilling of onsite soils, as required during construction.
7. Coordination of all disposal activities as required to complete the work described in this Section and as required/detailed in the contract document. The site contractor shall be responsible for the cost of legal disposal, off-site, including permitting and/or fees, of all unsuitable or surplus excavated and or stockpiled materials.

8. Coordination of material testing shall be the responsibility of the Contractor as outlined under testing requirements. All imported material tested shall be under ASTM D442 and shall be paid for by the Contractor.
9. Furnishing, from an approved borrow source or processing material onsite, fill or backfill materials for placement and compaction on site as required to complete the work of this section.
10. Furnish and supply shoring, sheeting, and support of excavations.
11. Dewatering excavations as required to construct all foundations and place all backfill "in the dry". Obtaining and maintaining all permits required for legal discharge of groundwater and run-off. The Contractor shall be responsible for control, pumping, and disposal of groundwater, precipitation or other water which accumulates in the excavation to allow all below-grade construction to be conducted in-the-dry.
12. Proof rolling trenches and excavations.
13. Excavation, bedding, backfill and compaction for:

    a. Building footings, slabs, walls, pads, bases, etc.
    b. Drainage piping, building and field subdrains, structures, etc.
    c. Electrical and utility lines, conduits, light poles, light pole feeds, transformers and other utility pads.
    d. Sanitary sewer piping.
    e. Water and fire service. Abandon and cap existing, excavation, bedding, backfill and compaction.
    f. All pads, posts, stairs, and items indicated on the drawings.
    g. Parking areas, handicap areas, ramps, curb cuts, etc.
    h. Data/communications service conduits and piping.
    i. Fill slopes and site retaining walls.
    j. All other work indicated on the drawings requiring excavation, backfill and/or compaction including but not limited to excavation and backfill for all trades inside the new building footprint.

14. Adjust all manhole and catch basin frame and grates for all utilities where grades are adjusted, and structures are to remain.
15. Coordinate with all trades for complete building systems as follows:

    a. Water service: Provide and install all excavation and backfill. Sleeve concrete as directed by the Subcontractors. Coordinate all work and comply with all the requirements of the controlling municipal agency.
    b. Electrical service: Excavation, bedding, backfill, concrete encasement, and precast light pole bases for the electric service. The conduits shall be provided and installed under Section 260000 ELECTRICAL. Electrical back charge fee as identified in the Electrical Section shall be paid by the Owner.
    c. Communications: Telephone and spare conduits shall be provided and installed by the electrical contractor. Excavation, backfill, and the concrete encasement shall be provided by the General Contractor.
    d. Gas service: Gas service pipes and appurtenances shall be provided and installed by the Gas Company. The General Contractor shall provide excavation and backfill for the gas services to the new building.
    e. Excavation, bedding, and backfill for all interior utilities, including underground electrical, foundations, and work.

16. Soil around the school, under playgrounds, play areas and plantings within the 'inner ring' of the site access drives shall be clean material with less than 20 ml/l of arsenic.

Areas where arsenic concentrations are higher must have fabric warning layer and 12 inches clean fill, or 36 inches clean fill with no fabric warning layer, or be placed under pavement section (asphalt and base course material) as indicated in the Drawings and indicated in plans and specifications prepared by the Licensed Site Professional.

17. Erosion and sedimentation control.
18. All engineering and survey work to verify existing conditions and layout the complete construction. See Section 3110 00 SITE PREPARATION.
19. Provide, operate, and maintain all temporary shoring and/or hoisting equipment and provide, maintain, and remove all staging and scaffolding, and rigging required for all work.
20. Contractor shall be responsible for notifying all affected utility companies and Digsafe before starting work.
21. Installing fencing and safety devices or controls as specified and as necessary.

B. The Work of this Section shall include performance of pre and post blasting surveys, preparation of a blast design plan and analysis, and provision of all services in accordance with requirements of 527 CMR 13.00 Explosives and the Contract Documents, for all existing building structures and utilities located within 500 feet of the Limit of Work Line (LOW) as indicated on the Drawings. The Contractor shall coordinate with the City of Worcester Fire Department to provide fire watch services before, during, and after all blasting performed under the Contract, in accordance with requirements of 527 CMR 13.00 Explosives and the Contract Documents.

C. Related Work: The following items are not included in this Section and will be performed under the designated Sections:

1. SECTION 31 10 00 – SITE CLEARING for site stripping, grubbing, stripping and stockpiling topsoil, and removal of above- and below-grade improvements.
2. SECTION 31 25 00 – EROSION AND SEDIMENTATION CONTROLS for temporary erosion and sedimentation control measures.
3. Division 02, 22, 23, and 26 Sections for installing underground mechanical and electrical utilities and buried mechanical and electrical structures.
4. SECTION 33 10 00 – WATER UTILITIES for installing underground water pipes, valves, hydrants, and appurtenances.
5. SECTION 33 30 00 – SANITARY SEWERAGE UTILITIES for installing underground sewer pipes and manholes.
6. SECTION 33 4000 – STORM DRAINAGE UTILITIES for installing underground drain pipes, manholes, area drains, water quality structures, and water storage tanks.

1.4 UNIT PRICES

A. Unit prices for certain types of earthwork are included in Section 01 22 00 - UNIT PRICES.

B. Rock Measurement: Volume of rock actually removed. Unit prices for rock excavation include replacement with approved materials.

1.5 DEFINITIONS

A. Backfill: Soil material or Controlled Density Fill (CDF) used to fill an excavation.

1. Initial Backfill: Backfill placed beside and over pipe in a trench, including haunches to support sides of pipe.
2. Final Backfill: Backfill placed over initial backfill to fill a trench.

B. Base Course: Course placed between the subbase course and hot-mix asphalt paving and concrete paving.

C. Bedding Course: Course placed over the excavated subgrade in a trench before laying pipe.

D. Borrow Soil: Satisfactory soil imported from off-site for use as fill or backfill.

E. Dewatering includes lowering the water table and intercepting seepage which would otherwise emerge from the slopes or bottom of the excavation; increasing the stability of excavated slopes; preventing loss of material from beneath the slopes or bottom of the excavation; reducing lateral loads on sheeting and bracing; improving the excavation and hauling characteristics of sandy soil; preventing rupture of heaving of the bottom of any excavation; and disposing of pumped water.

1. Normal dewatering is defined as using conventional pumps installed in open excavations ditches, or sumps.

F. Drainage Course: Course supporting the pavement that also minimizes upward capillary flow of pore water.

G. Excavation: Removal of material encountered above subgrade elevations and to lines and dimensions indicated.

1. Authorized Additional Excavation: Excavation below subgrade elevations or beyond indicated lines and dimensions as directed by the Owner's Representative or the Designer. Authorized additional excavation and replacement material will be paid for according to Contract provisions for unit prices.
2. Bulk Excavation: Excavation more than 10 feet in width and more than 30 feet in length.
3. Unauthorized Excavation: Excavation below subgrade elevations or beyond indicated lines and dimensions without direction by the Owner's Representative or the Designer. Unauthorized excavation, as well as remedial work directed by Designer, shall be without additional compensation.

H. Fill: Soil materials used to raise existing grades.

I. Rock: Rock material in beds, ledges, unstratified masses, conglomerate deposits, and boulders of rock material that cannot be removed by normal rock excavating equipment without systematic drilling, ram hammering, ripping, or blasting, when permitted.

J. Structures: Buildings, footings, foundations, retaining walls, slabs, tanks, curbs, mechanical and electrical appurtenances, or other man-made stationary features constructed above or below the ground surface.

K. Subbase Course: Course placed between the subgrade and base course for hot-mix asphalt pavement, or course placed between the subgrade and a cement concrete pavement or a cement concrete or hot-mix asphalt walk.

L. Subgrade: Surface or elevation remaining after completing excavation, or top surface of a fill or backfill immediately below subbase, drainage fill, or topsoil materials.

M. Utilities: Onsite underground pipes, conduits, ducts, and cables, as well as underground services within buildings.

N. Unsuitable Soils: Excavated soils that are determined by the Designer to not be reusable as fill or backfill on-site due to gradation, moisture content, and/or the presence of deleterious materials.

1.6 SUBMITTALS

A. Product Data: For the following:

1. Each type of plastic warning tape.
2. Geotextile.
3. Controlled Density Fill, including design mixture.

B. Material Test Reports: From a qualified testing agency indicating and interpreting test results for compliance of the following with requirements indicated:

1. Classification according to ASTM D 2487 of each onsite and borrow soil material proposed for fill and backfill.
2. Laboratory compaction curve according to ASTM D 1557 for each onsite and borrow soil material proposed for fill and backfill.

C. Submit a detailed construction sequence plan for project excavation indicating temporary stockpile areas, side slopes of excavations, limits of required temporary excavation support and sequence, and procedures for subgrade protection, excavation, concrete placement, moisture conditioning of onsite excavated soils used as fill, filling, backfill, and compaction.

D. Backfill Materials: Provide 50-pound sample for third-party testing of each backfill material from each proposed source, including on-site materials. Submit a grain size analysis and distribution curve performed in accordance with ASTM D422 for each proposed backfill material for review by the Engineer. The sieve analysis will be based on a washed sieve test. Additional samples and analysis shall be submitted if a change in material occurs at the borrow source. Material that is processed by crushing of onsite materials shall be tested for compliance with the gradation requirements specified herein at the Contractor's expense. The Geotechnical Engineer will review the suitability of fill materials. Installation of materials prior to testing and/or review and response by Architect is at Contractor's risk.

E. Submit the name of each material supplier and specific type and source of each material. Any change in source throughout the job requires approval of the Architect or Geotechnical Engineer. No fill material shall be delivered to the site or placed until the material has been approved.

F. Soil Samples:

1. Initial soil testing shall be performed by a third party and coordinated and paid for by the General Contractor. A plan indicating the location of each soil sample shall be provided for each test. If approval is based on the test results from a sample of material to be imported, additional tests, including grain-size analyses and laboratory compaction tests should be performed on the material after it is delivered to the site.
2. Classification in accordance with ASTM D422 preferred or D2487 for each on-site or borrow soil material proposed for use onsite.

3. Laboratory compaction curve in accordance with ASTM D1557 for each on-site or borrow soil material.
4. The Contractor shall submit a scale plan daily that defines the location, limits, and depths of the area excavated.
5. Particle size analysis in accordance with ASTM D422 with gradation curves and envelope corresponding to the specified material. The sieve analysis will be based on a washed sieve test but will not require a hydrometer test unless requested by the Architect. The gradation curve must be entirely within the specified envelope for a material to be approved for use.
6. Soil samples from all on-site materials that are processed on site shall be sieve tested. The sieve test results shall be submitted to the design team for every 500 cubic yards of material prepared on-site.
7. Architect will be sole and final judge of suitability of all materials. Remove rejected materials and replace with new, whether in stockpiles or in place.

G. Submit a detailed construction sequence plan for project excavation indicating temporary stockpile areas, side slopes of excavations, limits of any required temporary excavation support and sequence and procedures for slope protection, subgrade protection, excavation, concrete placement, moisture conditioning of on-site excavated soils used as fill, filling, backfill, and compaction.

H. Dewatering system: Contractor shall submit, for record, drawings and design data prepared, stamped, and signed by a registered professional engineer in the Commonwealth of Massachusetts who is experienced in groundwater control system design. The submittal shall show arrangement locations, and details of wells and well points and sump pumps; locations of risers, headers, filters, pumps, power units, all treatment components, and discharge lines; and means of discharge, control of sediment, and disposal of water. The submittal of the dewatering system will not relieve the Contractor from the responsibility for the adequacy of the dewatering system to achieve the required results specified in these Specifications and all permit requirements.

1. Include layouts of piezometers and flow-measuring devices for monitoring performance of dewatering system.
2. Include a written plan for dewatering operations including control procedures to be adapted if dewatering problems arise.
3. Include design calculations demonstrating adequacy of the proposed dewatering system and equipment.
4. Provisions and methods of sediment removal and disposal of water.
5. All permits required for the work.

I. Support of Excavation: Contractor shall submit, for record, proposed excavation support systems (if required). The proposed lateral support systems shall be designed and stamped by a registered professional engineer licensed in the Commonwealth of Massachusetts. Despite the submittal of the design of excavation support and protection systems, the Contractor shall remain solely responsible for the adequacy and safety of materials and methods used in construction. Include the following as a minimum on the drawings:

1. Details, arrangements, and methods of construction of the proposed system(s).
2. The method of installation and installation equipment.
3. The elevation of struts, shores, and tiebacks, as applicable, and permissible depth to which excavation may be carried before such supports are installed.

4. The excavation depths, the depth below the main excavation to which the support system will be installed, and the maximum design load to be carried by various members of the support system.
5. Design calculations including references to design methods used, assumptions, design parameters, design soil profile, material properties, allowable stresses, and other pertinent information stamped by a Professional Engineer registered in the Commonwealth of Massachusetts.
6. The location of existing utilities, facilities and/or structures nearby.

J. Pre-excavation Photographs and Videotape: Show existing conditions of adjoining construction and site improvements, including finish surfaces, that might be misconstrued as damage caused by earthwork operations. Submit before earthwork begins. Maintain catalog of up-to-date photographs at the site.

K. Plan to Maintain Safe Path of Travel: Submit plans for maintaining safe paths of travel for the general public during the entire project, including requirement for police details if necessary.

L. Filter fabric: Submit the manufacturer's information and a one square foot representative sample of the filter fabric.

M. Within one week after making field adjustments, resubmit revised working drawings as necessary to reflect changes required by field conditions.

N. Obtain required permits for discharge of dewatering effluent. Submit two copies of all permits obtained at least one week prior to system installation.

1.7 REFERENCE STANDARDS

A. The following standards are applicable to the work of this section to the extent referenced herein or if the item is indicated on the Drawings or specified without a detail.

1. City of Worcester Department of Public Works and Parks Standard Specifications and Details, latest edition.
2. MassDOT Construction Standards, latest edition with amendments, hereinafter referred to as the “Construction Standards”.
3. ASTM: American Society for Testing and Materials.
4. S.S.H.B. Standard Specifications for Highways and Bridges, the Commonwealth of Massachusetts, Department of Public Works, latest edition.

B. See the Appendix to this specification for previous soil test results for material processed on site.

1.8 COORDINATION

A. Prior to start of earthwork, the Contractor shall arrange an onsite meeting with the Architect, Engineer, the Geotechnical Engineer, and the testing agency for the purpose of establishing the Contractor's schedule of operations, and scheduling observation and testing procedures and requirements.

B. As construction proceeds, the Contractor shall be responsible for notifying the Geotechnical Engineer and the testing agency prior to the start of earthwork operations requiring observation and/or testing.

C. The work of this Section shall be coordinated with that of other trades affecting, or affected by, this work, as necessary to ensure the steady progress of all work of the Contract.

1.9 PROJECT CONDITIONS

A. Existing Utilities: Do not interrupt utilities serving facilities occupied by the Owner or others unless permitted in writing by the Owner's Representative and then only after arranging to provide temporary utility services according to requirements indicated.

1. Notify the Owner's Representative not less than two days in advance of proposed utility interruptions.
2. Do not proceed with utility interruptions without the Owner's Representative's written permission.
3. Contact utility-locator service for area where Project is located before excavating.

a. The Contractor shall notify "Dig Safe" at 1-888-DIG-SAFE prior to commencing any excavation work.

B. Demolish and completely remove from site existing underground utilities and structures indicated to be removed. Coordinate with utility companies to shut off services if lines are active.

C. Project-Site Information: A geotechnical report has been prepared for this Project and is available for information only. The opinions expressed in this report are those of the Geotechnical Engineer and represent interpretations of subsoil conditions, tests, and results of analyses conducted by the Geotechnical Engineer. Neither the Owner nor the Geotechnical Engineer will be responsible for interpretations or conclusions drawn from the data.

1. The geotechnical report does not represent and shall not be construed to represent a guarantee of subsurface conditions.
2. Interpretation of this data for purposes of construction is the responsibility of the Contractor. It is the Contractor's responsibility to make interpretations and draw conclusions with respect to the character of materials to be encountered and groundwater conditions at the site and their impact upon Contractor's work based on his expert knowledge of the area, construction dewatering methods, and support of excavation methods.
3. Make additional test borings and conduct other exploratory operations necessary for dewatering and excavation support and protection.
4. The geotechnical report is referenced elsewhere in the Project Manual.

D. Survey Work: Contractor shall engage a qualified land surveyor or professional engineer to survey adjacent existing buildings, structures, and site improvements; establish exact elevations at fixed points to act as benchmarks. Clearly identify benchmarks and record existing elevations.

1. During earth moving operations, installation of excavation support and protection systems and dewatering, regularly resurvey benchmarks, maintaining an accurate log of surveyed elevations and positions for comparison with original elevations and positions. Promptly notify Owner's Representative if changes in elevations or positions occur or if cracks, sags, or other damage is evident in adjacent construction.

E. The Contractor shall not close or obstruct any street, sidewalk, or passageway without written permission from authorities having jurisdiction unless otherwise indicated on the Con-

tract Drawings. The Contractor shall conduct the construction operations as to minimize interference with the use of roads, driveways, or other facilities near enough to the project to be affected by the work.

F. The Contractor shall provide police details when working in roadways as required by local jurisdictional authorities. The Contractor shall pay for any and all police details.

1.10 SUBSURFACE CONDITIONS

A. Geotechnical Engineering Report for the Proposed School, prepared by Lahlaf Geotechnical Consulting, Inc. (LGCI), 100 Chelmsford Road, Suite 2, Billerica MA 01862 dated April 9, 2018 and attached to Section 31 00 00 – Subsurface Investigation and hereby made a part of the Contract Documents.

B. The Owner assumes no responsibility for the Contractor's failure to make his own site investigation and makes no representation of subsurface conditions. Failure by the Contractor to be aware of existing site conditions shall not be cause for additional cost to the Owner. Information on subsurface conditions is made available for the convenience of the Bidders. The Owner does not present the information to the Contractor as either an accurate or a comprehensive indication of subsurface conditions. Bidders are invited to review the information to apprise themselves of the information available, and also to make additional investigations at their own expense.

C. No claim for extra cost or extension of time resulting from reliance by the Contractor on information presented herein shall be allowed, except as provided in the Contract Documents.

1.11 REUSE OF ONSITE MATERIALS

A. The Contractor may re-use onsite excavated soils that meet the gradation requirements of materials specified herein.

B. The Contractor may utilize a crusher onsite and to blend and crush blasted rock, boulders, and overburden soils to produce materials that meet the gradation requirements specified herein for reuse onsite.

C. Solid waste consisting of brick (brick is not from building demolition), concrete, asphalt, cobbles and boulders that measure less than 3 cubic yards in volume shall become the property of the Contractor and be legally disposed of off-site at no additional cost to the Owner.

D. Excavated on-site soils which are suitable for re-use at the time of excavation but become frozen or too wet for re-use due to poor material handling practices shall be disposed of off-site and replaced as necessary at no additional cost to the Owner.

E. The processing of the existing building concrete and brick materials into Ordinary Fill shall be allowed under Section 02 41 17 Building Demolition.

F. The Contractor must review all existing stockpiles on site including soil testing for each stockpiled material.

G. The Contractor must amend the existing stockpiles if testing determines that the stockpiles do not meet the specifications for their intended use. The Contractor shall provide third par-

ty sampling and testing in accordance with Section 1.03 Submittals for all soils amended on-site.

H. Excavation material free of organic matter and approved for re-use by the environmental professional can be placed in paved areas at depths greater than 3 feet from the bottom of the subbase layer provided that the maximum particle size is less than 2/3 of the lift thickness and that the material is compacted to a minimum relative compaction of 95 percent.

I. The Contractor is cautioned that the onsite materials are high in fines. Materials with high fines contents are typically difficult to handle when wet as they are sensitive to moisture content variations. Subgrade support capacities may deteriorate when such soils become wet and/or disturbed. The contractor shall keep exposed subgrades properly drained and free of ponded water. Subgrades shall be protected from machine and foot traffic to reduce disturbance. Placed onsite material that become soft and unsuitable to support additional lifts of fill shall be removed and replaced at no additional cost to the owner.

1.12 EXCAVATION

A. The Contractor shall perform all excavations and of whatever materials encountered, in a manner as required to allow for placing of temporary earth support, forms, installation of pipe and other work, and to permit access for the purpose of observing the work. Excavations shall be to such widths as will give suitable space for the required work. Bottoms of trenches and excavations shall be protected from frost and shall be firm, dry and in an acceptable condition to receive the work. Work shall not be placed on frozen surfaces nor shall work be placed on wet or unstable surfaces.

B. All excavations made in open cut will be controlled by the conditions existing at that location. In no case shall earth be excavated or disturbed by machinery so near to the finished subgrade for structures and pipelines as to result in the disturbance of the earth below the subgrade. The final excavation to subgrade should be accomplished with a smooth faced bucket or by hand.

1.13 EXCAVATION SUPPORT AND PROTECTION

A. The Contractor shall furnish, install, monitor and maintain excavation support and protection systems (sheeting, shoring, and bracing) at locations necessary to support the sides of excavations and resist soil and hydrostatic pressure and superimposed and construction loads; to prevent danger to persons or damage to adjacent pavements, facilities, utilities, or structures; to prevent injurious caving or erosion or the loss of ground; and to maintain pedestrian and vehicular traffic as required by the Contract Documents, the Contractor's sequence of construction, and as directed by the Owner's Representative.

B. In all sheeting, shoring and bracing operations, care shall be taken to prevent collapse of excavations, injury to persons or damage to adjacent structures, facilities, utilities, and services. Any injuries to persons shall be the responsibility of the Contractor; and any damage to the work occurring as a result of settlement, water or earth pressure, or other causes due to inadequate bracing or other construction operations of the Contractor shall be satisfactorily repaired and made good by the Contractor, at no additional cost to the Owner.

C. The excavation support system shall be of sufficient strength and be provided with adequate bracing to support all loads to which it will be subjected. The excavation support system shall be designed to prevent any movement of earth that would diminish the width of the excavation or damage or endanger adjacent structures.

D. Where sheeting is to be used, it shall be driven ahead of excavation operations to the extent practicable so as to avoid the loss of material from behind the sheeting; where voids occur outside of the sheeting, they shall be filled immediately with ordinary fill, thoroughly compacted.

E. The Contractor shall leave in place all sheeting and bracing at the locations and within the limits ordered by the Owner's Representative in writing. The Contractor shall cut off the sheeting at elevations as indicated on the Contract Drawings or be determined with the approval of the Owner's Representative.

F. The Contractor shall comply with all federal, state, and local safety regulations, and requirements.

1.14 DEWATERING

A. The Contractor shall provide, at his own expense, adequate pumping and drainage facilities to maintain the excavated area sufficiently dry from groundwater and/or surface runoff so as not to adversely affect construction procedures nor cause excessive disturbance of underlying natural ground. The flows of all water resulting from pumping shall be managed so as not to cause erosion, siltation of drainage systems, or damage to adjacent property.

B. Any damage resulting from the failure of the dewatering operations of the Contractor, and any damage resulting from the failure of the Contractor to maintain all the areas of work in a suitable dry condition, shall be repaired by the Contractor, as directed by the Owner's Representative and/or the Designer, at no additional cost to the Owner. The Contractor's pumping and dewatering operations shall be carried out in such a manner as to prevent damage to the Contract work and so that no loss of ground will result from these operations. Precautions shall be taken to protect new work from flooding during storms or from other causes. Pumping shall be continuous to protect the work and/or to maintain satisfactory progress.

C. All pipelines or structures not stable against uplift during construction or prior to completion shall be thoroughly braced or otherwise protected. Water from the trenches, excavations, and stormwater management operations shall be disposed of in such a manner as to avoid public nuisance, injury to public health or the environment, damage to public or private property or damage to the work completed or in progress.

D. The Contractor shall control the grading in the areas surrounding all excavations so that the surface of the ground will be properly sloped to prevent water from running into the excavated area. Where required, temporary ditches shall be provided to control drainage. Upon completion of the work and when directed, all areas shall be restored by the Contractor in a satisfactory manner and as directed.

E. Remove dewatering system when no longer required for construction.

F. The Contractor shall obtain and maintain all required local, state, and federal permits necessary for construction dewatering for the duration of dewatering activities including all chemical testing required for disposal and discharge of dewatering effluent. The Contractor shall be responsible for treatment of water, if necessary, to meet minimum discharge criteria specified in the permits.

1.15 QUALITY CONTROL

A. The Owner may retain and pay for the services of an independent testing agency to monitor backfill operations and to perform field density tests, and a Geotechnical Engineer to periodically observe the earthwork operations and observe the preparation of the subgrade for footings, slabs, and paved areas. The geotechnical engineer may from time to time request that the contractor excavate tests pits ahead of excavation to confirm subsurface conditions.

B. The Contractor shall make provisions for allowing observations and testing of Contractor's Work by the Geotechnical Engineer and by the independent testing and inspection firm. The presence of the independent testing agency and/or the Geotechnical Engineer does not include supervision or direction of the actual work of the Contractor, his employees or agents. Neither the presence of the independent testing agency and/or the Geotechnical Engineer, nor any observations and testing performed by them, nor failure to give notice of defects shall excuse the Contractor from defects discovered in his work.

C. If fill soils are not obtained from a commercial gravel pit, the Contractor shall provide certified analytical testing of offsite backfill to demonstrate that the soil does not exceed the limitations for MCP reference/reportable concentrations. Analyses shall include RCRA-8 metals, Extractable and Volatile Petroleum Hydrocarbons (EPH/VPH), and Volatile Organic Compounds (by EPA Method 8260B/5035). No testing will be required of imported fill soils obtained from a commercial gravel pit, provided the soils are free of odors, discoloration, staining or other conditions indicative of contamination, in the opinion of the Geotechnical Engineer and/or the Designer.

D. Costs related to retesting due to unacceptable quality of work and failures discovered by testing shall be paid for by the Contractor at no additional expense to Owner, and the costs thereof will be deducted by the Owner from the Contract Sum.

E. Tests and analysis of soil material will be performed in accordance with ASTM D422, ASTM D1557, ASTM D2922, ASTM D3017 and ASTM D4318.

F. If tests indicate materials do not meet specified requirements, the Contractor shall identify an alternative borrow source, test the new material, and submit results to the Designer at no cost to Owner.

1.16 EXCAVATION CLASIFICATIONS

A. Additional Excavation:

1. When excavation has reached required subgrade elevations, notify the Owner's Representative who will review subgrade conditions.
2. If unsuitable bearing materials are encountered at the required subgrade elevations, carry excavations deeper and replace excavated material as directed.
3. Removal of unsuitable material beyond the grades and lines shown on the Drawings and specified herein and its replacement as directed will be paid on the basis of contract conditions relative to changes in work or as provided for under the unit rates for this classification.

B. Rock Excavation:

1. Rock excavation in trenches includes removal and disposal of materials and obstructions encountered which cannot be excavated with a 1.0 cubic yard (heaped) capacity, 42-inch wide bucket on medium-size track-mounted hydraulic excavator equivalent to Caterpillar Model 215, rated at not less than 90HP flywheel power and 30,000 lb. drawbar pull. Trenches in excess of 10-feet in width are classified as open excavation.
2. Rock excavation in open excavations includes removal and disposal of materials and obstructions encountered which cannot be dislodged and excavated with modern track-mounted heavy-duty hydraulic excavating equipment without drilling or ripping. Rock excavation equipment is defined as Caterpillar Model No. 973 or No. 977K, or equivalent track-mounted loader, rated at not less than 170HP flywheel power and developing 40,000-lb. breakout force (measured in accordance with SAE J732C).
3. Determination of rock excavation classification will be made by the Owner's Representative. Typical of materials classified as rock are boulders 3.0 cubic yards or more in volume, solid rock, rock in ledges, and rock-hard cementitious aggregate deposits. Intermittent drilling or ripping performed to increase production and not necessary to permit excavation of material encountered will be classified as earth excavation. Do not perform rock excavation work until material to be excavated has been cross-sectioned and classified by the Owner's Representative. Visual observation of the completed excavation may be made by the Owner's Representative to modify the excavation classifications. Removal of rock excavation prior to classification by the Owner's Representative shall be considered as earth excavation unless accepted by the Owner's Representative in writing. Rock excavation will be paid on the basis of contract unit rates for this classification.
4. Rock payment lines (if applicable) are limited to the following:

    a. Two feet outside of concrete work for which forms are required.
    b. In pipe trenches, depth limits shall be 6 inches below the bottom of the pipe:

Depth From Ground Surface to Invert of Pipe	Pay Width (Pipe ID)	
	0-24”	Over 24”
0 to 12’	5’-0”	Pipe I.D. +3’-0”
12’ to 20’	7’-0”	Pipe I.D. +7’-0”
Over 20’	9’-0”	Pipe I.D. +7’-0”

    c. Payment lines for columns and footings within the building shall be a vertical line one foot from the toe of the footings; the depth shall be measured at 24 inches below the bottom elevations shown on the Drawings. Payment lines for rock excavation under slabs on grade shall be six inches below the bottom elevation of the specified gravel base course outside of the building and 24 inches below subgrade for slabs within the building.
    d. Payment lines for manholes, catch basins, and other utility structures shall be one foot outside of the outer wall and six inches below the bottom of the base material beneath the structure.
    e. Rock sloping across the width of trench shall have the top of rock established at the rock elevation over the centerline of the pipe.

5. Measurement

a. When, during the process of excavation, rock is encountered, it shall be uncovered and exposed in such a manner that the unbroken ledge surface is clearly visible, and the
b. Architect shall be notified by the Contractor, before proceeding further. The areas in question shall then be cross-sectioned as hereinafter specified.
c. Failure on the part of the Contractor to uncover the rock surface and to notify the Architect and proceeding by the Contractor with the rock excavation before cross-sections are taken, will forfeit the Contractor's right of claim towards the stated allowance or additional payment over and above the stated allowance at the quoted unit price.
d. The Contractor shall employ and pay for a licensed Registered Civil Engineer or Land Surveyor to take cross-sections of rock before removal and to make computations of volume of rock encountered within the Payment Lines. Cross-sections shall be taken in the presence of the Geotechnical Engineer and the computations approved by the Architect. The Owner has the option to perform independent cross-sections and computations of rock quantities.

~~C.~~ Estimated Quantities ~~Please refer to Section 01 22 00 UNIT PRICES and to Pay Lines as defined in this Section 1.16C. Unit Quantities to be carried in the base bid are as follows:~~

~~1. Rock excavation in trenches and pits, removed from the site, and any placement of fill required to bring excavated surface to specified subgrade: **xxxx CY**~~
~~2. Rock excavation as open excavation, removed from the site, and any placement of fill required to bring excavated surface to specified subgrade: **xxxx CY**~~
~~3. Boulder excavation, removed from the site, and any placement of fill required to bring excavated surface to specified subgrade: **xxxx CY**~~

~~a. These unit quantities are estimated based on the drawings and assumed ledge elevations. Actual project quantities will vary.~~

1. ***Refer to Construction Manager's Scope of Work 31-3 Early Site Bid Package # 2 Document for all unit costs.*** (Add. #3)

D. Determination of Actual Quantities

1. The contractor shall provide all excavation to expose the top of ledge in any area requiring excavation by blasting.
2. After exposing top of rock, Architect shall be notified and the top of rock shall be cross-sectioned by a registered engineer or professional land surveyor as approved by Architect and paid for by the contractor.

a. Any rock removed prior to notification of the Architect and subsequent cross sectioning shall be considered general excavation and any payment for rock shall not apply.
b. Cross sections of rock shall be created as needed for accurate definition of rock removed. Maximum stationing allowed will be 25 feet. Include the following items on the cross section:
1) Existing ledge
2) Items of construction and pay limits
a) Roads
b) Utilities with inverts
c) Rock slopes

d) Finished grades

3) Actual rock removed.

c. Cross sections shall clearly differentiate between trench and open excavation rock quantities.

3. The Contractors Engineer or Surveyor shall calculate the difference between the profiled top grade and the excavation limit indicated material in place. No additions for expansion after removal are allowed.

a. Sealed calculations, work sheets and cross sections shall be submitted to Architect for approval.

4. If alternate methods of rock removal are employed (pre-splitting or other methods) the contractor is required to verify the top of rock, as defined above, to the satisfaction of the Architect. Failure to meet the Architect's requirements will be cause to consider all rock so removed as general excavation.

E. Payment Credit

~~1. Actual quantities of rock shall be compared with estimated quantities and additional payment or credit will be established based on the unit prices referenced in Section 01 22 00 UNIT PRICES.~~

1. Refer to Construction Manager's Scope of Work 31-3 Early Site Bid Package # 2 (Add. #3)

F. All ordinary site earthen excavations are unclassified, Refer to Construction Manager's Scope of Work 31-3 Early Site Bid Package # 2.

1. All building excavation limits are to remove in its entirety; all fill materials placed as part of the original school's earthwork operations. Reference the published soils borings and test pits that indicate the strata change between fill and original soils for vertical excavation limits.

2. Horizontal limits shall extend beyond the proposed building footprint a distance equal to the distance between the bottom of the proposed footings and the natural soil or 5 feet, whichever is greater.

3. Building excavation limits at the soldier pile retaining shall be to the inside face of the retaining, and further defined in the Construction Manager's Scope of Work 31-3 Early Site Bid Package # 2.

4. All fill within the building from the above noted excavations to the bottom of interior slab crushed stone base or as defined in the documents shall be structural fill. (Add. #3)

G. Unit Prices

1. Unit prices for rock excavation, shall include the full compensation for all required labor, products, tools, equipment, plant, transportation services and incidentals required for excavation and transport of excavated materials; establishment of subgrade; and mark-up for overhead and profit.
2. Materials, methods of installation and definitions of terms set forth under the various unit price items are indicated in the Schedule of Unit prices and indicated in the Contract Documents.

3. The payment lines for rock excavation shall be as indicated in the Contract Documents or specified herein.

    a. Rock Measurement: Volume of rock actually removed, measured in original position, but not to exceed the following:

        1) 24 inches (600 mm) outside of concrete forms other than at footings.
        2) 12 inches (300 mm) outside of concrete forms at footings.
        3) 12 inches below bottom of footing.
        4) 12 inches (150 mm) outside of minimum required dimensions of concrete walls cast against grade.
        5) 6” Outside dimensions of concrete walls indicated to be cast against rock without forms or exterior waterproofing treatments.
        6) 12 inches (150 mm) beneath bottom of concrete slabs on grade.
        7) 12 inches (150 mm) beneath pipe in trenches, and the greater of 24 inches (600 mm) wider than pipe or 42 inches (1065 mm) wide.
        8) Payment lines for manholes and catch basins and drainage structures shall be one 12” outside of the outer walls and six 12 inches below the bottom of the structure.
        9) Face of exposed rock slope as directed by the geotechnical engineer.
        10) 24” below proposed finished grades in lawn and planted areas.
        11) At bottom of subgrade layer for light duty and heavy-duty pavements.
        12) At bottom of designed section as shown on the details for all speciality paving and concrete paving and concrete pads.

4. Performance of work which is not required under the Contract Documents or which is not authorized by Change Order, whether or not such work item is set forth hereunder as a Unit Price Item, shall not be considered cause for any extra payment. The contractor will be held fully responsible for such unauthorized work, including the performance of all corrective measures required by the Architect.
5. Quantities for adjustment shall be calculated by a registered Professional Engineer or Surveyor retained by the Contractor, as agreed to by the Architect. Profiles of rock, work sheets, plans and method of calculation shall be submitted to Architect for approval.
6. Excavations of materials beyond the payment lines shall be at the expense of the Contractor.

H. Methods of Measurement of Ledge Excavation

1. The volume of each excavation shall be measured to the nearest cubic yard.
2. Solid boulders in original stratification will be measured to the one half cubic yard.
3. Excavation outside the specified lines, whether due to slides or other causes, or made for any reason will not be paid for. The contractor at his own expense shall remove any material sliding into the excavation.
4. A trench shall be defined as an excavation of any depth where the width is less than twice the depth and the width is less than ten feet
5. Basis of payment: The Base Bid assumes cubic yards of rock excavation as listed in subparagraph 1.12 A above. The Unit Price per cubic yard for excavation shall include the cost of furnishing all labor, materials, and equipment necessary to complete the work, including shoring, sheeting, and bracing required by the State or local codes, establishment of design subgrades, and all mark-up for overhead and profit.

6. Carefully examine rock excavations for foundations, and remove loose or shaken rock down to solid bearing; level the rock surface or shelve it to a slope not exceeding one inch per foot, or as directed, leaving no undrained pockets in the surface.

1.17 LAYOUT AND GRADES

A. The Contractor is responsible for establishing vertical and horizontal control for the work and shall establish permanent benchmarks and replace as directed any, which are destroyed or disturbed. The Contractor shall maintain sufficient reference points at all times during construction to properly perform site grading. The existing survey benchmark shall be protected throughout the construction project.

B. Finished grades, contours, and elevations indicated on the Drawings describe final surface elevation for completed construction. The words “finished grade” as used herein shall mean final grade elevations indicated on the Drawings. Spot elevations shall govern over proposed contours. Where not otherwise indicated, project site areas shall be given uniform slope between points and existing established grades.

1.18 QUALITY ASSURANCE

A. Pre-Excavation Conference: Conduct conference at Project Site to comply with requirement in Section “Project Coordination”.

1. Before commencing earthwork, meet with representatives of the governing authorities, Owner, Architect, Engineer, consultants, independent testing agency, and other concerned entities. Review earthwork procedures and responsibilities including testing and inspection procedures and requirements. Notify participants at least 3 working days prior to convening conference. Record discussions and agreements and furnish a copy to each participant.

B. Testing: Compaction tests will be required by the Owner and will be paid for by the owner. No specific testing schedule has been established at this time. If tests indicate that density requirement have not been achieved, the contractor continue compacting the tested material. All retesting is these areas shall be paid for by the contractor.

C. Density and Compaction Testing: The contractor is responsible to schedule compaction tests and allow adequate time for the proper execution of said tests.

D. The Owner’s Testing Agency will perform water content, gradation tests on onsite and processed materials, and compaction tests at a frequency and at locations as required. The results of these tests will be submitted to the Architect, and a copy submitted to the Contractor, on a timely basis so that the Contractor can take such action as is required to remedy the indicated deficiencies.

E. Field inspection and testing may be performed by a Geotechnical Engineer at the Owner’s expense to supplement the Contractor’s Quality Control testing. Classification of all materials will be made by the Geotechnical Engineer whose decision shall be final and binding on the Contractor.

F. The Contractor shall be responsible for managing and tracking all materials excavated and placed in stockpiles for testing.

G. Comply with governing EPA notification regulations before beginning dewatering. Comply with hauling and disposal regulations of authorities having jurisdiction.

H. The Contractor is responsible for the adequacy of the dewatering systems.

1. The dewatering systems shall be capable of effectively reducing the hydrostatic pressure and lowering the groundwater levels to a minimum of 2 feet below excavation bottom unless otherwise directed by the Designer so that all excavation bottoms are firm and dry.
2. The dewatering system shall be capable of maintaining a dry and stable subgrade until the structures, pipes, and appurtenance to be built therein have been completed to the extent that they will not be floated or otherwise damaged.
3. The dewatering system and excavation support shall be designed so that the lowering of the groundwater level outside the excavation does not adversely affect adjacent structures, utilities or other improvements.

I. The Owner will perform in place density tests in accordance with ASTM D2922 or D3017 as the Work progresses, to determine the degree of compaction. Any corrective work required as a result of such tests, such as additional compaction, or a decrease in the thickness of layers, shall be performed by the Contractor at no additional expense to Owner. In place, density testing shall be made at the Contractor's expense by a qualified geotechnical testing laboratory.

J. The Designer's duties do not include the supervision or direction of the actual work by the Contractor, his employees or agents. Neither the presence of the Designer nor any observation and testing by the Geotechnical Engineer shall excuse the Contractor from defects discovered in his Work at that time or subsequent to the testing.

K. Contractor shall assist the Owner's Testing Laboratory in performing in-place density testing at a minimum frequency of one test per lift but no less than one test per 200 cubic yards of material placed in any one lift. Compaction testing will be performed in accordance with ASTM D1557, D2922, and D3017.

L. Subgrades shall be approved for compactness and material composition prior to placing subsequent lifts. If inspections indicate Work does not meet specified requirements, the work shall be removed, replaced, and compacted at no additional cost to Owner.

1.19 REGULATORY REQUIREMENTS

A. Comply with the Safety and Health regulations of the U.S. Department of Labor set forth in 29 CFR, Part 1926, and to the Massachusetts Department of Labor and Industries, Division of Industrial Safety "Rules and Regulations for the Prevention of Accidents in Construction Operations (454 CMR 10.0 et seq.). Contractors shall be familiar with the requirements of these regulations.

1. All excavations shall comply with the requirements of OSHA excavation safety standards (29 CFR Part 1926.650 Subpart P), State, and local requirements. Where conflict between OSHA, State, and local regulations exist, the most stringent requirements shall apply.

B. Comply with governing EPA notification regulations before, during, and upon completion of dewatering. Comply with hauling and disposal regulations of authorities having jurisdiction.

C. Comply with all rules, regulations, laws, and ordinances of the municipality, the Commonwealth of Massachusetts, and other authorities having jurisdiction over the project site or

work. All labor, materials, equipment, and services necessary to make the work comply with requirements shall be provided by the Contractor without additional cost to the Owner.

D. The Contractor shall obtain and pay for all permits and licenses required to complete the work specified herein and indicated on the Contract Drawings.

E. The Contractor shall not close or obstruct any street, sidewalk, or passageway without written permission from authorities having jurisdiction unless otherwise indicated on the Contract Drawings. The Contractor shall conduct his operations as to minimize interference with the use of roads, driveways, or other facilities near enough to the work to be affected by the work.

F. The Contractor shall notify “Dig Safe” at 1-888-DIG-SAFE prior to commencing any excavation work.

G. The Contractor shall provide police details when working in roadways as required by local jurisdictional authorities. The Contractor shall pay for any and all details.

1.20 EXAMINATION OF SITE AND DOCUMENTS

A. It is hereby understood that the Contractor has carefully examined the site and all conditions affecting work under this Section. No claim for additional costs will be allowed because of a lack of knowledge of existing conditions as indicated in the Contract Documents, or obvious from observation of the site.

B. Plans, surveys, measurements, and dimensions under which the work is to be performed are believed to be correct, but the Contractor shall have examined them for himself during the bidding period and formed his own conclusions as to the full requirements of the work involved.

1.21 PROTECTION OF EXISTING CONDTIONS

A. All work shall be executed in such a manner as to prevent any damage to existing buildings, streets, curbs, paving, service utility lines, structures and adjoining property.

B. Locate and mark underground utilities to remain in service before beginning the work. Protect all existing utilities to remain in service during operations. Do not interrupt existing utilities except when authorized in writing by authorities have jurisdiction unless otherwise indicated on the Contract Drawings.

C. When an active utility line is exposed during construction its location and elevation shall be recorded on the Record Drawings by the Contractor and both the Engineer and the Utility Owner shall be notified in writing. Active utilities existing on the site shall be carefully protected from damage or relocated as required by the work.

D. Inactive or abandoned utilities encountered during construction operations shall be removed, plugged, capped or filled. The location of such utilities shall be recorded on the Record Drawings.

E. Provide barricades, fences, lights, signs, and all other safety devices required to protect the public against injury.

F. In case of any damage or injury caused in the performance of the work the Contractor shall, at his own expense make good such damage or injury to the satisfaction of, and without cost to, the Owner. Existing streets, sidewalks and curbs damaged during the project work shall be repaired or replaced to their condition prior to commencement of Earth Moving operations.

G. Acceptance of any of the Contractor's plans, design calculations and methods of construction by the Designer shall not relieve the Contractor of the responsibility for the adequacy of the excavation lateral support system; preventing damage to existing or new structures, utilities and streets adjacent to excavations; the safety of persons working within excavated areas and the public at large; and excavation dewatering.

1.22 DISPOSAL

A. All excess and unsuitable excavated soil shall be removed from the site and legally disposed offsite by the Contractor at no additional cost to the Owner.

PART 2 - PRODUCTS

2.1 SOIL MATERIALS

A. General: Provide borrow soil materials when sufficient satisfactory soil materials are not available from excavations.

B. Fill material shall be free from frost/ice and snow, rocks with a diameter greater than 2/3 of the loose lift thickness as specified herein, and foreign matter, such as construction debris, asphalt, trash, wood, roots, leaves, sod, and organic matter. All fill material shall be maintained by the contractor at suitable moisture contents for proper placement and compaction as specified herein.

C. Offsite pulverized pavement and crushed concrete are not acceptable for fill material. Onsite concrete that is crushed to meet one of the gradation requirements specified herein can be used as backfill.

D. Fill material shall be obtained from required onsite cut to the extent suitable material is available, and off-site to the extent suitable material is not available from onsite cuts.

E. Fill material below the roadway pavement section (pavement, dense grade and gravel borrow material) shall be sieved and the sieve analysis reviewed by the design team prior to installation. Placement of the material shall be in six (6) inch lifts and compacted to 95% under Section 3.05 Compaction.

F. Onsite material for use in compacted fill shall be natural inorganic granular soil taken from areas of cut after removal of pavement, topsoil, or other unsuitable materials. Onsite materials should be tested for compliance with the specifications before placement. Onsite materials that do not meet the gradation requirements of the specification should be used in landscaped areas, relocated onsite if directed by the Owner, or disposed of offsite.

G. Ordinary Fill shall be well-graded, natural inorganic soil with a plasticity index of less than 6 and with no stone greater than 6 inches maximum dimension. The materials shall be free of trash, ice, snow, tree stumps, roots, and other organic and deleterious materials. It shall be free of materials subject to decay, or other materials that will corrode piping or metals. Soil finer than the No. 200 sieve shall be non-plastic Ordinary Fill shall have a maximum dry

density from a laboratory compaction tests of not less than 110 pounds per cubic foot. It shall be of such a nature and character that it can be compacted to the specified densities. Topsoil shall not be considered Ordinary Fill. Existing available fill materials from onsite excavations may be reused as Ordinary Fill if it meets the above requirements and the gradation requirements. It shall be graded within the following limits:

U. S. Standard Sieve Size	Percent Finer by Weight
6 inch	100
1 inch	50-100
No. 4	20-100
No. 20	10-70
No. 60	5-45
No. 200	0-20

H. Gravel Borrow: Gravel borrow shall meet the requirements of MassDOT M1.03.0, Type B. It shall be an inert, hard, durable sand and gravel or stone soil obtained from an offsite commercial source. It shall be free of ice, snow, roots, sod, rubbish, oil, hazardous material, and other deleterious or organic matter. It shall be graded within the following limits:

U. S. Standard Sieve Size	Percent Finer by Weight
3 inch	100
½ inch	50-85
No. 4	40-75
No. 50	8-28
No. 200	0-10*

*7% max. under sidewalks

I. Structural Fill shall consist of inert, hard, durable sand and gravel, free from ice and snow, organic matter, clay, surface coatings, and deleterious materials, and shall have a plasticity index of less than 6. Structural fill shall be placed in 9-inch loose lifts and shall conform to the following gradation requirements:

U. S. Standard Sieve Size	Percent Finer by Weight
3 inches	100
1 ½ inches	80-100
½ inches	50-100
No. 4	30-85
No. 20	15-60
No. 60	5-35
No. 200	0-10*

*7% max. under sidewalks

The fines content of imported Structural Fill shall be less than 10 percent as shown in the table above. The fines content of Structural Fill processed onsite shall be less than 12 percent, except in the top 12 inches immediately beneath the slab or the under-slab drainage system where it shall be less than 10 percent.

Existing structural fill must be used and amended with sand to provide under 10% or 5% for the #200 sieve under pavements and walks. Existing structural fill may also be amended

with sand, re-crushed to provide dense grade crushed stone (required directly under walks and pavements).

J. Select Structural Fill shall meet the requirements of Structural Fill except that the percent passing the No. 200 sieve shall be less than 7 percent.

K. ½" Crushed Stone: ½" crushed stone shall meet the requirements of MassDOT M2.01.5. It shall consist of durable crushed rock or crushed gravel stone, free of ice, snow, sand, silt, clay, loam, shale, or other deleterious or organic matter. It shall be graded within the following limits:

U. S. Standard Sieve Size	***Percent Finer by Weight***
5/8 inch	***100***
1/2 inch	***85-100***
3/8 inch	***15-45***
No. 4	***0-15***
No. 8	***0-5***

(Add. #3)

L. ¾" Crushed Stone: ¾" crushed stone shall meet the requirements of MassDOT M2.01.4. It shall consist of durable crushed rock or crushed gravel stone, free of ice, snow, sand, silt, clay, loam, shale, or other deleterious or organic matter. It shall be graded within the following limits:

U. S. Standard Sieve Size	Percent Finer by Weight
1 inch	100
¾ inch	90-100
½ inch	10-50
3/8 inch	0-20
No. 4	0-5

M. 1-1/2" Crushed Stone: 1-1/2" crushed stone shall meet the requirements of MassDOT M2.01.1. It shall consist of durable crushed rock or crushed gravel stone, free of ice, snow, sand, silt, clay, loam, shale, or other deleterious or organic matter. It shall be graded within the following limits:

U. S. Standard Sieve Size	Percent Finer by Weight
2 inch	100
1-1/2 inch	95-100
1 inch	35-70
¾ inch	0-25

N. Crushed stone required around utility piping, detention/recharge systems, other stormwater infrastructure, underslab drain piping and radon mitigation piping within the building, and building perimeter drain piping shall meet the gradation requirements of Sections K and L above. Onsite material may be processed and crushed to meet those requirements.

O. Dense Graded Crushed Stone: Dense graded crushed stone shall meet the requirements of MassDOT M2.01.7. It shall consist of a mixture of crusher-run aggregate of crushed stone mixed with natural sand and gravel soil obtained from an offsite commercial source.

It shall be free of ice, snow, roots, sod, rubbish, soil, hazardous material, and other deleterious or organic matter. It shall be graded within the following limits:

U. S. Standard Sieve Size	Percent Finer by Weight
2-inch	100
1-½ inch	70-100
¾ inch	50-85
No. 4	30-55
No. 40	8-24
No. 200	3-10*

*7% max. under sidewalks

P. Sand: Sand shall meet the requirements of MassDOT M1.04.1. It shall consist of clean inert, hard, durable grains of quartz or other hard durable rock, free from clay, organics, surface coatings, or other deleterious or organic matter. It shall be graded within the following limits:

U. S. Standard Sieve Size	Percent Finer by Weight
½ inch	100
3/8 inch	85-100
No. 4	60-100
No. 16	35-80
No. 50	10-55
No. 100	2-10

Q. Dumped Riprap: Stone used for dumped riprap shall be hard, durable, angular in shape stones, resistant to weathering and shall meet the gradation requirement specified. Neither breadth nor thickness of a single stone should be less than one-third its length. Rounded stone or boulders will not be accepted unless authorized by the Engineer. Each load of riprap shall be reasonably well graded from the smallest to the maximum size specified. Stone shall be free from overburden, spoil, shale, and organic material and shall conform to the following gradation with no more than 5% by weight passing a 2-inch sieve:

Weight of Stone (lbs.)	Percent Finer by Weight
400	100
300	50
200	30
25	10

R. Stone for Pipe Ends: Stone for pipe ends shall be sound, curable rock which is angular in shape. Rounded stones, boulders, sandstone or similar stone or relatively thin slabs will not be acceptable. Each stone shall weigh not less than 50 pounds not more than 125 pounds and at least 75% of the volume shall consist of stones weighing not less than 75 pounds each. The remainder of the stones shall be so graded that when placed with the larger stones the entire mass will be compact.

S. Controlled Density Fill (CDF) shall be a cement concrete backfill material that flows like a liquid, supports like a solid when cured, and levels without tamping or vibrating to reach 100 percent compaction. CDF shall meet the requirements of MassDOT Specifications M4.08.00 for Type 1E (Very Flowable, Excavatable) or type 2E (Flowable, Excavatable)

CDF. The mix formulation will be submitted to the Designer for review prior to placement of the material in the project.

T. Reuse of Excavated Rock: Excavated onsite rock materials processed by the Contractor meeting the gradation limits for ¾" Crushed Stone, 1-½" Crushed Stone, Dense Graded Crushed Stone, and Stone for Pipe Ends contained herein may be segregated and reused as approved by the Owner.

2.2 UNSUITABLE MATERIALS

A. Unsuitable material shall be material having at least one of the following properties:

1. Material with a maximum unit dry weight per cubic foot less than 100 lbs., as determined by ASTM D1557.
2. Material containing greater than 3% organic matter by weight, topsoil, organic silt, peat, construction debris, roots and stumps.
3. Material which has a Liquid Limit greater than 55 when tested in accordance with ASTM D 4318.
4. Materials that do not meet one of the gradation specifications in this section.
5. Material classified as unsuitable by the Geotechnical Engineer.
6. Unsuitable material shall be disposed of off-site as directed by the Architect.
7. Materials that are unstable as a result of inadequate construction dewatering, excessive subgrade disturbance, or other means and methods used by the Contractor are not considered unsuitable materials.
8. Onsite processed material that is not well graded and that exhibits honeycombing during placement and compaction.

2.3 GEOTEXTILES

A. Subsurface Drainage Geotextile: Nonwoven needle-punched geotextile, manufactured for subsurface drainage applications, made from polyolefins or polyesters; complying with AASHTO M 288 and the following, measured per test methods referenced:

1. Survivability: Class 2; AASHTO M 288.
2. Elongation: 50% minimum; ASTM D 4632
3. Grab Tensile Strength: 160 lbs; ASTM D 4632.
4. Trapezoid Tear Strength: 60 lbs; ASTM D 4533.
5. CBR Puncture Strength: 410 lbs; ASTM D 6241
6. Apparent Opening Size: No. 70 sieve maximum; ASTM D 4751.
7. Permittivity: 1.50 sec-1 minimum; ASTM D 4491
8. UV Stability: 70% after 500 hours' exposure; ASTM D 4355.

B. Separation Geotextile: Woven geotextile fabric, manufactured for separation applications, made from polyolefins or polyesters; complying with AASHTO M 288 and the following, measured per test methods referenced:

1. Survivability: Class 1; AASHTO M 288.
2. Elongation: 15% maximum; ASTM D 4632
3. Grab Tensile Strength: 315 lbs; ASTM D 4632.
4. Trapezoidal Tear Strength: 120 lbs; ASTM D 4533.
5. Puncture Strength: 1,000 lbs; ASTM D 6241.
6. Apparent Opening Size: No. 40 sieve, maximum; ASTM D 4751.
7. Permittivity: 0.05 sec-1 minimum; ASTM D 4491.

8. UV Stability: 70% after 500 hours' exposure; ASTM D 4355.

2.4 ACCESSORIES

A. Detectable Underground Warning Tapes: Acid and alkali-resistant polyethylene plastic film warning tape, 6-inches wide by 4-mils minimum thickness, with continuously printed caption in black letters "CAUTION - xxxxx LINE BURIED BELOW." The text and color of the tape shall be as shown in the table below. The tape shall have a metallic core encased in a protective jacket for corrosion protection and be detectable by a metal detector when the tape is buried up to 2.5-feet deep.

Color	Utility
Safety Red	Electric
High Visibility Safety Yellow	Gas, Oil, Steam
Safety Alert Orange	Telephone, Communications, Cable Television
Safety Precaution Blue	Water System, Irrigation
Safety Green	Sanitary Sewer, Storm Sewer
White	Proposed Excavation

2.5 USES OF MATERIALS

A. Fill materials listed in Paragraph 2.1 above shall be utilized as follows and as otherwise indicated on the Drawings, specified or directed.

B. Gravel Borrow:

1. As fill (base course) below the Dense Graded Crushed Stone placed immediately beneath concrete and asphalt pavements as shown on the Contract Drawings.
2. Bedding for ductile iron drain, water, and sewer piping.

C. Dense Graded Crushed Stone:

1. As base course soils immediately below concrete and asphalt pavement as shown on the Contract Drawings.

D. ¾" and 1-½" Crushed Stone:

1. Base for drain manholes, catch basins, sewer manholes, and utility structures.
2. Bedding for drain pipe and sewer pipe.
3. Around perforated drain lines.
4. To stabilize wet subgrade conditions.
5. Elsewhere as shown on the Drawings or specified herein.
6. To aid in dewatering.

E. Sand:

1. Bedding for drain, water, sewer, and other utility piping.
2. Elsewhere as shown on the Drawings or specified herein.

F. Structural Fill

1. Within the proposed building footprint.
2. Under site retaining walls.
3. Backfill with the 3 feet of the back face of site retaining walls.

G. Ordinary Fill:

1. For general site fill outside of the proposed building footprint, concrete, and below subbase layer of asphalt and concrete pavement areas.
2. Trench backfill material.
3. In fill slopes.
4. Elsewhere as shown on the Drawings or specified herein.

H. Geotextiles:

1. Subsurface non-woven Drainage Geotextile shall fully wrap 3-4-inch Crushed Stone.
2. Use to prevent soil intrusion into drains and/or to assist in stabilizing soil subgrades prior to placement of fill materials.
3. Subsurface woven separation geotextile as separation material between crushed stone and gravel borrow base materials below concrete and asphalt pavement as shown on the Contract Drawings.
4. Where indicated or shown in the Contract Drawings.
5. A geotextile fabric shall not be used between crushed stone and soil fill material at the base of retaining walls. Where separation between crushed stone and soil fill material is required, the crushed stone should be choked by means of a soil filter.

I. Controlled Density Fill (CDF):

1. CDF shall be used as shown on the Contract Drawings.
2. CDF shall be used if directed by the DESIGNER as fill at the limits of the excavation areas.

PART 3 - EXECUTION

3.1 GENERAL REQUIREMENTS

A. The Contract Drawings indicate the proposed finish alignment, elevation, and grade of the work. Establish the line and grade in close conformity with the Contract Drawings. The Owner's Representative, however, may make minor adjustments in the field as necessary due to conditions encountered.

B. The Contractor is responsible for establishing construction phasing, means, and methods and interim grading and temporary conditions required to attain the finish product required by the Contract Documents. The Contractor is responsible for all construction, protection, movement, and maintenance of stockpiles. Establish and maintain suitable benchmarks and grade control to accurately perform the work.

C. Protect all benchmarks, monuments, and property boundary pins. Replace if destroyed by contractor's operation.

D. All excavation shall be performed in the dry. Excavation and dewatering shall be accomplished by methods, which preserve the undisturbed state of the subgrade soils.

E. No excavation will be permitted below a line drawn downwards at 2 horizontal to 1 vertical from the underside of the closest edge of any in-place footing or utility at a higher elevation without providing adequate sheeting and bracing to prevent movement of the in-place footing or utility.

F. When excavations have reached the prescribed depths, the condition of the bottom of the trench or hole shall be inspected by the Owner's Representative. After inspection, the Contractor will receive approval to proceed if conditions meet project requirements.

G. No excavation shall be deposited or stockpiled at any time to endanger portions of new or existing structures, either by direct pressure or indirectly by overloading banks contiguous to the operation. Material, if stockpiled, shall be stored so as not to interfere with the established sequence of the construction. If there is not sufficient area available for stockpiling within the limits of the project, the Contractor will be required to furnish his own area for stockpiling.

H. When the plans require excavation in areas in close proximity to existing buildings, roads, structures and utilities it shall be the responsibility of the Contractor at his expense to use satisfactory means and methods to protect and maintain the stability of such roads, and structures located immediately adjacent to but outside the limits of excavations.

I. Temporary ditches shall be made as needed to drain off surface water to avoid damaged to areas of cut or fill. Such ditches shall be maintained as required for efficient operations, at no additional cost to the Owner.

J. Provide shoring, sheeting, and/or bracing at excavations, as required, to assure complete safety against collapse of earth at the side of excavations. Provide shoring of public utility lines where exposed in the excavations in accordance with rules and regulations of the local authorities, as no additional cost to the Owner.

K. Cut and remove trees, remove stumps and brush. Legally dispose of off-site. Woodwastes may be chipped and shredded onsite and reused onsite with permission of the Architect.

L. Strip topsoil to its full depth within the Contract limits. Remove the subsoil, roots, stumps and other deleterious matter entirely under footings, slabs, and paved areas.

M. Sump pumps shall be surrounded by suitable filter media to minimize the fines removed during pumping. Pumped groundwater and surface water runoff shall be pumped to a settling basin to remove suspended solids prior to discharge.

N. Discharge of pumped water, either surface water runoff or groundwater, shall be in compliance with discharge criteria contained in permits issued by governing agencies, and all legal requirements and regulations. All permits shall be obtained by the Contractor.

O. The crushed stone placed in the sump pump pits should be wrapped in a geotextile fabric. Where a geotextile fabric is not used, the crushed stone should be entirely removed after the sump pump is no longer in use and the sump pump pit should be restored with suitable backfill.

3.2 PREPARATION

A. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by earthwork operations.

B. Preparation of subgrade for earthwork operations including removal of vegetation, topsoil, debris, obstructions, and deleterious materials from ground surface is specified in Section 311000 - SITE CLEARING.

C. Protect and maintain erosion and sedimentation controls, which are specified in Section 312500 – EROSION AND SEDIMENTATION CONTROLS, during earthwork operations.

D. Provide protective insulating materials to protect subgrades and foundation soils against freezing temperatures or frost.

3.3 DEWATERING

A. Provide Dewatering as required to maintain dry excavations.

B. Prevent surface water and groundwater from entering excavations, from ponding on prepared subgrades, and from flooding Project site and surrounding area.

C. Protect subgrades from softening, undermining, washout, and damage by rain or water accumulation.

1. Reroute surface water runoff away from excavated areas. Do not allow water to accumulate in excavations. Do not use excavated trenches as temporary drainage ditches.
2. Install a dewatering system to keep subgrades dry and convey groundwater away from excavations. Maintain until dewatering is no longer required.
3. Where soil has been softened or eroded by flooding, equipment, traffic or placement of fill or concrete during unfavorable weather or such other conditions, it shall be removed and replaced by the Contractor with suitable material and at the Contractor's expense. The necessity and extent of such removals shall be determined by the Designer.

D. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by dewatering operations.

E. Monitor dewatering systems continuously.

F. Install dewatering system utilizing wells, well points, or similar methods complete with pump equipment, standby power and pumps, filter material gradation, valves, appurtenances, water disposal, and surface-water controls.

1. Space well points or wells at intervals required to provide sufficient dewatering.
2. Use filters or other means to prevent pumping of fine sands or silts from the subsurface.

G. Before excavating below ground-water level, place system into operation to lower water to specified levels. Operate system continuously until drains, sewers, and structures have

been constructed and fill materials have been placed or until dewatering is no longer required.

H. Provide an adequate system to lower and control groundwater to permit excavation, construction of structures, and placement of fill materials on dry subgrades. Install sufficient dewatering equipment to drain water-bearing strata above and below bottom of foundations, drains, sewers, and other excavations.

1. Do not permit open-sump pumping that leads to loss of fines, soil piping, subgrade softening, and slope instability.

I. Reduce hydrostatic head in water-bearing strata below subgrade elevations of foundations, drains, sewers, and other excavations.

1. Maintain piezometric water level a minimum of 24 inches below surface of excavation.

J. Dispose of water removed by dewatering in a manner that avoids endangering public health, property, and portions of work under construction or completed. Dispose of water and sediment in a manner that avoids inconvenience to others. Provide sumps, sedimentation tanks, and other flow-control devices as required by authorities having jurisdiction.

K. Provide standby equipment on site, installed and available for immediate operation, to maintain dewatering on continuous basis if any part of system becomes inadequate or fails. If dewatering requirements are not satisfied due to inadequacy or failure of dewatering system, restore damaged structures and foundation soils at no additional expense to the Owner.

1. Remove dewatering system from Project site on completion of dewatering. Plug or fill well holes with sand or cut off and cap wells a minimum of 36 inches below overlying construction.

L. Damages: Promptly repair damages to adjacent facilities caused by dewatering operations.

3.4 EXCAVATION SUPPORT AND PROTECTION

A. Work shall not be started until all materials and equipment necessary for the construction are either on the site of the work or satisfactorily available for immediate use as required.

B. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards that could develop during excavation support and protection system operations.

1. Shore, support and protect utilities encountered.

C. Install excavation support and protection systems to ensure minimum interference with roads, streets, walks, and other adjacent occupied and used facilities.

1. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from the Owner's Representative and authorities having jurisdiction. Provide alternate routes around closed or obstructed traffic ways if required by authorities having jurisdiction.

D. Locate excavation support and protection systems clear of permanent construction so that forming and finishing of concrete surfaces or installation of improvements is not impeded.

E. The excavation support and protection systems shall be securely and satisfactorily braced to withstand all pressures to which it may be subjected and be sufficiently tight to minimize lowering of the groundwater level outside the excavation.

F. Monitor excavation support and protection systems daily during excavation progress and for as long as excavation remains open. Promptly correct bulges, breakage, or other evidence of movement to ensure that excavation support and protection systems remain stable.

G. Promptly repair damages to adjacent facilities caused by installing excavation support and protection systems.

H. Responsibility for the satisfactory construction and maintenance of the excavation support system, complete in place, shall rest with the Contractor. Any work done, including incidental construction, which is not acceptable for the intended purposed shall be either repaired or removed and reconstructed by the Contractor at his expense

I. Remove excavation support and protection systems when construction has progressed sufficiently to support excavation and bare soil and hydrostatic pressures. Remove in stages to avoid disturbing underlying soils or damaging structures, pavements, facilities, and utilities.

1. Remove excavation support and protection systems to a minimum depth of 48 inches below overlaying construction and abandon remainder.
2. Fill voids immediately with approved backfill compacted to density specified herein.
3. Repair or replace, as approved by Owner's Representative, adjacent work damaged or displaced by the installation, performance, and removal of the excavation support and protection systems.

3.5 ROCK BLASTING

A. Blasting:

1. Obtain written permission and approval of method from local authorities before proceeding with rock excavation. Explosives shall be stored, handled, and employed in accordance with state and local regulations or, in the absence of such, in accordance with the provisions of the "Manual of Accident Prevention of Construction" of the Associated General Contractors of America, Inc.
2. Notify the Architect at least 48 hours before any intended blasting and do no blasting without his specific approval of each blasting operation.
3. Contractor shall present evidence that his insurance includes coverage for blasting operations before doing any blasting work. A pre and post survey shall be performed for all buildings and utilities within 500 feet of the nearest blasting operations, conforming to the Municipal ordinance governing blasting and the Municipal Fire Department regulations.
4. All rock blasting shall be well covered with heavy mats or timbers chained together and the Contractor shall take great care to do no damage to existing structures, utility lines and trees to remain.
5. Any damage caused by the work of the Contractor shall be repaired to the full satisfaction of the Architect at no additional cost to the Owner.

6. Any rock fragments or loose material from blasting operations shall be removed. All voids shall be filled with a leveling layer of suitable fill or lean concrete as directed by the Geotechnical Engineer.
7. Additional blasting requirements:

    a. Comply fully with National and City of Worcester Regulations.
    b. All documentation submitted with application for “Use and Handling’ PERMIT. 527 CMR 13:04 (11) E-1 states “A Use and Handling” Permit may be suspended or revoked by the head of the Fire Department or the Marshal or their designees for any violation of 527 CMR 13:00, or MGL c. 148”
    c. Meet all requirements of 527 CMR 13;00
    d. All Pre-Blast Surveys completed per 527 CMR 13:00
    e. Hours of Blasting 09:00 hrs through 15:00 hrs (3:00 p.m.) Mon. through Fri. unless approved in writing or earlier over summer and school holidays.
    f. No Blasting Saturdays, Sundays or Holidays (including summer vacation) unless approved in writing by the Owner.
    g. All shots to be double matted unless approved in advance by the City of Worcester Fire Chief.
    h. Shot size limited to 500 lbs unless approved in advance by the City of Worcester Fire Chief.
    i. Blast warning signals to be sounded in accordance with 527 CMR 13:00
    j. 24 and 1 hour notification to the fire department of intent to blast
    k. In or near residential areas, written notification must be distributed to homes advising of intent to blast at least three (3) days prior to blasting operations. Such written notification to include time frame of blasting operations and description of warning signals. The area of distribution shall be determined by the Fire Chief during pre-blast conference. A Fire Department detail will be required unless waived by the Fire Chief.
    l. One or more seismographs required on all shots.
    m. All seismographs to be calibrated and certified according to manufactures specifications and 527 CMR 13:00
    n. The Contractor shall excavate the rock at a minimum 24 inches below subgrade of footings, slabs and paved areas, and athletic fields unless otherwise directed by the Architect or Geotechnical Engineer.
    o. No blasting shall be performed on the day concrete is poured anywhere at the site.
    p. Blasting shall not be performed within 250 feet of concrete structures until the concrete has reached full strength. This criterion may be relaxed if the Contractor demonstrates that the peak particle velocity is less than 0.5 inches per second as distances less than 250 feet.

B. Rock surfaces for foundations shall be carefully examined. Loose or shaken rock shall be removed to solid bearing, and the rock surface leveled, or shelved to a slope not exceeding one inch per two feet, or as directed. Depressions in the rock surface shall be filled with suitable fill.

C. If rock excavation is carried beyond the depth and dimensions to subgrade in other areas, the Contractor shall, at his own expense, furnish and install suitable compacted fill to subgrade as directed by the Architect.

D. Granular fill should not be placed directly on rock surfaces containing voids between fractures. Suitably sized crushed stone or a geotextile should be placed on the fractured surface prior to placing the fill to limit migration of smaller particles into the voids.

E. Rock surfaces that heave due to blasting should be compacted with a vibratory roller that imparts a minimum of 40 kips to the rock surface, prior to placing fill. Heaved rock in excess of 2 feet in thickness should be removed and replaced at the Contractor's expense.

F. To reduce the magnitude of rock heave, drilling for blast holes should extend no more than 2 feet beneath footing bearing elevations; and beneath floor slab, roadways, and athletic fields.

G. To reduce the amount of overblast Contractor may use pre-splitting or controlled blasting. Rock cuts more than 25 feet in height should be pre-split in stages.

H. Complaints:

1. Report all blasting complaints to the Architect within 24 hours of receipt thereof. Include the name, address, date, time received, date and time of blast complained about, and a brief description of the alleged damages or other circumstances upon which the complaint is predicated. Assign each complaint a number, and number all complaints consecutively in order of receipt.
2. Submit a summary report to the Architect each week which indicates the date, time and name of person investigating the complaint, and the amount of damage, if any.
3. When settlement of a claim is made, furnish the Architect with a copy of the release of claim by the claimant.
4. Immediately notify the Architect, throughout the statutory period of liability, of any formal claim or demands made by attorneys on behalf of claimants, or of serving of any notice, summons, subpoena, or other legal documents incidental to litigation, and of any out-of-court settlement or court verdict resulting from litigation.
5. Immediately notify the Architect of any investigations, hearings, or orders received from any governmental agency, board or body claiming to have authority to regulate blasting operations.

I. Basis of Payment: The total amount of rock excavation will be based upon the volume of rock excavated within and/or above the lines referred to in the next paragraph as "Payment Lines".

J. Payment Lines for Rock Excavation – see item 1.15.

3.6 PROCESSING OF BLASTED ROCK ONSITE

A. The Contractor shall be allowed to mobilize a rock crusher to the site to process boulders, blasted rock, and imported rock by blending these materials with the existing fill and natural soil and crushing them to produce a well graded materials, provided that these materials are maintained at suitable moisture contents for proper compaction Processed material obtained by crushing blasted rock, boulders, and soil shall meet the gradation requirements of Ordinary Fill and Structural Fill. Material produced by the crushing operation shall be well graded so as to reduce the potential for formation of honeycombs during its placement and compaction.

B. Re-use of Unprocessed Material: The contractor shall be allowed to use unprocessed material in deep fill areas within the proposed paved areas and athletic fields if the following recommendations are followed:
   1. Large particles (larger than 2/3 of lift thickness) should be culled out or screened.
   2. Unprocessed materials should not be used within 3 feet of the bottom if the subbase of parking lots and athletic fields.
   3. Unprocessed materials should not be used within the proposed building footprint.
   4. Unprocessed materials should not be used during wet weather or when they are wet.

C. The contractor should protect stockpiled unprocessed materials from exposure to moisture using tarps. The tarps should be secured so as not to be moved by wind or other action.

D. Where placed and compacted unprocessed material becomes soft, it should be removed and replaced with suitable backfill at the Contractor's expense.

E. When processing the blasted rock, the Contractor shall mix the blasted rock with onsite soil, including subsoil that is free of organics to produce a well graded processed material.

F. Before blasted rock that is crushed and processed onsite is reused, it should be observed and approved by the geotechnical engineer. The soil to rock proportions placed into the crusher should be varied until the processed material meets the appropriate gradation requirements. The soil to rock proportion thus achieved should be maintained throughout the duration of the project.

G. The material placed into the crusher should be free of organics, wood, and other deleterious matter.

H. The jaws of the crusher should be adjusted periodically to maintain the crushing gradation.

I. Excess blasted rock, processed or unprocessed, not used on site shall be the property of the Contractor and shall be removed offsite at no additional cost to the Owner.

3.7 EXCAVATION, GENERAL

A. Unclassified Excavation: Excavate to subgrade elevations regardless of the character of surface and subsurface conditions encountered. Unclassified excavated materials may include rock, soil materials, and obstructions.

   1. If excavated materials intended for fill and backfill include unsatisfactory soil materials and rock, replace with satisfactory soil materials.
   2. Remove rock to lines and grades indicated to permit installation of permanent construction without exceeding the following dimensions:

      a. 24 inches outside of concrete forms.
      b. 6 inches outside of minimum required dimensions of concrete cast against grade.
      c. 6 inches beneath pipe in trenches, and the greater of 24 inches wider than pipe or 42 inches wide.

B. Provide sheeting, shoring and bracing to complete and protect all excavated areas, are required for safety and compliance with OSHA. Cost for sheeting, shoring and bracing shall be included as a part of the contract price for completing the work and Owner shall make no separate payment for this work.

C. Perform excavation work in accordance with all applicable Federal, State, and Local regulations regarding safe excavation work.

D. Excavation in the area of existing utilities. Expose utilities by hand or other excavation methods that will prevent damage. Required excavation near electric, gas, water lines, and fiber-optic telecommunication lines shall be hand dug within 3 feet of the lines.

E. Do not excavate to full depths when freezing temperatures may be expected unless subgrades are protected from freezing.

3.8 EXCAVATION FOR STRUCTURES

A. Excavate to indicated elevations and dimensions within a tolerance of plus or minus 1 inch If applicable, extend excavations a sufficient distance from structures for placing and removing concrete formwork, for installing services and other construction, and for inspections.

1. Excavation for Underground Tanks, Manholes, Basins, Mechanical and/or Electrical Utility Structures, Drainage and Sewer Systems, Infiltration Systems, and Utility Structures: Excavate to elevations and dimensions indicated within a tolerance of plus or minus 1 inch. Do not disturb bottom of excavations intended as bearing surfaces.

3.9 EXCAVATION FOR WALKS AND PAVEMENTS

A. Excavate surfaces under walks and pavements to indicated lines, cross sections, elevations, and subgrades.

3.10 EXCAVATION FOR UTILITY TRENCHES

A. Excavate trenches to indicated gradients, lines, depths, and elevations.

1. Beyond building perimeter, excavate trenches to allow installation of top of pipe below frost line.

B. Excavate trenches to uniform widths to provide the following clearance on each side of pipe or conduit. Excavate trench walls vertically from trench bottom to 12 inches higher than top of pipe or conduit, unless otherwise indicated.

1. Clearance: 12 inches each side of pipe or conduit.

C. Trench Bottoms: Excavate and shape trench bottoms to provide uniform bearing and support of pipes and conduit. Shape subgrade to provide continuous support for bells, joints, and barrels of pipes and for joints, fittings, and bodies of conduits. Remove projecting stones and sharp objects along trench subgrade.

1. For pipes and conduit less than 6 inches in nominal diameter and flat-bottomed, multiple-duct conduit units, hand-excavate trench bottoms and support pipe and conduit on an undisturbed subgrade.
2. For pipes and conduit 6 inches or larger in nominal diameter, shape bottom of trench to support bottom 90 degrees of pipe circumference. Fill depressions with tamped sand backfill.
3. Excavate trenches 6 inches deeper than elevation required in rock or other unyielding bearing material to allow for bedding course.

3.11 SUBGRADE PREPARATION AND INSPECTION

A. The subgrade shall be shaped to line, grade, and cross section, and be thoroughly compacted in accordance with the requirements of paragraph 3.03. This operation shall include any required reshaping and wetting to obtain proper compaction. All soft or otherwise unsuitable material shall be removed and replaced with suitable material from excavation or borrow. The resulting area, and all other low sections, holes, or depressions shall be brought to the required grade with accepted material and the entire subgrade shaped to line, grade and cross section and thoroughly compacted. The geotechnical engineer may at his discretion request proof-rolling using a loaded rubber tire truck.

B. Before surface or base materials are spread, the subgrade shall be shaped to an accurate and true surface conforming to the line and grades indicated on the Contract Drawings. All surface irregularities shall be filled with suitable material or removed and such areas recompacted until the surface is properly shaped and properly compacted. A tolerance of 3/8-inch in paved areas and 1/2-inch in non-paved areas above or below the finished subgrade elevation will be allowed provided that this dimension above or below grade is not maintained for a distance longer than 50-feet and that the required crown is maintained in the subgrade. Any portion, which is not accessible to a roller, shall be thoroughly compacted by other mechanical or manual methods.

C. Notify the Owner's Representative when excavations have reached required subgrade.

D. If the Owner's Representative, Geotechnical Engineer, and/or the Designer determines that unsatisfactory soil is present, continue excavation and replace with compacted backfill or fill material as directed.

E. Proof-roll granular subgrade below structures and pavements with heavy vibrating drum roller to identify soft pockets and areas of excess yielding. Do not proof-roll wet or saturated subgrades.

1. Completely proof-roll subgrade in one direction, repeating proof-rolling in direction perpendicular to first direction. Limit vehicle speed to 3 mph.
2. Proof-roll with approved equipment weighing not less than 15 tons.
3. Excavate soft spots, unsatisfactory soils, and areas of excessive pumping or rutting, as determined by Designer, and replace with compacted backfill or fill as directed.

F. Reconstruct subgrades damaged by freezing temperatures, frost, rain, accumulated water, or construction activities, as directed by the Geotechnical Engineer and/or the Designer, without additional compensation.

G. Protect all subgrades from disturbance.

1. Place Gravel Borrow or Crushed Stone wrapped in non-woven geotextile over clayey, silty or wet footing subgrades. Fill shall not be placed in standing water.
2. Grade around prepared subgrade areas to direct stormwater runoff away from the work area.
3. Protect subgrades from frost at all times during construction. Fill should not be placed over frozen soil.

3.12 UNAUTHORIZED EXCAVATION

A. Fill unauthorized excavations under site improvement construction or utility pipe as directed by Designer. Lean concrete fill, with 28-day compressive strength of 2500 psi may be used when approved by Designer.

3.13 STORAGE OF SOIL MATERIALS

A. Stockpile borrow soil materials (from offsite sources) and excavated satisfactory soil materials without intermixing. Place, grade, and shape stockpiles to drain surface water. Cover to prevent windblown dust.

1. Stockpile soil materials away from edge of excavations. Do not store within drip line of remaining trees.
2. Stockpile soil materials in a location, acceptable to the Owner's Representative, that will preclude having to relocate stockpiled soil materials that would otherwise delay or impact the Work.

3.14 BACKFILL

A. Place and compact backfill in excavations promptly, but not before completing the following:

1. Construction below finish grade including, where applicable, subdrainage, dampproofing, waterproofing, and perimeter insulation.
2. Surveying locations of underground utilities for Record Documents.
3. Testing and inspecting underground utilities.
4. Removing concrete formwork.
5. Removing trash and debris.
6. Removing temporary shoring and bracing, and sheeting.
7. Installing permanent or temporary horizontal bracing on horizontally supported walls.

B. Place backfill on previously placed and compacted fill and/or subgrades free of mud, frost, snow, or ice.

C. Excavated onsite natural soils may be used as Ordinary Fill, provided the material can be placed and compacted as required herein and at the approval of the Designer.

D. The Contractor shall not commence backfilling operations without approval of the Owner's Representative and/or the Designer.

E. The Contractor shall maintain a dry and firm subgrade throughout construction. Dewatering shall be performed as needed at the Contractor's expense.

F. The Contractor shall strip the existing subgrade of any vegetation, topsoil, organics, debris, or other unsuitable materials. The subgrade shall be proof compacted using a vibratory roller to treat any loose or disturbed areas and to provide a dense uniform surface.

G. After the subgrade has been prepared, fill material shall be placed and built-up in successive layers until the required elevations are reached. No fill shall be placed on a frozen surface, nor shall snow, ice, or other frozen materials be included in fill. Wet materials containing moisture in excess of the amount necessary for satisfactory placement or compaction shall not be used.

H. All fills shall be placed in horizontal layers. Fill shall not be placed following the natural contours of the ground. Fill shall be placed starting in the lowest areas working up to finish grades in horizontal layers in the manner specified herein. Each layer of fill shall be benched into the existing slope in order to avoid the formation of a shear plane.

I. All fill shall be brought up in essentially level lifts and shall be placed in levels by standard methods. Layers of fill outside of utility trenches shall not exceed nine (9) inches in uncompacted thickness before compaction, unless otherwise specified, or as required for proper subgrade stabilization.

J. Filling operations shall continue until the fill has been brought up to the finished slopes, lines, and grades making proper allowances for thickness of the overlying topsoil.

K. The entire surface of the work shall be maintained free from ruts and in the condition that will permit construction equipment to travel over any section readily. The top surface of each layer shall be made level or slightly sloped toward the center of the filled area.

L. Backfilling shall not be performed when weather conditions or the conditions of the materials are such that, in the opinion of the Geotechnical Engineer or the Designer, work cannot be performed satisfactorily.

M. Backfill Material: Unless otherwise specified or directed, material used for filling and backfilling shall meet the material requirements specified herein. In general, the material used for backfilling utility trench excavations shall be material removed from the excavations provided that the reuse of these materials result in the required trench compaction and meets the requirements specified for Ordinary Fill. All backfill placed within the building limits shall be Structural Fill unless otherwise specified. In areas where the bottom of the excavation is in fine sand and silt, and is below the groundwater table, the first lift of backfill shall be 12 inches of 3/4-inch maximum crushed stone to provide a working mat and drainage layer. Place backfill to a maximum loose lift thickness of 12-inches. Maintain backfill material with a uniform moisture content, with no visible wet or dry streaking, between plus two percent and minus three percent of optimum moisture content. The final filled soil mass shall be as uniform as possible in lift thickness, moisture content, and effort required to compact soil mass.

3.15 BACKFILLING AGAINST STRUCTURES

A. Place backfill on subgrades free of mud, frost, snow, or ice.

B. Backfilling against masonry or concrete shall not be done until permitted by the Owner's Representative. The Contractor shall not place backfill against or on structures until they have attained sufficient strength to support the loads (including construction loads) to which they will be subjected, without distortion, cracking or other damage.

C. As soon as practicable after the structures are structurally adequate and other necessary work has been satisfactorily completed and approved, special leakage tests of the structures shall be made by the Contractor, as required by the Owner's Representative. After the satisfactory completion of leakage tests and the satisfactory completion of any other required work in connection with the structures, the backfilling around the structures shall proceed using suitable and approved excavation material.

D. The best of the backfill material shall be used for backfilling within 2-feet of the structure. Just prior to placing backfill, the areas shall be cleaned of all excess construction material and debris and the bottom of excavations shall be in a thoroughly compacted condition.

E. Symmetrical backfill loading shall be maintained. Special care shall be taken to prevent any wedging action or eccentric loading upon or against the structures. During backfilling operations, care shall be exercised that the equipment used will not overload the structures in passing over and compacting these fills. Except as otherwise specified or directed, backfill shall be placed in layers not more than 12 inches in loose depth and each layer of backfill shall be compacted thoroughly and evenly using approved types of mechanical equipment. Each pass of the equipment shall cover the entire area of each layer of backfill.

F. In compacting and other operations, the Contractor shall conduct his operations in a manner to prevent damage to structures due to passage of heavy equipment over, or adjacent to, structures, and any damage thereto shall be made good by the Contractor at no additional expense to the Owner.

3.16 UTILITY TRENCH BACKFILL

A. Place backfill on subgrades free of mud, frost, snow, or ice.

B. Place and compact bedding course on trench bottoms and where indicated. Shape bedding course to provide continuous support for bells, joints, and barrels of pipes and for joints, fittings, and bodies of conduits.

C. Backfill trenches excavated under footings and within 18 inches of bottom of footings with satisfactory soil; fill with concrete to elevation of bottom of footings. Concrete is specified in Section 033000 - CAST-IN-PLACE CONCRETE.

D. Provide 4-inch- thick, concrete-base slab support for piping or conduit less than 30 inches below surface of roadways. After installing and testing, completely encase piping or conduit in a minimum of 4 inches of concrete before backfilling or placing roadway subbase.

E. Place and compact initial backfill of subbase material free of particles larger than 1 inch in any dimension, to a height of 12 inches over the utility pipe or conduit.

1. Carefully compact initial backfill under pipe haunches and compact evenly up on both sides and along the full length of utility piping or conduit to avoid damage or displacement of piping or conduit. Coordinate backfilling with utilities testing.

F. Backfill voids with satisfactory soil while installing and removing shoring and bracing.

G. Backfill material shall be placed in maximum 6-inch lifts and mechanically competed as specified herein.

H. Place and compact final backfill of satisfactory soil to final subgrade elevation.

I. Refer to Document from Lord Associates dated 02/12/2018 Published as appendix D regarding the reuse of existing earthen material and required cover at areas. These requirements are limited to areas of increased exposure and are defined as all areas inside of the interior curb around the building and sports field. Areas outside this ring the existing excavated materials can be used as backfill, subject to meeting grading and other requirements specified herein. (Add. #3)

J. Install warning tape directly above utilities, 12 inches below finished grade, except 6 inches below subgrade under pavements and slabs.

K. Any trenches or excavations improperly backfilled or where settlement occurs shall be reopened, to the depth required for proper compaction, then refilled and compacted with the surface restored to the required grade and condition, at no additional expense to the Owner.

L. During filling and backfilling operations, pipelines will be checked by the Owner's Representative to determine whether any displacement of the pipe has occurred. If the observation of the pipelines shows poor alignment, displaced pipe or any other defects they shall be remedied in a manner satisfactory to the Owner's Representative at no additional cost to the Owner.

3.17 SOIL FILL

A. Plow, scarify, bench, or break up sloped surfaces steeper than 1 vertical to 4 horizontal so fill material will bond with existing material.

B. Place and compact fill material in layers to required elevations as follows:

1. Under grass and planted areas, use satisfactory soil material.
2. Under walks and pavements, use satisfactory soil material.

C. Place soil fills on subgrades free of mud, frost, snow, or ice.

D. In freezing weather, a layer of fill shall not be left in an uncompacted state at the close of the day's operations. Prior to terminating work for the day, the final layer of compacted fill shall be rolled with a smooth wheeled roller to eliminate ridges of soil left by compaction equipment.

3.18 SOIL MOISTURE CONTROL

A. Uniformly moisten or aerate subgrade and each subsequent fill or backfill soil layer before compaction to within 2 percent of optimum moisture content.

1. Do not place backfill or fill soil material on surfaces that are muddy, frozen, or contain frost or ice.
2. Remove and replace or scarify and air dry otherwise satisfactory soil material that exceeds optimum moisture content by 2 percent and is too wet to compact to specified dry unit weight.
3. In no case shall fill be placed over material that is frozen. Fill material shall not be placed, spread or rolled during unfavorable weather conditions. When work is interrupted by heavy rains, fill operations shall not be resumed until the moisture content and the density of the previously placed fill are as specified.
4. Fill that is too dry for proper compaction shall receive water uniformly applied over the surface of the loose layer. Sufficient water shall be added to allow compaction to the required density.

3.19 COMPACTION OF SOIL BACKFILLS AND FILLS

A. Place backfill and fill soil materials in layers not more than 8 inches in loose depth for material compacted by heavy compaction equipment, and not more than 4 inches in loose depth for material compacted by hand-operated tampers.

B. Place backfill and fill soil materials evenly on all sides of structures to required elevations, and uniformly along the full length of each structure.

C. Compact soil materials to not less than the following percentages of maximum dry unit weight according to ASTM D 1557:

Area	ASTM Density Degree of Compaction
Structural Fill below footings	95%
Structural Fill below slabs	95%
Dense Graded Crushed Stone and Gravel Borrow for pavement and walkway base/subbase course	95%
Pavement and walkway subgrade where scarified	95%
Ordinary Fill below pavement and walkway subbase and in fill slopes	95%
Ordinary Fill for trench backfill - below pavements - below landscaped areas - below structures	 95% 92% 95%
All other areas	90%

1. Under structures and pavement, proof-compact existing subgrade. Compact each layer of backfill soil material at 95 percent of the soils' maximum dry density (per ASTM D 1557). Fill areas within the 1H:1V influence zone of foundations and retaining wall footings shall also be compacted to 95 percent of the soils' maximum dry density (per ASTM D 1557).
2. Under walkways, scarify and re-compact top 6 inches below subgrade to 95 percent of the soils' maximum dry density (per ASTM D 1557). Fill and base course material within 2 feet of the finished asphalt or concrete pavement grade shall be compacted to 95 percent of the soils' maximum dry density (per ASTM D 1557).
3. For utility trenches in paved areas, compact each layer of initial and final backfill soil material to at least 95 percent of the soils' maximum dry density (per ASTM D 1557).
4. For utility trenched in lawn or unpaved areas, compact each layer of backfill soil material to at least 92 percent of the soils' maximum dry density (per ASTM D 1557).
5. Under lawn or unpaved areas, scarify and re-compact top 6 inches below subgrade and compact each layer of backfill or fill soil material to at least 90 percent of the soils' maximum dry density (per ASTM D 1557).

6. Fill placed in the top 3 feet under natural and synthetic turf should be compacted per the requirements of the turf designer and the landscape architect.

D. In confined areas, place Crushed Stone in maximum 6-inch lifts and compact each lift with at least 4 passes of a vibratory plate compactor to a firm and unyielding surface. In open areas, place Crushed Stone in maximum 12-inch lifts and compact each lift with at least four passes of a vibratory drum roller with a minimum static weight of 10,000 pounds. Crushed stone fill shall be wrapped on all sides with non-woven filter fabric.

3.20 GRADING

A. General: Uniformly grade areas to a smooth surface, free of irregular surface changes. Comply with compaction requirements and grade to cross sections, lines, and elevations indicated.

1. Provide a smooth transition between adjacent existing grades and new grades.
2. Cut out soft spots, fill low spots, and trim high spots to comply with required surface tolerances.

B. Site Grading: Slope grades to direct water away from buildings and to prevent ponding. Finish subgrades to required elevations within the following tolerances:

1. Lawn or Unpaved Areas: Plus or minus 1 inch.
2. Walks: Plus or minus 1 inch.
3. Pavements: Plus or minus 1/2 inch.

3.21 SUBSURFACE DRAINAGE

A. Subdrainage Pipe: Specified in Division 2 Section "Subdrainage."

B. Subsurface Drain: Place subsurface drainage geotextile around perimeter of subdrainage trench. Place a 6-inch course of filter material on subsurface drainage geotextile to support subdrainage pipe. Encase subdrainage pipe in a minimum of 12 inches of filter material, placed in compacted layers 6 inches thick, and wrap in subsurface drainage geotextile, overlapping sides and ends at least 6 inches.

1. Compact each filter material layer to 85 percent of maximum dry unit weight according to ASTM D 1557.

C. Drainage Backfill: Place and compact filter material over subsurface drain, in width indicated, to within 12 inches of final subgrade, in compacted layers 6 inches thick. Overlay drainage backfill with 1 layer of subsurface drainage geotextile, overlapping sides and ends at least 6 inches.

1. Compact each filter material layer to 85 percent of maximum dry unit weight according to ASTM D 1557.
2. Place and compact impervious fill over drainage backfill in 6-inch-thick compacted layers to final subgrade.

3.22 SUBBASE AND BASE COURSES

A. Place subbase and base course on subgrades free of mud, frost, snow, or ice.

B. On prepared subgrade, place subbase and base course under pavements and walks as follows:

1. Install separation geotextile fabric on prepared subgrade, where indicated on the Contract Drawings, according to manufacturer's written instructions, overlapping sides, and ends.
2. Place base course material over subbase course under asphalt pavement.
3. Shape subbase and base course to required crown elevations and cross-slope grades.
4. Place subbase and base course 6 inches or less in compacted thickness in a single layer.
5. Place subbase and base course that exceeds 6 inches in compacted thickness in layers of equal thickness, with no compacted layer more than 6 inches thick or less than 3 inches thick.
6. Compact subbase and base course at optimum moisture content to required grades, lines, cross sections, and thickness to not less than 95 percent of maximum dry unit weight according to ASTM D 1557.

C. Pavement Shoulders: Place shoulders along edges of subbase and base course to prevent lateral movement. Construct shoulders, at least 12 inches wide, of satisfactory soil materials and compact simultaneously with each subbase and base layer to not less than 95 percent of maximum dry unit weight according to ASTM D 1557.

3.23 DRAINAGE COURSE

A. Place drainage course on subgrades free of mud, frost, snow, or ice.

B. On prepared subgrade, place and compact drainage course under pavements, walkways and cast-in-place concrete slabs-on-grade as follows:

1. Install subdrainage geotextile on prepared subgrade according to manufacturer's written instructions, overlapping sides, and ends.
2. Compact each layer of drainage course to required cross sections and thicknesses to not less than 95 percent of maximum dry unit weight according to ASTM D 1557.

3.24 FIELD QUALITY CONTROL

A. Independent Testing Agency: Cooperate with the Independent Testing Agency engaged by the Owner for field quality control activities for the Work of this Section. Refer also to Section 014325 - TESTING AGENCY SERVICES.

B. Cooperate with field quality control personnel.

C. Additional inspections and retesting of materials which fail to comply with specified material and installation requirements shall be performed at Contractor's expense.

D. Allow testing agency to inspect and test subgrades and each fill or backfill layer. Proceed with subsequent earthwork only after test results for previously completed work comply with requirements.

E. Testing agency will test compaction of soils in place according to ASTM D 1556, ASTM D 2167, ASTM D 2922, and ASTM D 2937, as applicable. Tests will be performed at the following locations and frequencies:

1. Paved Areas: At subgrade and at each compacted fill and backfill layer, at least 1 test for every 2000 sq. ft. or less of paved area or building slab, but in no case fewer than 3 tests.
2. Trench Backfill: At each compacted initial and final backfill layer, at least 1 test for every 150 feet or less of trench length, but no fewer than 2 tests.

F. When testing agency reports that subgrades, fills, or backfills have not achieved degree of compaction specified, scarify and moisten or aerate, or remove and replace soil to depth required; recompact and retest until specified compaction is obtained. Costs related to re-testing due to unacceptable quality of work and failures discovered by the testing shall be borne by the Contractor.

G. Notify the Independent Testing Agency a minimum of 72 hours prior to start of earthwork operations, to comply with Code requirement that a registered design professional be present at all times during backfill to assure adequate compaction with no bridging effects. The services of the Testing Agency, Geotechnical Engineer, and the Designer shall include, but not be limited to, the following:

1. Observation during excavation, backfilling, and compaction.
2. Laboratory testing and analysis of fill materials specified or proposed for use as required.
3. Observation of construction and performance of water content, gradation, and compactions tests at a frequency and at locations that he/she shall selects. The results of these test will be submitted to the Owner's Representative so that the Contractor can take such action as is required to remedy any indicated deficiencies.
4. Observation of proof-compaction of exposed subgrades. Proof-compaction may be waived if, in the opinion of the Geotechnical Engineer, disturbance will occur and cause loss of strength of underlying soil.

H. The Contractor shall make provisions for allowing observations and testing of Contractor's Work by the Testing Agency and the Geotechnical Engineer, and the Designer. The presence of the Testing Agency, Geotechnical Engineering, and/or the Designer does not include supervision or direction of the actual work by the Contractor, his/her employees, or agents. Neither the presence of the Testing Agency, Geotechnical Engineer, and/or the Designer nor any observations and testing performed by those entities or any notice or failure to give notice, shall excuse the Contractor from defect discovered in his/her work.

3.25 PROTECTION

A. No excavation will be permitted below a line drawn downwards at 2 horizontal to 1 vertical from the underside of the closest edge of any proposed in-place footing or utility at a higher elevation without providing adequate sheeting and bracing or underpinning to prevent loss of support of the footing or utility.

B. Protecting Graded Areas: Protect newly graded areas from traffic, freezing, and erosion. Keep free of trash and debris.

C. Repair and reestablish grades to specified tolerances where completed or partially completed surfaces become eroded, rutted, settled, or where they lose compaction due to subsequent construction operations or weather conditions.

1. Scarify or remove and replace soil material to depth as directed by Designer; reshape and recompact.

D. Where settling occurs before Project correction period elapses, remove finished surfacing, backfill with additional soil material, compact, and reconstruct surfacing.

1. Restore appearance, quality, and condition of finished surfacing to match adjacent work, and eliminate evidence of restoration to greatest extent possible.

3.26 DISPOSAL OF SURPLUS AND WASTE MATERIALS

A. Disposal: Contractor shall remove surplus satisfactory soil and waste material, including unsatisfactory soil, trash, and debris, and legally dispose of it off the Owner's property.

End of Section

Section 31 25 00

EROSION AND SEDIMENTATION CONTROLS

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.

1.2 DESCRIPTION OF WORK

A. Work Included: Provide labor, materials, and equipment necessary to complete the work of this Section, including but not limited to the following:

1. Control measures to prevent all erosion, siltation, and sedimentation of wetlands, waterways, construction areas, adjacent areas and off-site areas.
2. Control measures shall be accomplished adjacent to or in the following work areas:

   a. Soil stockpiles and on-site storage and staging areas.
   b. Cut and fill slopes and other stripped and graded areas.
   c. Constructed and existing swales and ditches.
   d. Retention ponds.
   e. At edge of wetlands areas, if applicable, as shown on Drawings.

3. The Contract Drawings indicate the minimum requirements for sedimentation and erosion control. The Contractor shall install all measures needed to control sediment and erosion as required by the Contractor and Sub-contractor's construction methods and operations, the weather conditions, and as directed by the Engineer.
4. Additional means of protection shall be provided by the Contractor as required for continued or unforeseen erosion problems, at no additional cost to the Owner.
5. Periodic maintenance of all sediment control structures shall be provided to ensure intended purpose is accomplished. Sediment control measures shall be in working condition at the end of each day.
6. After any significant rainfall, sediment control structures shall be inspected for integrity. Any damaged device shall be corrected immediately.

B. Alternates: Not Applicable.

C. Items to Be Installed Only: Not Applicable.

D. Items to Be Furnished Only: Not Applicable.

E. Related Work: The following items are not included in this Section and will be performed under the designated Sections:

1. Section 31 10 00 – SITE CLEARING for protection of existing trees and other vegetation to remain.
2. Section 31 20 00 – EARTH MOVING for soil materials, excavating, backfilling, and site grading and removal of site utilities.

1.3 SUBMITTALS

A. Refer to SECTION 01 33 00 – SUBMITTALS for submittal provisions and procedures.

1. At least 20 days prior to the start of the project, the Contractor shall submit an Appendix by a qualified person to the Draft Stormwater Pollution Prevention Plan (SWPPP) indicating project phasing, Contractor operation areas, work areas, stockpile locations, construction staging/sequencing, and sedimentation and erosion control measures to be used. This Appendix shall become part of the SWPPP that is to be updated and maintained by the Contractor.
2. As part of the Contract Closeout procedures, the Contractor is responsible for filing a Notice of Termination with the EPA once the project has been completed and is permanently stabilized. Stabilization is complete when all temporary stormwater and erosion controls have been removed, all permanent stormwater and erosion controls are in place and functional and all vegetated areas are at least 70% viable.
3. The Contractor shall provide the manufacturer's literature, material specification, and installation instructions for sedimentation and erosion control materials and devices for approval. Do not order materials until approval of certifications or test results has been obtained. Delivered materials shall match the approved submittals.
4. LEED Supporting Documentation: Submit LEED supporting documentation as outlined in Section 01 81 10 SUSTAINABLE DESIGN REQUIREMENTS for materials and products that have been extracted, harvested, or recovered, as well as manufactured within 500 miles of the project site.

1.4 QUALITY ASSURANCE

A. When applicable, comply with the requirements of Stormwater Pollution Prevention Plan prepared for the NPDES permit, which are incorporated herein by reference, and all other applicable requirements of governing authorities having jurisdiction. The specifications and drawings are not represented as being comprehensive, but rather convey the intent to provide complete slope protection and erosion control for both the project site and adjacent property.

1. Provide temporary erosion and sedimentation control measures to prevent soil erosion and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways, according to a sediment and erosion control plan specific to the site, that complies with EPA 832/R-92-005 or requirements of authorities having jurisdiction, whichever is more stringent.

B. Erosion control measures shall be established at the beginning of construction and maintained during the entire period of construction. On-site areas which are subject to severe erosion, and off-site areas which are especially vulnerable to damage from erosion and/or sedimentation, are to be identified and receive special attention.

C. The Contractor shall install and maintain sedimentation control devices during construction to prevent the movement of sediment from the construction site to off-site areas, into adjacent water bodies via surface runoff or into underground drainage systems. Measures to prevent the movement of sediment off-site shall be installed, maintained, removed, and cleaned up at no additional cost to the Owner.

D. All land-disturbing activities are to be planned and conducted to minimize the size of the area to be exposed at any one time, and the length of time of exposure.

E. Surface water runoff originating upgrade of exposed areas should be controlled to reduce erosion and sediment loss during the period of exposure.

F. When the increase in the peak rates and velocity of storm-water runoff resulting from a land-disturbing activity is sufficient to cause accelerated erosion of the receiving stream bed, provide measures to control both the velocity and rate of release so as to minimize accelerated erosion and increased sedimentation of the stream.

G. All land-disturbing activities are to be planned and conducted so as to minimize off-site sedimentation damage.

H. The Contractor is responsible for cleaning out and disposing of all sediment once the storage capacity of the sediment facility is reduced by one-half.

I. Inspect, repair, and maintain erosion and sedimentation control measures during construction until permanent vegetation has been established.

J. Remove erosion and sedimentation controls and restore and stabilize areas disturbed during removal.

1.5 REFERENCE STANDARDS

A. The following standards are applicable to the work of this Section to the extent referenced herein:

1. “Massachusetts Erosion and Sedimentation Control Guidelines for Urban and Suburban Areas, A Guide for Planners, Designers and Municipal Officials”, prepared by the Massachusetts Department of Environmental Protection, Bureau of Resource Protection, dated March 1997, reprinted May 2003.

1.6 EXAMINATION OF SITE AND DOCUMENTS

A. It is hereby understood that the Contractor has carefully examined the site and all conditions affecting work under this Section. No claim for additional costs will be allowed because of a lack of knowledge of existing conditions as indicated in the Contract Documents, or obvious from observation of the site.

B. Plans, surveys, measurements, and dimensions under which the work is to be performed are believed to be correct, but the Contractor shall have examined them for himself during the bidding period and formed his own conclusions as to the full requirements of the work involved.

1.7 PERMITS, CODES, AND REGULATIONS

A. Comply with all rules, regulations, laws, and ordinances of the City and State, and all other authorities having jurisdiction over the project site. All labor, materials, equipment, and services necessary to make the work comply with such requirements shall be provided by the Contractor without additional cost to the Owner.

B. Comply with all applicable regulations of the Commonwealth of Massachusetts Department of Environmental Protection (DEP) and the EPA.

C. The Contractor shall comply with the requirements of the NPDES CGP for this project.

1.8 STORM WATER POLLUTION PREVENTION PLAN

A. A professional engineer has prepared a Draft Storm Water Pollution Prevention Plan (SWPPP). The Contractor shall locate the SWPPP and review its contents thoroughly. Upon the award of the Contract, the Contractor becomes responsible for implementing the

SWPPP and meeting the requirements and standards detailed within the SWPPP. The Contractor is also responsible for all record keeping associated with maintaining the SWPPP and for maintaining in good operating condition all SWPPP controls. The Contractor shall modify the SWPPP as necessary to reflect changes in project scope, schedule, or approach. All labor, materials, equipment, and services necessary to make the work comply with such requirements shall be provided by the Contractor without additional cost to the Owner.

B. The Contractor shall fill out all pertinent information within the SWPPP.

C. The Contractor shall locate the EPA "Notice of Intent for Storm Water Discharges Associated with CONSTRUCTION ACTIVITY Under a NPDES General Permit" (NOI) form in the SWPPP. The Contractor is responsible for signing and filing his copy of the NOI at least 14 calendar days prior to the start of any construction activity and placing a signed copy along with proof of mailing in the SWPPP.

D. The Contractor is responsible for obtaining a copy of the Owner's filed copy of the NOI form and proof of mailing and placing it in the SWPPP.

E. The Contractor is responsible for filling in the Contractor and Sub-Contractor information in the areas indicated within the SWPPP and for completing the Contractor's Certification portion of the SWPPP.

F. The Contractor is responsible for maintaining the following records on site:

1. Completed SWPPP as indicated in sections B, C, D, and E.
2. Completed Inspection Reports
3. Completed Maintenance Reports
4. Construction Activity Reports
5. Spill Records
6. Other Materials relevant to the NOI Permit and SWPPP
7. A copy of the Notice of Termination

G. The Contractor is responsible for filing a Notice of Termination once the project has been completed and is permanently stabilized. Stabilization is complete when all temporary storm water and erosion controls have been removed, all permanent storm water and erosion controls are in place and functional and all vegetated areas are at least 70% viable.

H. All labor, materials, equipment, and services necessary to make the work comply with the above requirements shall be provided by the Contractor without additional cost to the Owner.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Straw Bales: Wire or nylon bound bales of straw, oriented around sides, rather than over and under.

B. Stakes: Stakes for bales shall be one of the following materials: Wood stakes of sound hardwood 2 by 2 inches in size or steel reinforcing bars of at least No. 4 size. Lengths shall be approximately three feet.

C. Straw Wattles

1. Straw wattles shall consist of weed-free rice straw inside biodegradable netting. Straw wattles shall measure at least nine (9) inches in diameter.
2. Stakes for wattles shall be one of the following materials. Lengths shall be approximately two feet (2').

    a. Wood stakes of sound hardwood, one inch by one inch (1" x 1") in size.
    b. Steel reinforcing bars of at least No. 4 size.

D. Siltation Fence

1. Fabricated or prefabricated unit consisting of the following filter fabric properties:

a.	Grab Tensile Strength (lbs)	124	ASTM D4632
b.	Elongation at Failure (%)	15	ASTM D4632
c.	Mullen Burst Strength (PSI)	280-300	ASTM D3786
d.	Puncture Strength (lbs)	60-65	ASTM D4833
e.	Water Flow Rate (gal/min/sf)	8-10	ASTM D4491
f.	Apparent Opening Size (Sieve)	30	ASTM D4751
g.	Ultraviolet Radiation Stability (%)	70-80	ASTM D4355

2. Use only commercially available fabric that is certified in writing by the manufacturer for the purpose intended.
3. Acceptable fabric materials include "Mirafi Envirofence" by Mirafi Construction Products, "Style 2130" by Amoco Fabrics Co., and "IVI 3617C Silt Fence" by Indian Valley Industries, Inc., or approved equal by the Engineer.
4. Silt fence posts: Posts may be wood or metal. Wood post shall be a minimum 1¼ inch by 1¼ inch by 5 feet long hardwood stakes commonly used to support siltation fabric. Metal posts shall be a minimum of 1 inch wide and 5 feet long. Posts shall be spaced at a maximum distance of 8 feet on center.
5. Provide suitable heavy nylon cord for securing abutting silt fence posts.

E. Fencing: Steel posts shall be standard 6-foot-long metal stamped drive stakes commonly used to support snow fences. Fencing shall be new four-foot height wood lath snow fencing. Provide suitable steel staples or heavy nylon cord for securing filter cloth to support system.

F. Crushed Stone: Crushed Stone: Crushed stone shall consist of durable crushed rock or durable crushed gravel stone, free from ice and snow, sand, clay, loam, or other deleterious or organic material. The crushed stone shall be uniformly blended and shall conform to the following requirements.

Percent Passing by Weight		
Sieve Size	**1 1/2-inch Stone**	**3/4-inch Stone**
2-inch	100	---
1 1/2-inch	95-100	---
1 1/4-inch	---	---
1-inch	35-70	100
3/4-inch	0-25	90-100
1/2-inch	---	10-50
3/8-inch	---	0-20

Percent Passing by Weight		
Sieve Size	**1 1/2-inch Stone**	**3/4-inch Stone**
No. 4	---	0-5

G. Protective Measures: As temporary coverings on ground areas subject to erosion, provide one of the following protective measures, and as directed by the Designer with concurrence of the Owner's Representative:

1. Hay or straw temporary mulch, 100 pounds per 1,000 square feet.
2. Wood fiber cellulose temporary mulch, 35 pounds per 1,000 square feet.
3. Tackifier for anchoring mulch or straw shall be a non-petroleum based liquid bonding agent specifically made for anchoring hay or straw.
4. Provide natural (jute, wood excelsior) or man-made (glass fiber) covering with suitable staples or anchors to secure to ground surface. Note that wire staples and non-biodegradable coverings shall not be used for any area that will be mown turf.
5. Temporary vegetative cover for graded areas shall be undamaged, air dry threshed straw or hay free of undesirable weed seed.

H. Temporary Covers For Drainage Structures

1. Filter fabric for use as temporary covers for drainage structures shall be the same as noted above for siltation fence.
2. Wire mesh for use at temporary drainage structure covers shall be 6" x 6", W2.9 welded wire mesh.
3. Crushed stone shall be as specified herein before.
4. Silt-Sac, Hydro-FloGard + Plus Catch Basin Insert, Ultra-DrainGuard Insert, or approved equal, may be used in lieu of hay bales and filter fabric at catch basins.

PART 3 - EXECUTION

3.1 GENERAL REQUIREMENTS

A. The Contractor shall provide suitable and adequate means of sedimentation and erosion control during construction. Control measures shall prevent all erosion, siltation, and sedimentation of waterways, drainage systems, construction areas, adjacent areas and off-site areas. Work shall be accomplished on and/or adjacent to the following work areas:

1. Earthwork stockpiles and on-site storage and staging areas.
2. Cut and fill slopes and other stripped and exposed graded areas.
3. Constructed and existing swales and ditches.
4. Unestablished lawns and seeded embankments.

B. Means of protection as noted on the Contract Drawings indicate the minimum provisions necessary. Additional means of protection shall be provided by the Contractor as required for continued or unforeseen erosion problems, at no additional expense to the Owner.

C. Periodic maintenance of all sediment control installations shall be provided to ensure intended purposes are accomplished. Sediment control measures shall be in working condition at the end of each day.

D. After any significant rainfall, sediment control devices shall be inspected for integrity. Any damaged device shall be corrected immediately.

E. The Contractor shall provide adequate means of control of runoff, as to not detrimentally impact downstream conditions during construction. The Contractor shall plan his operations so that permanent drainage mitigation systems such as detention/retention/infiltration basins and chambers are in place and properly functioning prior to connecting upland drainage flows to these systems. The Contractor shall plan his operations such that downstream drainage mitigation measures are in place and functioning before attempting to tie in upgradient drainage systems.

F. In the event that the Contractor is unable to sequence the work so that construction of the permanent drainage mitigation systems precedes the upland work, then the Contractor shall submit a plan indicating his proposed methods of otherwise controlling runoff from the site.

G. The "Massachusetts Erosion and Sedimentation Control Guidelines for Urban and Suburban Areas" should be consulted as a guide for the selection and installation of Best Management Practices to suit the conditions encountered.

3.2 STRAW BALE BARRIERS

A. Excavation shall be to the width of the bale and the length of the proposed barrier to a minimum depth of 4 inches.

B. Bales shall be placed in a single row, lengthwise on proposed line, with ends of adjacent bales tightly abutting one another. In swales and ditches, the barrier shall extend to such a length that the bottoms of the end bales are higher in elevation than the top of the lowest middle bale.

C. Staking shall be accomplished to securely anchor bales by driving at least two stakes or rebars through each bale to a minimum depth of 18 inches.

D. The gaps between bales shall be filled by wedging straw in the gaps to prevent water from escaping between the bales.

E. The excavated soil shall be backfilled against the barrier. Backfill shall conform to ground level on the downhill side and shall be built up to 4 inches on the uphill side. Loose straw shall then be scattered over the area immediately uphill from a straw barrier.

F. Inspection shall be frequent, and repair or replacement shall be made promptly as needed.

G. Bales shall be removed when they have served their usefulness so as not to block or impede stormwater flows or drainage.

3.3 STRAW WATTLE BARRIERS

A. Install straw wattles in locations as shown on Contract Drawings and as directed.

1. Wattles shall be placed in a row with ends overlapping a minimum of two (2) feet.
2. Each wattle shall be embedded in the soil a minimum of two (2) and a maximum of six (6) inches.
3. Wattles shall be securely anchored in place by stakes or rebars driven through the wattles and a minimum twelve (12) inches into the soil. Stakes shall be placed four (4) feet on center.

B. Inspection shall be frequent, and repair or replacement shall be made as needed.

C. Wattles shall be removed when they have served their usefulness so as not to block or impede stormwater flows or drainage.

3.4 STABILIZED CONSTRUCTION ENTRANCE AND STONE BERMS

A. Stone size: Use ASTM designation C-33, size No. 2 (1-1/2" to 2-1/2"). Use crushed stone.

B. Length: As effective, but not less than 50 feet.

C. Thickness: Not less than eight inches.

D. Width: Not less than full width of all points on ingress or egress, but not less than 25 feet.

E. Washing: When necessary, wheels shall be cleaned to remove sediment prior to entrance onto public right-of-way. When washing is required, it shall be done on an area stabilized with crushed stone which drains into an approved sediment trap or sediment basin. All sediment shall be prevented from entering any storm drain, ditch, or watercourse through the use of sandbags, gravel boards or other approved methods.

F. Maintenance: The entrance shall be maintained in a condition which will prevent tracking or flowing of sediment onto public rights-of-way. This may require periodic top dressing with additional stone as conditions demand and repair and/or cleanout of any measures used to trap sediment. All sediment spoiled, dropped, washed or tracked onto public rights-of-way must be removed immediately.

G. Place crushed stone berms in locations required and as directed. Berms shall have side slopes of 1:3 or less.

H. Inspect stone berms periodically and replace and/or regrade crushed stone as required.

3.5 SILT FENCING

A. Excavate a 6-inch trench along the upstream side of the desired fence location.

B. Drive fence posts a minimum of 1'-6" into the ground. Install fence, well-staked at maximum eight-foot intervals in locations as shown on Drawings. Secure fabric to fence and bury fabric end within the six-inch deep trench cut.

C. Lay lower 12 inches of silt fence into the trench, 6 inches deep and 6 inches wide. Backfill trench and compact.

D. Overlap joints in fabric at post to prevent leakage of silt at seam.

E. Inspect siltation fence after major storm events and periodically and remove accumulated sediment and debris. If a breach or failure of the siltation fence occurs, the fence shall immediately be restored.

3.6 EROSION CONTROL GRASSING

A. Grassing shall be applied according to State of Massachusetts Highway Department Standard Specifications.

3.7 INLET PROTECTION

A. Install silt fence or straw bales around inlet as specified herein.

B. Install temporary covers at drainage structure locations that may be subject to erosion infiltration and as directed by the Engineer.

C. Inspect drainage structures periodically. Remove sediment accumulation and regrade or replace materials as required.

3.8 DUST CONTROL

A. Throughout the construction period the Contractor shall carry on an active program for the control of fugitive dust within all site construction zones, or areas disturbed as a result of construction. Control methods shall include the following: Apply calcium chloride at a uniform rate of one and one-half (1 ½) pounds per square yard in areas subject to blowing. For emergency control of dust apply water to affected areas. The source of supply and the method of application for water are the responsibility of the contractor.

B. The frequency and methods of application for fugitive dust control shall be as directed by the Designer with concurrence by the Owner's Representative.

3.9 TEMPORARY PROTECTIVE COVERINGS

A. Place temporary soil coverings to control erosion and sedimentation on all disturbed or graded areas as required by the construction methods employed and as directed by the Engineer. Erosion control matting shall be installed in all areas seeded or hydroseeded with slopes of one vertical foot to three-foot horizontal, or steeper, immediately after such areas have been seeded and a hay mulch applied as follows:

1. The area to receive matting shall have been recently seeded and shall have a smooth surface free front stones, clods or depressions.
2. Roll out of the matting perpendicular to the slope, do not stretch the fabric. In drainage swales, center the fabric along the flow line. Install the matting in a check slot at the top and bottom of the slope and at the edges of the area to be covered. Check slots shall be six inches deep and six inches wide. Fabric shall extend down one wall of the check slot and across the full width of the base. Overlap edges of matting rolls four (4) inches minimum and overlap the ends eighteen (18) inches minimum.
3. Install staples in check slots, edges, center, and ends of rolls by driving specified steel staples two feet on center over the entire area to be covered except at check slots and ends of rolls, where staples shall be placed six inches on center. All staples shall be driven below finished grade.
4. Fill check slots with loam and tamp firmly.
5. Reseed check slots and all disturbed areas per Specifications.
6. Following matting installation, roll the entire area with a smooth drum roller weighing between fifty and seventy-five (50-75) pounds per linear foot of roller. The finished installation of matting shall be firmly in contact with the seeded area and provide a smooth, finished appearance free from lumps or depressions.

B. Install erosion control matting as a temporary ground cover in all disturbed or graded areas subject to erosion and as directed by the Engineer. The temporary ground cover shall protect the site from erosion until a full permanent lawn can be installed. Install and anchor in place temporary erosion control matting in accordance with manufacturer's printed instructions or as directed by the Engineer and remove all temporary erosion control matting prior to installation of a permanent lawn.

C. Inspect protective coverings periodically and reset or replace materials as required.

3.10 TEMPORARY PROTECTIVE COVERINGS (AFTER GROWING SEASON)

A. Place temporary covering for erosion and sedimentation control on all areas that have been graded and left exposed after October 30. Contractor shall have the choice to use either or both of the methods described herein.

B. Hay or straw shall be anchored in place by one of the following methods and as approved by the Designer with concurrence by the Owner's Representative: Mechanical "crimping" with a tractor-drawn device specifically devised to cut mulch into top two inches of soil surface or application of non-petroleum based liquid tackifier, applied at a rate and in accordance with manufacturer's instructions for specific mulch material utilized.

C. Placement of mesh or blanket matting and anchoring in place shall be in accordance with manufacturer's printed instructions.

D. Inspect protective coverings periodically and reset or replace materials as required.

3.11 REMOVAL AND FINAL CLEANUP

A. Once the site has been fully stabilized against erosion, and with the approval of the Owner's Representative remove sediment control devices and all accumulated silt. Dispose of silt and waste materials offsite. Regrade all areas disturbed during this process and stabilize against erosion with surfacing materials as indicated.

End of Section

Section 32 12 16

ASPHALT PAVING

PART 1-GENERAL

1.1 GENERAL PROVISIONS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.

1.2 DESCRIPTION OF WORK

A. Work Included: Provide labor, materials, and equipment necessary to complete the work of this Section, including but not limited to the following:

1. Hot-mix asphalt paving, including walkways, ramps, and curbs.
2. Hot-mix asphalt patching.
3. Pavement-marking paint.
4. Setting of Curb.

B. Alternates: Not Applicable.

C. Items to Be Installed Only: Not Applicable.

D. Items to Be Furnished Only: Not Applicable.

E. Related Work: The following items are not included in this Section and will be performed under the designated Sections:

1. Section 31 20 00 - EARTH MOVING for aggregate subbase and base courses and for aggregate pavement shoulders.

1.3 SUBMITTALS

A. Product Data: For each type of product indicated. Include technical data and tested physical and performance properties.

1. Job-Mix Designs: Certification, by authorities having jurisdiction, of approval of each job mix proposed for the Work.

B. Shop Drawings: Indicate pavement markings, lane separations, and defined parking spaces. Indicate, with international symbol of accessibility, spaces allocated for people with disabilities. Submit shop drawings for curbing items.

C. Material Certificates: For each paving material, from manufacturer.

1.4 REFERENCE STANDARDS

A. The following standards are applicable to the work of this Section to the extent referenced herein:

1. Commonwealth of Massachusetts, Massachusetts Highway Department (MHD), Standard Specifications for Highways and Bridges, latest English Edition with amendments. All references to method of measurement, basis of payment and payment items in the Standard Specifications are hereby deleted. References made to particular sections or paragraphs in the Standard Specifications shall include all related articles mentioned herein.
2. ASTM: American Society for Testing and Materials
3. AASHTO: American Association of State Highway and Transportation Officials
4. ACI: American Concrete Institute
5. MUTCD: Manual on Uniform Traffic Control Devices
6. City of Worcester Department of Public Works and Parks Standard Specifications and Details, latest edition.

1.5 QUALITY ASSURANCE

A. Manufacturer Qualifications: A paving-mix manufacturer registered with and approved by the Massachusetts Highway Department (MHD).

B. Regulatory Requirements: Comply with materials, workmanship, and other applicable requirements of the Massachusetts Highway Department (MHD) for hot mix asphalt paving work.

1. Comply with requirements of the Massachusetts Highway Department (MHD) Standard Specifications for Highways and Bridges, including supplemental specifications and special provisions.
2. Comply with requirements of the Americans with Disabilities Act (ADA) and the Massachusetts Architectural Access Board (MAAB). If these requirements cannot be met with the grades and slopes indicated on the plans, notify the Designer immediately.
3. Comply with requirements of the local authority having jurisdiction concerning the location and construction of accessible curb cuts.

C. Preinstallation Conference: Conduct conference at Project site to comply with requirements in Division 01.

1. Review methods and procedures related to hot-mix asphalt paving including, but not limited to, the following:
    a. Review proposed sources of paving materials, including capabilities and location of plant that will manufacture hot-mix asphalt.
    b. Review condition of subgrade and preparatory work.
    c. Review requirements for protecting paving work, including restriction of traffic during installation period and for remainder of construction period.
    d. Review and finalize construction schedule and verify availability of materials, Installer's personnel, equipment, and facilities needed to make progress and avoid delays.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver pavement-marking materials to Project site in original packages with seals unbroken and bearing manufacturer's labels containing brand name and type of material, date of manufacture, and directions for storage.

B. Store pavement-marking materials in a clean, dry, protected location within temperature range required by manufacturer. Protect stored materials from direct sunlight.

1.7 PROJECT CONDITIONS

A. Traffic Control: Maintain access for vehicular and pedestrian traffic as required for other construction activities.

B. Environmental Limitations: Do not apply asphalt materials if subgrade is wet or excessively damp, if rain is imminent or expected before time required for adequate cure, or if the following conditions are not met:

1. Tack Coat: Minimum surface temperature of 60 deg F.
2. Asphalt Base Course: Minimum surface temperature of 40 deg F and rising at time of placement.
3. Asphalt Surface Course: Minimum surface temperature of 60 deg F at time of placement.

C. Pavement-Marking Paint: Proceed with pavement marking only on clean, dry surfaces and at a minimum ambient or surface temperature of 40 deg F for thermoplastic materials, and not exceeding 95 deg F.

1.8 EXAMINATION OF SITE AND DOCUMENTS

A. It is hereby understood that the Contractor has carefully examined the site and all conditions affecting work under this Section. No claim for additional costs will be allowed because of a lack of knowledge of existing conditions as indicated in the Construction Documents, or obvious from observation of the site.

B. Plans, surveys, measurements, and dimensions under which the work is to be performed are believed to be correct, but the Contractor shall have examined them for himself during the bidding period and formed his own conclusions as to the full requirements of the work involved.

1.9 ADA AND MAAB COMPLIANCE

A. Comply with American with Disabilities Act (ADA) and the requirements of the Massachusetts Architectural Access Board (MAAB).

1. Slopes: Walkways, as defined by Section 22.1 of 521 CMR, shall be graded to a maximum of 4.5%. The cross-pitch (perpendicular to travel) for walkways and paths shall be constructed at 1.5%. The slopes of ramps and side slopes on handicap curb cuts as defined by Section 21.1 of 521 CMR shall be constructed at 7% maximum. Ramps, as defined in Section 24.1 of 521 CMR, shall be constructed to a maximum slope of 7%.
2. The Contractor is to assume that sidewalk grades will be verified and checked with a 2-foot long electronic ‘smart level’.
3. A 5’-0” minimum level, 1.5% pitch, area shall be provided at entrances to buildings. Puddling or ponding of water at the entrances will not be accepted.
4. Handicap parking spaces and access aisles shall be graded level with the slope not to exceed 1.8% in any direction.
5. The requirements specified hereinabove shall supersede the grades indicated on the Drawings. If these requirements cannot be met with the grades indicated on the Drawings, the Designer shall be notified immediately for direction.

PART 2-PRODUCTS

2.1 AGGREGATES

A. Coarse Aggregate: ASTM D 692, sound; angular crushed stone, crushed gravel, or cured, crushed blast-furnace slag.

B. Fine Aggregate: ASTM D 1073 or AASHTO M 29, sharp-edged natural sand or sand prepared from stone, gravel, cured blast-furnace slag, or combinations thereof.

C. Mineral Filler: ASTM D 242 or AASHTO M 17, rock or slag dust, hydraulic cement, or other inert material.

D. Reclaimed Asphalt Pavement (RAP): Provide material obtained from the highways or streets by crushing, milling, or planing existing hot mix asphalt pavements.

1. The proportion of RAP to virgin aggregate for base course mixtures and intermediate course mixtures shall be limited to a maximum of 40% for drum mix plants and 20% for modified batch plants. The maximum amount of RAP for surface course mixtures shall be 10%.

E. RECLAIMED BASE COURSE

1. The work under this item shall consist of scarifying and pulverizing in place the existing asphalt pavement and underlying material, mixing and blending the material, and spreading and compacting the mixture to the lines and grades shown on the Contract Drawings.
2. Equipment such as rear-mounted ripper crushers and cold planing/milling equipment will not be permitted to perform the work under this item.
3. Prior to scarifying and pulverizing the pavement, the Contractor shall locate, protect, or remove all drainage and utility structure castings. All lowered structures shall be protected and covered by a steel plate and all watergates shall be covered as well to prevent any materials from falling into the bottom sections. All materials that fall into any structures as a result of the Contractor's operations shall be removed by the Contractor at no additional cost.
4. The existing full bituminous pavement structure and underlying base materials shall be simultaneously crushed, pulverized, and blended into a homogenous material to create the following gradation:

Sieve Designation	Percent Passing
2-inch	100
1½-inch	70-100
½-inch	50-85
No. 4	30-60
No. 50	8-28
No. 200	0-10

5. The construction operation shall be performed in such a manner as to allow for continuous vehicular access as required by the project schedule. Emergency vehicular access shall be maintained at all times.

2.2 ASPHALT MATERIALS

A. Asphalt Binder, Performance Graded: AASHTO M320 or AASHTO MP 1a, performance grade as required by MHD Specifications.

B. Tack Coat: AASHTO M 140 emulsified asphalt, or AASHTO M 208 cationic emulsified asphalt, slow setting, diluted in water, of suitable grade and consistency for application.

2.3 AUXILIARY MATERIALS

A. Herbicide: Commercial chemical for weed control, registered by the EPA. Provide in granular, liquid, or wettable powder form.

B. Pavement-Marking Paint: White Thermoplastic Reflectorized Pavement Markings and Yellow Thermoplastic Reflectorized Pavement Markings as specified in the “Standard Specifications” under Sections M7.01.03 and M7.01.04, respectively.

1. Color: As indicated

C. Detectable Warning Panels shall have dome geometry in accordance with ADA Regulations for Detectable Warning on Curb Ramps. They shall be raised truncated domes with a nominal diameter of 0.9-inches, a nominal height of 0.2-inches, and a center-to-center spacing of 1.6 inches to 2.4-inches. Panels shall be 24-inches deep in the direction of travel and the full width of the proposed ramp. The panel shall be a homogeneous glass and carbon reinforced composite, which is colorfast, and UV stable. The panel is to be colored throughout and not a painted coating. The color shall be yellow. The panels shall have a compressive strength in excess of 10,000 psi, flexural strength in excess of 3,000 psi and a slip resistance in excess of 0.8 wet or dry.

D. Thermo-applied asphalt pattern: StreetPrint by the manufacturer Genuine Stamped Asphalt shall be applied in the “Running Bond” pattern to vehicular areas as indicated in the construction documents.

E. Wheel Stops: Precast, air-entrained concrete, 2500-psi minimum compressive strength, 4-1/2 inches high by 9 inches wide by 72 inches long. Provide chamfered corners, drainage slots on underside, and holes for anchoring to substrate.

1. Dowels: Galvanized steel, 3/4-inch diameter, 10-inch minimum length.

2.4 ASPHALT MIXES

A. Hot-Mix Asphalt: Dense, hot-laid, hot-mix asphalt plant mixes approved by MHD Specifications and designed according to procedures in AI MS-2, "Mix Design Methods for Asphalt Concrete and Other Hot-Mix Types".

B. Mix design shall be Superpave 9.5mm Level 2 for top course and Superpave 12.5mm Level 2 for binder course.

2.5 ASPHALT CURB

A. Bituminous concrete curb shall conform to Section 501.64 of the Standard Specifications for Class 1 Bituminous Concrete Curb, Type-2 and Type-3 and shall meet the dimensions as shown on the Contract Drawings.

B. Bituminous concrete shall meet the requirements of Dense Mix as specified in the Standard Specifications under Section M3.12.00.

2.6 GRANITE CURB AND EDGING

A. Granite curb and edging shall be light gray in color, free of seams and other imperfections, which would affect its structural integrity. The front face of the stone shall be at right angles to the plane of the top and the ends and shall have a smooth surface. The ends of the stones shall be square with the planes of the top and front face to provide flush joints. Top surface shall be sawn cut with a split front face.

B. Granite curb shall have a top width of six-inches and a depth of 17 to 19-inches and a minimum length of 6-feet. Granite edging shall have a thickness of five to six inches and a depth of 11 to 13-inches with a minimum length of 4-feet.

C. Granite curb to be set on a radius of 100-feet or less shall be cut to the required radius. Granite edging set on a radius of 160-feet or less shall be supplied in lengths shorter than 6-feet but no less than 1-foot to provide a smooth appearance.

D. The ends of all transition curb shall be cut with a power-driven saw to provide a flush vertical joint with adjacent curbing

2.7 PRECAST CONCRETE CURB

A. Precast concrete curb units shall consist of castings conforming to a 6-inch by 18-inch nominal profile size with a 7-inch base dimension. Straight curb shall be cast in minimum lengths of 6 feet. Straight and curved curb may be cast in lengths of not less than 3 feet for closure sections only. Curb on a radius of 100 feet or less shall be cast in radius forms to the correct radius. The Contractor shall supply special cast corner sections for all corners where curb runs change direction. All curbs shall have a ½ inch chamfered edge on both ends and front sides as detailed. The front top edge shall have a ¾ inch radius and the back-top edge shall have a ¼-inch radius.

B. Curb shall be made of Portland cement types I or III, conforming to ASTM C150. Admixtures shall meet ASTM C233. Forms shall be made of metal to tight, rigid construction with true surfaces. Wood forms are not acceptable except for cast-in-place closure sections.

C. Concrete mix for curb shall be made of a maximum ¾-inch aggregate with a design strength of 5,000 psi at 28 days. An air-entraining agent shall be added to the mixer in accurately proportioned amounts to give air content to the concrete of not less than 5 percent and not more than 7 percent by volume. A high range water-reducing agent (superplasticizer) shall be added to the mixer in accurately proportioned amounts to meet design strength requirements and maintain a smooth, dense surface on the curb.

D. Surface Treatment: Upon removal from the forms, the surfaces of the curb shall have all surfaces rubbed with a carborundum stone to fully remove any rough or imperfections in the cast finish. All curbing sections shall have a uniform color and finish appearance and shall be approved by the Architect. An approved sample shall be standard for the entire job.

E. Curb shall be reinforced with bars conforming to ASTM A615.

2.8 SEALCOAT

A. Asphalt emulsion sealcoat shall conform to the requirements of the Asphalt Institute for seal coating. Non-volatile solids shall be 40-70%. No additional water shall be added. The emulsion shall be produced using a colloid mill to ensure homogeneity and appropriate size of the particles in suspension.

B. Sand shall be washed and graded silica sand, or crushed, washed, and graded slag, free of all contaminants, and conforming within a 40-70 mesh gradation range. The addition of sand shall target 3 lbs.−4 lbs. per gallon.

C. Sand shall be slowly added into the emulsion with the mixer engaged during the addition of the sand to ensure uniform dispersion and to prevent overloading of the mixing device. No additional water shall be added.

D. Slow mixing shall be continuous from the time all materials are placed into the mixer until the pavement sealer mix is applied to the pavement by the application equipment. During the entire mixing process, no breaking, segregating, or hardening of the emulsion, and no balling or lumping of the aggregate shall be permitted.

E. The Contractor shall submit a certified analysis of the proposed asphalt bulk emulsion, non-volatiles content, and ash content.

2.9 SEALANT FOR CRACK FILLING/SEALING

A. The sealant material shall be a hot pour elastomeric type conforming to the requirements of ASTM D 6690 Type II, together with the following modifications:

Cone Penetration at 77ºF (25ºC), 150 g, 5 sec.	50 – 90
Flow at 140ºF (60ºC), 75-degree angle, 5 hrs.	5 mm
Bond at 0ºF (-18ºC), 100 percent extension, ½" (12.7mm) thick specimen	Pass 5 cycles
Resilience at 77ºF (25ºC)	25 - 60

B. Storage, heating instructions, and cautions shall be printed on each box of sealant. The sealant must be able to be reheated to application temperature at least once after the initial heat up without degradation of sealant specifications. Sealant shall have an application life at application temperature of approximately 12 to 15 hours.

C. Prior to the use of the sealant material, the contractor shall submit to the Engineer, the appropriate material certification or laboratory test indicating that the material meets specification requirements.

PART 3-EXECUTION

3.1 EXAMINATION

A. Examine exposed subgrades and subbase surfaces for compliance with requirements for dimensional, grading, and elevation tolerances.

B. Proof-roll subgrade below pavements with heavy pneumatic-tired equipment to identify soft pockets and areas of excess yielding. Do not proof-roll wet or saturated subgrades.

C. Proceed with paving only after unsatisfactory conditions have been corrected.

3.2 COLD MILLING

A. This work consists of removing bituminous or cement concrete pavements by use of a cold planer in areas designed on the Contract Drawings. The cold planer must be equipped with an elevating device capable of loading planed material directly into dump trucks while

operative. It shall have all the necessary safety devices, such as reflectors, headlights, taillights, flashing lights, and backup signals so as to operate safely in traffic both day and/or night.

B. The cold planer shall be designed and built for planing flexible pavements and possess the ability to plane cement concrete patches when encountered in bituminous pavement. It shall be self-propelled and have the means for planing without tearing or gouging the underlying surface. Variable lacing patterns shall be provided to permit a rough grooved or smooth surface as directed.

C. The cold planer shall be able to make up to a 3-inch cut or any specified lesser depth may be required in one pass. The minimum width of pavement planed in each pass shall be 6 feet, except in areas to be trimmed and edged. The machine shall be adjustable as to crown and depth and meet the standards set by the Air Quality Act for noise and air pollution.

D. The planed surface shall conform to the grade and cross-slope required. The surface shall not be torn, gouged, shoved, broken, or excessively grooved. It shall be free of imperfections in workmanship that prevent resurfacing after this operation. Surface texture shall be as specified by the Engineer and excess material shall be removed so the surface is acceptable to traffic if required.

E. Clean existing pavement surface of loose and deleterious material immediately before cold milling. Remove existing asphalt pavement by cold milling to grades and cross sections indicated.

3.3 PATCHING

A. Existing Hot-Mix Asphalt Pavement: Saw-cut perimeter of patch and excavate existing pavement section to sound base. Excavate rectangular or trapezoidal patches, extending 12 inches into adjacent sound pavement, unless otherwise indicated. Cut excavation faces vertically. Remove excavated material. Recompact existing unbound-aggregate base course to form new subgrade.

B. Existing Portland Cement Concrete Pavement: Break cracked slabs and roll as required to reseat concrete pieces firmly.

1. Remove disintegrated or badly cracked pavement. Excavate rectangular or trapezoidal patches, extending into adjacent sound pavement, unless otherwise indicated. Cut excavation faces vertically. Recompact existing unbound-aggregate base course to form new subgrade.

C. Tack Coat: Apply uniformly to vertical surfaces abutting or projecting into new, hot-mix asphalt paving at a minimum rate of 0.05 to 0.15 gal./sq. yd.

1. Allow tack coat to cure undisturbed before applying hot-mix asphalt paving.
2. Avoid smearing or staining adjoining surfaces, appurtenances, and surroundings. Remove spillages and clean affected surfaces.

D. Patching: Fill excavated pavements with hot-mix asphalt base mix for full thickness of patch and, while still hot, compact flush with adjacent surface.

3.4 SURFACE PREPARATION

A. General: Immediately before placing asphalt materials, remove loose and deleterious material from substrate surfaces. Ensure that prepared subgrade is ready to receive paving.

B. Herbicide Treatment: Apply herbicide according to manufacturer's recommended rates and written application instructions. Apply to dry, prepared subgrade or surface of compacted-aggregate base before applying paving materials.

C. Tack Coat: Apply uniformly to surfaces of existing pavement at a rate of 0.05 to 0.15 gal./sq. yd.

1. Allow tack coat to cure undisturbed before applying hot-mix asphalt paving.
2. Avoid smearing or staining adjoining surfaces, appurtenances, and surroundings. Remove spillages and clean affected surfaces.

3.5 HOT-MIX ASPHALT PLACING

A. Machine place hot-mix asphalt on prepared surface, spread uniformly, and strike off. Place asphalt mix by hand to areas inaccessible to equipment in a manner that prevents segregation of mix. Place each course to required grade, cross-section, and thickness when compacted.

1. Spread mix at minimum temperature of 250 deg F.
2. Regulate paver machine speed to obtain smooth, continuous surface free of pulls and tears in asphalt-paving mat.

B. Place paving in consecutive strips not less than 10 feet wide unless infill edge strips of a lesser width are required.

C. Promptly correct surface irregularities in paving course behind paver. Use suitable hand tools to remove excess material forming high spots. Fill depressions with hot-mix asphalt to prevent segregation of mix; use suitable hand tools to smooth surface.

3.6 JOINTS

A. Construct joints to ensure a continuous bond between adjoining paving sections. Construct joints free of depressions, with same texture and smoothness as other sections of hot-mix asphalt course.

1. Clean contact surfaces and apply tack coat to joints.
2. Offset longitudinal joints, in successive courses, a minimum of 6 inches.
3. Offset transverse joints, in successive courses, a minimum of 24 inches.
4. Construct transverse joints at each point where paver ends a day's work and resumes work at a subsequent time. Construct these joints using either "bulkhead" or "papered" method according to AI MS-22, for both "Ending a Lane" and "Resumption of Paving Operations."

3.7 COMPACTION

A. General: Begin compaction as soon as placed hot-mix paving will bear roller weight without excessive displacement. Compact hot-mix paving with hot, hand tampers or with vibratory-plate compactors in areas inaccessible to rollers.

1. Complete compaction before mix temperature cools to 185 deg F.

B. Breakdown Rolling: Complete breakdown or initial rolling immediately after rolling joints and outside edge. Examine surface immediately after breakdown rolling for indicated crown, grade, and smoothness. Correct laydown and rolling operations to comply with requirements.

C. Intermediate Rolling: Begin intermediate rolling immediately after breakdown rolling while hot-mix asphalt is still hot enough to achieve specified density. Continue rolling until hot-mix asphalt course has been uniformly compacted to the following density:

1. Average Density: ASTM D 2041, per MHD Specifications.

D. Finish Rolling: Finish roll paved surfaces to remove roller marks while hot-mix asphalt is still warm.

E. Edge Shaping: While surface is being compacted and finished, trim edges of pavement to proper alignment. Bevel edges while asphalt is still hot; compact thoroughly.

F. Protection: After final rolling, do not permit vehicular traffic on pavement until it has cooled and hardened.

G. Erect barricades to protect paving from traffic until mixture has cooled enough not to become marked.

3.8 ASPHALT CURBS

A. Construct hot-mix asphalt curbs over compacted pavement surfaces. Apply a light tack coat unless pavement surface is still tacky and free from dust. Spread mix at minimum temperature of 250 deg F.

1. Asphalt Mix: Same as pavement surface-course mix.

B. Place hot-mix asphalt to curb cross section indicated or, if not indicated, to local standard shapes, by machine or by hand in wood or metal forms. Tamp hand-placed materials and screed to smooth finish. Remove forms after hot-mix asphalt has cooled.

3.9 CURBING AND EDGING

A. Construct curbing and edging of the type and at the locations shown on the Contract Drawings.

B. Construct curbing and edging in accordance with the details shown on the Contract Drawings.

1. The foundation for curb and edging shall consist of gravel spread upon the subgrade and after being thoroughly compacted shall be 6 inches in depth. The bottom of the curbstones shall be fully seated and supported on the compacted subgrade.
2. The joints between curbstones shall be carefully filled with cement mortar and neatly pointed on all exposed surfaces.
3. After pointing, the curbstones shall be cleaned of all excess mortar.

C. After curbing and edging is in place at the line and grade shown on the Contract Drawings, backfill and compact equally on both sides with subbase course material, as specified in Section 312000 – EARTH MOVING. Compaction shall be by vibratory, hand-operated equipment, and shall achieve the same density as specified for subbase course in Section 312000 – EARTH MOVING.

3.10 INSTALLATION TOLERANCES

A. Accessibility: Comply with requirements of Massachusetts Architectural Access Board and ADAAG requirements. Remove and replace paving that does not meet required tolerances when measured with a 2-foot straight edge.

B. Pavement Thickness: Compact each course to produce the thickness indicated within the following tolerances:

1. Base Course: Plus or minus 1/2 inch.
2. Surface Course: Plus 1/4 inch, no minus.

C. Pavement Surface Smoothness: Compact each course to produce a surface smoothness within MHD Specification tolerances as determined by using a 10-foot straightedge applied transversely or longitudinally to paved areas.

3.11 SEALCOATING

A. Contractor shall provide all tools and equipment necessary to perform the work, including but not limited to brushes, hand squeegees, pumps and hose equipment, storage tanks, mixing tanks, water distributors, power sweepers, blowers, barricades, and applicator equipment.

1. Spray equipment used on the job shall have full sweep mechanical agitators incorporated in their construction to assure homogeneous mixing of the asphalt emulsion sealer, sand, and water (if required). The pumping system must be adequate to apply a uniform coating at the specified rates of application. Equipment requiring pressurization of the mixing tank for distribution will not be used.
2. Motorized squeegee application equipment used on the job will have two or more devices such as squeegees and/or drag broom assemblies to assure even distribution of the asphalt emulsion sealer. A full sweep mechanical agitator will be incorporated into the construction of the applicator to assure homogeneous mixing of the emulsion.
3. Mixing or agitating equipment may be either portable powered or a tank-type power mixer. In any case, mixers shall be of sufficient capacity to assure homogeneous mixing of the emulsion and to maintain complete suspension of mineral aggregate until the emulsion is applied to the pavement. All storage tanks shall be equipped with mechanical agitators sufficient to keep the asphalt emulsion homogeneous during storage.

B. The contractor shall coordinate their activities with each other to ensure the availability of the work area to avoid delaying the execution of the project, to maintain traffic flow, and to minimize activities that might be detrimental to the work in progress, other customer or construction traffic.

C. Surface to receive sealcoat must be free of all foreign material and dry immediately prior to application of sealer.

D. Remove oil and grease spots that have not permanently damaged or softened the pavement by scrubbing with a detergent and flushing with water until a water-break-free surface is obtained. Oil and grease spots with deeper penetration will be treated by burning with hand-held propane torch, and then coating the spot with an approved oil spot primer compatible with the sealer. If the oil spot is so severe as to cause permanent deterioration of the pavement, or if the pavement has failed due to other causes, the pavement shall be removed to the full depth of the damage and replaced with new asphalt pavement.

E. Existing pavement markings shall be blackened with black epoxy or black acrylic coatings. Excessive buildup of old lines should be abraded before any prime coats of emulsion are applied.

F. Cracks in excess of 1/4”, but less than one inch in width must be crack filled prior to application.

G. Pavement shall be cleaned by air blowing, vacuum, or mechanical sweeper.

H. Asphalt sealcoat shall not be placed on new asphalt concrete until a 30-day cure time has occurred.

I. Application of asphalt sealcoat shall be by mechanical means using rubber-faced squeegees, brooms, distributor bar/wand in combination. Two (2) coat application.

1. The coating shall be applied uniformly over the entire pavement surface and free of voids and pinholes. Subsequent coats shall be applied only after the previous coat is dried, preferably after 24 hours of cure time, but after no less than 4 hours under ideal conditions. Ideal conditions are temperatures in excess of 70º F, sunshine, and less than 60% relative humidity. Marginal conditions can require curing times greater than 24 hours. Subsequent coats shall be applied at right angles to the previous coat, if possible.
2. First coat mechanical squeegee self−propelled is recommended, but wand application is allowed. Second coat by spray wand to lock down exposed aggregate and to return the parking lot to a proper aesthetic appearance free of streaks and marks.
3. Application rate for each coat shall be 13 to 17 gallons per 1,000 SF as recommended by the Asphalt Sealcoat Manufacturers Association. Alternative application rates may be allowed if approved by Engineer.
4. Sealer shall not be applied unless the temperature is a minimum 50º F and rising and pavement temperature is 60º F and rising. Work shall be completed so that there is a minimum of three hours of sunlight remaining after completing the day's work. Sealer shall not be applied under rainy or wet conditions such as an overcast sky with high humidity. UNDER NO CIRCUMSTANCES shall work, be performed under cold and/or wet conditions, nor shall emulsion be used that has been subjected to freezing weather.
5. In hot weather application 80º, F or higher (pavement temperatures are in excess of 120º F) fog spraying of pavement with potable water shall be used to achieve better bond and even spreading of material. Properly applied fog spray shall dampen pavement without leaving puddles. Seal coat application shall not commence until it is determined there is no standing water to prevent even application and drying of the asphalt sealer.
6. Striping for parking and traffic flow should be done only after the sealcoat has dried completely to accept approved traffic paint.

J. PAVEMENT CLEANING AND PROTECTION

1. The pavement surface and all work areas shall be left in a clean condition.
2. Vehicular traffic shall not be permitted on the pavement that has been sealed during the dry period. The contractor shall supply all temporary traffic control devices (barricades, cones, signing, etc.) to protect the sealant. Any damage to uncured sealant shall be repaired at the contractor’s expense.

3.12 CRACK FILLING/SEALING

A. Contractor shall provide all tools and equipment necessary to perform the work, including but not limited to Routers (Vertical−Spindle and/or Rotary−Impact), Hot Compressed Air Heat Lance, Hot-applied Sealant Applicators, Wire−brushes, and compressed air equipment.

1. Router: The routing machine shall be an impact router equipped with carbide-tipped vertical-sided bits. It shall be portable and capable of routing existing asphalt surfaces along and adjacent to the crack and joint. The unit shall be capable of following random cracks and be designed to adjust the cutting widths. The unit shall be equipped with a cutter head clutch and shall have an adjustable depth control.
2. Hot Compressed-Air Lance (HCA): The HCA shall be capable of producing air temperature up to 2500ºF and constructed of suitable hardware. It shall be provided with separate valves to control propane, burner air, and lance air. The fuel and burner air shall be mixed only at the point of combustion before leaving the burner tube. A separate air lance tube shall pass inside the burner chamber and be a maximum 1/4" orifice. At the fuel source, a high-pressure regulator to control fuel pressure from 5 PSI to 30 PSI and to prevent flashback shall be used. Burner BTU should range from 20,000 to 500,000 BTU. A wheel kit constructed to keep the unit at the proper height and angle from the pavement should be used. No external flame shall be allowed to touch the pavement.
3. Hot-Applied Sealant Applicator (melter): The melter applicator unit shall be a self-contained double boiler device with the transmittal of heat through a heat transfer oil. It must be equipped with an onboard automatic heat-controlling device to permit the attainment of a predetermined temperature, then maintain that temperature as long as required. The unit shall have a means to vigorously and continuously agitate the sealant. The sealant shall be transferred from the unit to the crack by means of a direct-connected feed hose and wand. The equipment should be designed to allow the sealant to be circulated back into the unit when sealing is not being performed or equipped with a temperature controlled heated hose and wand that does not required circulation. The sealant should not be heated to a temperature in excess of that specified by the manufacturer.

B. CRACK PREPARATION PROCEDURES

1. Hairline cracks (less than ¼") require no preparation
2. Small to Medium Cracks (1/4" to 1-1/4"): All open cracks and joints from 1/4" to 1-1/4" shall be routed to remove at least 1/8" from each sidewall. This will result in a minimum reservoir width of 1/2" to a maximum reservoir width of 1-1/2". Widening the cracks 1/8" from each sidewall will reduce the potential for raveling of the pavement along the edges of cracks and will provide a sealant reservoir that has vertical faces. The depth of the routing shall be approximately a one to one ratio (width to depth), with a minimum depth of approximately ¾". Backer rods can be used for deeper cracks (over 1-1/4" deep) to minimize material loss and still provide an acceptable seal.
3. Large Cracks (Greater than 1-1/4"). Cracks wider than 1-1/4" shall be prepared in the same manner as potholes. A saw shall be used to cut away damaged pavement to provide a vertical faces. The area should then be cleaned and filled with hot mix asphalt instead of sealed.
4. No sealant shall be installed until all cracks and joints have be cleaned free of all deleterious materials, including any dust, old sealant, incompressible material, and organic material, and are sufficiently dry. Following the initial routing and cleaning operation, all cracks and joints shall be HCA lanced within 10 minutes of application of the sealant. Equipment for the two operations should be kept in a compact configuration such that not more than 50 feet separates equipment required by the two operations. Extreme care shall be used to ensure the crack sidewalls do not become overheated and burned.
5. When vegetation exists in the cracks and joints, it shall be removed, and those cracks and joints shall be treated with an herbicide that sterilizes the soil.

C. APPLICATION OF CRACK AND JOINT SEALANT

1. The sealant shall be applied in the crack or joint reservoir uniformly from the bottom to the top and shall be filled without formation of entrapped air or voids.
2. Pouring pots or gravity-fed sealant applicators shall not be used for sealing cracks and joints.
3. Joints and cracks shall be filled flush with the surface and any overfill shall be squeegeed so that the overband cap does not exceed 1/16” above the surface and the width does not exceed 2” beyond the crack edges.
4. All overbanding shall be kept to a minimum. After the sealant has cooled, settling shall not exceed 3/8” below the surface.

D. PAVEMENT CLEANING AND PROTECTION

1. The pavement surface and all work areas shall be left in a clean condition.
2. Vehicular traffic shall not be permitted on the pavement in the areas of the treated cracks and joints during the curing period. The contractor shall supply all temporary traffic control devices (barricades, cones, signing, etc.) to protect the sealant. Any damage to uncured sealant shall be repaired at the contractor’s expense.

3.13 PAVEMENT MARKING

A. Do not apply pavement-marking paint until layout, colors, and placement have been verified with Designer.

B. Allow paving to age for a minimum of 30 days before starting pavement marking.

C. Sweep and clean surface to eliminate loose material and dust.

D. Apply paint with mechanical equipment to produce pavement markings, of dimensions indicated, with uniform, straight edges. Apply at manufacturer's recommended rates to provide a minimum wet film thickness of 15 mils.

3.14 WHEEL STOPS

A. Securely attach wheel stops to pavement with not less than two galvanized-steel dowels embedded at one-quarter to one-third points. Securely install dowels into pavement and bond to wheel stop. Recess head of dowel beneath top of wheel stop.

3.15 FIELD QUALITY CONTROL

A. Independent Testing Agency: Cooperate with the Independent Testing Agency engaged by Massachusetts State College Building Authority for field quality control activities for the Work of this Section. Refer also to Section 014325 - TESTING AGENCY SERVICES.

B. Test the plane of the finished surfaces of base, binder, and surface courses with a 16-foot straightedge, except use a 10-foot straightedge on vertical courses and on the top course of resurfaced streets which contain manhole covers, valve boxes, and the like.

C. Carefully apply the straightedge immediately after the first compaction by rolling, and from then on as may be necessary until and after the final compaction of the material in place. Hold the straightedge in successive positions parallel to the road centerline and in contact with the road surface; check the entire area from one side of the pavement to the other.

D. Correct irregularities which vary 3/8 inch from a true finished surface in base and binder courses, and 1/4 inch in top courses.

E. Irregularities which may develop before the completion of rolling and while the material is still workable may be remedied by loosening the surface mixture and removing or adding material as necessary. Should any unsatisfactory irregularities or defects remain after final compaction, the defective work shall be corrected by removing and replacing with new material to form a true and even surface.

3.16 OPENING TO TRAFFIC

A. No vehicular traffic or loads shall be permitted on the newly completed pavement until all of the following conditions are met:

1. Adequate stability has been attained.
2. The material has cooled sufficiently to prevent distortion or loss of fines.
3. The pavement has achieved a maximum temperature of 140 degrees F.

B. If the climatic or other conditions warrant it, the period of time before opening to traffic may be extended at the discretion of the Designer.

3.17 DISPOSAL

A. Except for material indicated to be recycled, remove excavated materials from the Project site, and legally dispose of them in an EPA-approved landfill.

End of Section

Section 32 12 93.10
ARTIFICIAL GRASS FIELDTURF
DUAL LAYER MONOFILAMENT

PART 1 GENERAL

1.0 RELATED DOCUMENTS

A. Division 00 – PROCUREMENT AND CONTRACTING REQUIREMENTS
Division 01 - GENERAL REQUIREMENTS, as listed in the Table of Contents, including but not limited to the following sections, shall be included in and made a part of this Section:
- 01 30 00 – SUBMITTALS
- 01 43 39 – MOCK-UPS
- 01 81 13 – SUSTAINABLE DESIGN REQUIREMENTS
- 01 40 00 – QUALITY REQUIREMENTS; Testing and inspection.

1.1 DESCRIPTION OF WORK

A. Furnish all labor, materials, tools and equipment necessary to install monofilament artificial grass FieldTurf as indicated on the plans and as specified herein; including components and accessories required for a complete installation including but not limited to:
1. Acceptance of prepared sub-base.
2. Coordination with related trades to ensure a complete, integrated, and timely installation: Aggregate base course, sub-base material (tested for permeability), grading and compacting, piping and drain components; as provided under its respective trade section.

1.2 RELATED WORK

A. Carefully examine all Contract Documents for requirements which affect the work of this Section. Other specification sections which directly relate to the work of this section include, but are not limited to the following:
1. Section 31 20 00, EARTHWORK.
2. Section 32 91 19, LANDSCAPE GRADING
3. Section 03 30 00, CAST-IN-PLACE CONCRETE
4. Section 11 68 33, FOOTBALL FIELD EQUIPMENT
5. Section 32 31 13, CHAIN LINK FENCE AND GATES

1.3 REFERENCE STANDARDS

A. FM Factory Mutual
1. P7825 - Approval Guide; Factory Mutual Research Corporation; current edition

B. ASTM – American Society for Testing and Materials.
1. D1577 - Standard Test Method for Linear Density of Textile Fiber
2. D5848 - Standard Test Method for Mass Per Unit Area of Pile Yarn Floor Covering
3. D1338 - Standard Test Method for Tuft Bind of Pile Yarn Floor Covering
4. D1682 - Standard Method of Test for Breaking Load and Elongation of Textile Fabrics
5. D5034 - Standard Test Method of Breaking Strength and Elongation of Textile Fabrics (Grab Test)
6. F1015 - Standard Test Method for Relative Abrasiveness of Synthetic Turf Playing Surfaces

7. D4491 - Standard Test Methods for Water Permeability of Geotextiles by Permittivity
8. D2859 - Standard Test Method for Ignition Characteristics of Finished Textile Floor Covering Materials
9. F355 - Standard Test Method for Shock-Absorbing Properties of Playing Surfaces.
10. F1936 - Standard Test Method for Shock-Absorbing Properties of North American Football Field Playing Systems as Measured in the Field

1.4 QUALITY ASSURANCE

A. Comply with SECTION 01 43 00, QUALITY ASSURANCE.

B. Manufacturer qualifications: company specializing in manufacturing products specified in this section. The turf contractor and/or the turf manufacturer:
   1. Shall be experienced in the manufacture and installation of specified type of infilled monofilament synthetic grass system for a minimum of three years. This includes a monofilament fiber, backing, the backing coating, and the installation method.
   2. The manufacturer must have ISO 9001, ISO 14001 and OHSAS 18001 certifications demonstrating its manufacturing efficiency with regards to quality, environment and safety management systems.
   3. Shall have a minimum of 5 installations in the State of Massachusetts.
   4. The fiber and turf carpet being proposed must have a documented Fiber Performance Index of at least 80. Official testing to be completed by Labosport.
   5. Artificial turf fiber proposed for the field(s) must have successfully undergone a minimum of 150,000 cycles on the Lisport wear tester, certified by an independent third party (ex: Labosport, Sports Labs, Penn State University).
   6. Manufacturer must provide proof that its turf systems have been subject to long-term independent, epidemiological and peer reviewed studies proving its ability to provide for a safe surface.

C. Installer: Company shall specialize in performing the work of this section. The Contractor shall provide competent workmen skilled in this specific type of synthetic grass installation.
   1. The designated Supervisory Personnel on the project shall be certified, in writing by the turf manufacturer, as competent in the installation of specified monofilament material, including sewing seams and proper installation of the infill mixture.
   2. Installer shall be certified by the manufacturer and licensed.
   3. The installer supervisor shall have a minimum of 5 years' experience as either a construction manager or a supervisor of synthetic turf installations

D. Pre-Installation Conference: Conduct conference at project site at time to be determined by Architect. Review methods and procedures related to installation including, but not limited to, the following:
   1. Inspect and discuss existing conditions and preparatory work performed under other contracts.
   2. In addition to the Contractor and the installer, arrange for the attendance of installers affected by the Work, The Owner's representative, and the Architect.

E. The Contractor shall verify special conditions required for the installation of the system.

F. The Contractor shall notify the Architect of any discrepancies.

1.5 SUBMITTALS

A. Substitutions: Other products are acceptable if in compliance with all requirements of these specifications. Submit alternate products with all submittal requirements to Architect for approval 10 days prior to bidding in accordance with Product Substitution Procedures.
Design Approval: The owner / engineer will review pre-bid submittals from all non-approved manufactures to ensure compliance to the specification 10 days prior to bid. If the system meets the system requirements of the specifications, a letter and/or addendum will be issued to the manufacturer indicating approval for the system submitted.

a. Verification
   i. Provide substantiation that proposed system does not violate any other manufacturer's patents, patents allowed or patents pending.
   ii. Provide a sample copy of insured, non-prorated warranty and insurance policy information.

b. Shop Drawings:
   i. Indicate field layout; field marking plan and details for the specified sports; i.e., NCAA Football; roll/seaming layout; methods of attachment, field openings and perimeter conditions.
   ii. Show installation methods and construction indicating field verified conditions, clearances, measurements, terminations, drainage.
   iii. Provide joint submission with related trades when requested by Architect.

c. Product Data: Due at time of Bid
   i. Submit manufacturer's catalog cuts, material safety data sheets (MSDS), brochures, specifications; preparation and installation instructions and recommendations; storage, handling requirements and recommendations.
   ii. Submit fiber manufacturer's name, type of fiber and composition of fiber.
   iii. Submit cryogenic suppliers name, sieve analysis and origin of materials.
   iv. Submit data in sufficient detail to indicate compliance with the contract documents.
   v. Submit manufacturer's instructions for installation.
   vi. Submit manufacturer's instructions for maintenance for the proper care and preventative maintenance of the synthetic turf system, including painting and markings.

d. Samples: Due at time of Bid. Submit samples, 9 x 12 inches, illustrating details of finished product in amounts as required by General Requirements, or as requested by Architect.

e. Product Certification: Due at time of Bid
   i. Submit manufacturer’s certification that products and materials comply with requirements of the specifications.
   ii. Submit test results indicating compliance with Reference Standards.

f. Project Record Documents: Record actual locations of seams, drains and other pertinent information in accordance with Specifications, General Requirements.

g. List of existing installations: Due at time of Bid. Submit list including respective Owner’s representative and telephone number. (min. 3)

h. Warranties: Submit warranty and ensure that forms have been completed in Owner's name and registered with approved manufacturer.

i. Submit Bills of Lading/Material Delivery Receipts for synthetic turf infill materials. Bills of lading shall bear the name of the project/delivery address, quantity of materials delivered, source/location of origin of infill materials and/or manufacturer, and date of delivery.

j. Testing Certification: Due at time of Bid. Submit certified copies of independent (third-party) laboratory reports on ASTM testing:
   i. Pile Height, Face Weight & Total Fabric Weight, ASTM D5848.
   ii. Primary & Secondary Backing Weights, ASTM D5848.
   iii. Tuft Bind, ASTM D1335.

iv. Grab Tear Strength, ASTM D1682 or D5034.
v. Water Permeability, ASTM D4491

k. The Turf Vendor shall submit a document holding the Owner and it's representatives harmless as to any liability and or costs of any type, including but not limited to legal costs, royalties, replacement costs, etc. associated with any claim by the Turf Vendor or others associated and with any patents or infringements of any current or future patent issued for the synthetic turf product, infill materials, installation methods or drainage characteristics. It is not the intent of these documents to promote or induce the use of intellectual property belonging to others or promote infringement of any known or currently not known patents, licenses or rights of others.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Comply with Section 01 60 00, Product Requirements.
B. Prevent contact with materials that may cause dysfunction.
C. Deliver and store components with labels intact and legible.
D. Store materials/components in a safe place, under cover, and elevated above grade.
E. Protect from damage during delivery, storage, handling and installation. Protect from damage by other trades.
F. Inspect all delivered materials and products to ensure they are undamaged and in good condition.
G. Comply with manufacturer's recommendations.

1.7 SEQUENCING AND SCHEDULING

Coordinate the Work with installation of work of related trades as the Work proceeds.
Sequence the Work in order to prevent deterioration of installed system.

1.8 WARRANTY AND GUARANTEE

A. See Section 01 77 00 - Closeout Submittals, For Additional Warranty Requirements.

The Contractor shall provide a warranty to the Owner that covers defects in materials and workmanship of the turf for a period of eight (8) years from the date of substantial completion. The turf manufacturer must verify that their representative has inspected the installation and that the work conforms to the manufacturer's requirements. The manufacturer's warranty shall include general wear and damage caused from UV degradation. The warranty shall specifically exclude vandalism, and acts of God beyond the control of the Owner or the manufacturer. The warranty shall be fully third party insured; prepaid for the entire 8 year term and be non-prorated. The Contractor shall provide a warranty to the Owner that covers defects in the installation workmanship, and further warrant that the installation was done in accordance with both the manufacturer's recommendations and any written directives of the manufacturer's representative. Prior to final payment for the synthetic turf, the Contractor shall submit to owner notification in writing that the field is officially added to the annual policy coverage, guaranteeing the warranty to the Owner. The insurance policy must be underwritten by an "AM Best" A rated carrier and must reflect the following values:

- Pre-Paid 8-year insured warranty from a single source.
- Maximum per claim coverage amount of $15,000,000.
- Minimum of fifteen million dollars ($15,000,000) annual.
- Must cover full 100% replacement value of total square footage installed, minimum of $7.00 per sq ft. (in case of complete product failure, which will include removal and disposal of the existing surface)
- Provide a sample copy of insured, non-prorated warranty and insurance policy information.
- Policy cannot include any form of deductible to be paid by the Owner.

B. The artificial grass system must maintain a G-max of less than 200 for the life of the Warranty as per ASTM F1936.

1.9 MAINTENANCE SERVICE

A. Contractor shall train the Owner's facility maintenance staff in the use of the turf manufacturer's recommended maintenance equipment.
B. Manufacturer must provide maintenance guidelines and a maintenance video to the facility maintenance staff.

1.10 SUB-BASE DRAINAGE TEST

A. Installed sub-base shall be tested for porosity prior to the installation of the monofilament turf. A sub base that drains poorly is an unacceptable substrate.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURER

A. Approved manufacturers are as follows:

1. FieldTurf USA Inc., 75 N. Industrial Blvd, Calhoun, GA 30701, P: 800-724-2969 Model: FieldTurf Core 2.5”
2. Matrix Turf by Hellas Construction, Inc, 12710 Research Boulevard Suite 240, Austin , TX 78759, p: 512.250.2910. www.matrixturf.com
3. Greenfields USA, 1131 Broadway St, Dayton, TN p: 855.773.6668, www.Greenfields.com
4. Sporturf, 200 Howell Drive, Dalton, Georgia 30721, p: (800) 798-1056, Sporturf.com

2.2 MATERIALS AND PRODUCTS

A. Artificial grass Turf system materials shall consist of the following:
1. Carpet made of monofilament polyethylene fibers tufted into a fibrous, non-perforated, porous backing.
2. Infill: graded sand and cryogenic rubber crumb that partially covers the carpet.
3. Glue, thread, paint, seaming fabric and other materials used to install and mark the artificial grass monofilament FieldTurf.

B. The installed artificial grass monofilament Turf shall have the following properties:

Standard	Property	Specification
ASTM D1577	Fiber Denier	14,000
ASTM D5823	Min. Pile Height	2 1/2”
ASTM D1577	Fiber Thickness	380 Microns
ASTM D5793	Stitch Gauge	3/4”
ASTM D5848	Pile Weight	42oz/square yard
ASTM D5848	Primary Backing	7+oz/square yard
ASTM D5848	Secondary Backing	14+oz/square yard
ASTM D5848	Total Weight	63+oz/square yard
ASTM D1335	Tuft Bind (Without Infill)	8+ lbs.
ASTM D5034	Grab Tear (Width)	200 lbs./force
ASTM D5034	Grab Tear (Length)	200 lbs./force

ASTM D4491	Carpet Permeability	>40 inches/hour
ASTM F1936	Impact Attenuation (Gmax)	<200
	Min. Infill Material Depth	1.75 inches
	Min. Sand Infill Component	6.2lbs/square foot
	Min. Cryogenic Rubber Infill	3lbs/square foot
	Total Product Weight	1388oz/square yard

Variation of +/- 5% on above listed properties is within normal manufacturing tolerances

C. Carpet shall consist of monofilament fibers tufted into a primary backing with a secondary backing.
D. Carpet Rolls shall be 15' wide rolls.
   1. Rolls shall be long enough to go from field sideline to sideline.
   2. Where the playing field is for football, the perimeter white line shall be tufted into the individual sideline rolls.

E. Backing:
   1. Primary backing shall be a minimum double-layered polypropylene fabric
   2. Secondary backing shall permanently lock the fiber tufts in place.
   3. Perforated (with punched holes), backed carpet are unacceptable.

F. Fiber shall be measuring no less than 2 ½ inches high. Fiber shall be 14,000 denier, low friction, UV-resistant. Each monofilament fiber is extruded with two layers of polyethylene polymers. A rigid polyethylene polymer as the inner core of the fiber for superior resilience and a soft yet extremely durable polyethylene polymer as the outer shell of the fiber for a realistic grass-like feel.
   1. Systems with less than a 2 ½ inch fibers are unacceptable.
   2. Infill shall consist of a resilient granular system, comprising selected and graded sand and cryogenically hammer-milled SBR rubber crumb.
   3. Artificial Grass products without cryogenically processed rubber shall not be accepted.

G. The sand infill will comply within the following characteristics:
   - Average Particle size between 20 and 30 mesh [calculated based on summing the midpoint of sieve pan fractions times the % retained on given screen fractions]
   - Average Particle shape > 0.4 on the Krumbein scale
   - Particle structure predominantly single grain
   - Produce < 0.4%, -50M in API crush test at 80psig

H. Non-tufted or inlaid lines and markings shall be painted with paint approved by the synthetic turf manufacturer.
I. Thread for sewing seams of turf shall be as recommended by the synthetic turf manufacturer.
J. Glue and seaming fabric for inlaying lines and markings shall be as recommended by the synthetic turf manufacturer.

2.3 QUALITY CONTROL IN MANUFACTURING

A. The manufacturer shall own and operate its own manufacturing plant. Manufacturing the fiber, tufting of the field fibers into the backing materials and coating of the turf system must be done in-house by the turf manufacturer. Outsourcing of any of these major processes is unacceptable.
B. The manufacturer shall have full-time certified in-house inspectors at their manufacturing plant that are experts with industry standards.
C. Primary backing shall be inspected by the manufacturer's full-time certified in-house inspectors before tufting begins.
D. The manufacturer's full-time in-house certified inspectors shall verify "pick count", yarn density in

relation to the backing, to ensure the accurate amount of face yarn per square inch.

E. The manufacturer's full-time, in-house, certified inspectors shall perform turf inspections at all levels of production including during the tufting process and at the final stages before the turf is loaded onto the truck for delivery.
F. The manufacturer shall have its own, in-house laboratory where samples of turf are retained and analyzed, based on standard industry tests, performed by full-time, in-house, certified inspectors.
G. The manufacturer must have ISO 9001, ISO 14001 and OHSAS 18001 certifications demonstrating its manufacturing efficiency with regards to quality, environment and safety management systems.

2.4 FIELD GROOMER & SWEEPER

A. Supply to owner field groomer as part of the work.
    1. Field Groomer: Greensgroomer 920SDE or equal shall include a towing attachment compatible with a field utility vehicle.
    2. Field Sweeper: Greensgroomer Litterkat 760 or equal shall include a towing attachment compatible with a field utility vehicle.

PART 3 EXECUTION

3.1 EXAMINATION

A. Verify that all sub-base leveling is complete prior to installation.
B. Installer shall examine the surface to receive the synthetic turf and accept the sub-base planarity in writing prior to the beginning of installation.
    i. Acceptance is dependent upon the Owner's test results indicating compaction and planarity are in compliance with manufacturer's specifications.
    ii. The surface shall be accepted by Installer as "clean" as installation commences and shall be maintained in that condition throughout the process.

C. Compaction of the aggregate base shall be 95%, in accordance with ASTM D1557 (Modified Proctor procedure); and the surface tolerance shall not exceed 0-1/4 inch over 10 feet and 0-½" from design grade.
D. Correct conditions detrimental to timely and proper completion of Work.
E. Do not proceed until unsatisfactory conditions are corrected.
F. Beginning of installation means acceptance of existing conditions.

3.2 PREPARATION

A. Prior to the beginning of installation, inspect the sub-base for tolerance to grade.
B. Sub-base acceptance shall be subject to receipt of test results (by others) for compaction and planarity that sub-base is in compliance with manufacturer's specifications and recommendations.
C. Dimensions of the field and locations for markings shall be measured by a registered surveyor to verify conformity to the specifications and applicable standards. A record of the finished field as-built measurements shall be made.

3.3 INSTALLATION - GENERAL

A The installation shall be performed in full compliance with approved Shop Drawings.
B. Only trained technicians, skilled in the installation of athletic caliber synthetic turf system working under the direct supervision of the approved installer supervisors, shall undertake any cutting, sewing, gluing, shearing, and topdressing or brushing operations.
C. The designated Supervisory personnel on the project must be certified, in writing by the turf

manufacturer, as competent in the installation of this material, including sewing seams and proper installation of the Infill mixture.

D. Designs, markings, layouts, and materials shall conform to all currently applicable National Collegiate Athletic Association rules, NFHS rules, and/or other rules or standards that may apply to this type of synthetic grass installation. Designs, markings and layouts shall first be approved by the Architect or Owner in the form of final shop drawings. All markings will be in full compliance with final shop drawings.

3.4 INSTALLATION

A. Install at location(s) indicated, to comply with final shop drawings, manufacturers'/installer's instructions.

B. The Contractor shall strictly adhere to specified procedures. Any variance from these requirements shall be provided in writing, by the manufacturer's on-site representative, and submitted to the Architect and/or Owner, verifying that the changes do not in any way affect the Warranty. Infill materials shall be approved by the manufacturer and installed in accordance with the manufacturer's standard procedures.

C. Carpet rolls shall be installed directly over the properly prepared aggregate base. Extreme care shall be taken to avoid disturbing the aggregate base, both in regard to compaction and planarity.

1. Repair and properly compact any disturbed areas of the aggregate base as recommended by manufacturer

D. Full width rolls shall be laid out across the field.

1. Turf shall be of sufficient length to permit full cross-field installation from sideline to sideline.
2. No cross seams will be allowed in the main playing area between the sidelines.
3. Each roll shall be attached to the next roll utilizing standard state-of-the- art sewing procedures.
4. When all of the rolls of the playing surface have been installed, the sideline areas shall be installed at right angles to the playing surface.

E. Artificial turf panel seams shall be sewn along the selvedge edging flap of the turf roll. Seams secured by other means including gluing are unacceptable. Installation shall be 99% sewn.

1. Minimum gluing will only be permitted to repair problem areas, corner completions, and to cut in any logos or inlaid lines as required by the specifications.
2. Seams shall be flat, tight, and permanent with no separation or fraying.
3. In the case of all lines and logos, turf carpet/field fibers must be sheared to the backing (do not cut the backing) and adhered using hot melt adhesives.

F. Infill Materials:

1. Infill materials shall be applied in numerous thin lifts. The turf shall be brushed as the mixture is applied.
2. Infill materials shall be installed to fill the voids between the fibers and allow the fibers to remain vertical and non-directional. The Infill installation consists of sand and cryogenically processed rubber. The Infill shall be installed to a minimum depth of 1 3/4".

G. Non-tufted or inlaid lines and markings shall be painted in accordance with turf and paint manufacturers' recommendations. Number of applications will be dependent upon installation and field conditions.

H. Synthetic turf shall be attached to the perimeter edge detail in accordance with the manufacturer's standard procedures.

G. Upon completion of installation, the finished field shall be inspected by the installation crew and

an installation supervisor.

3.5 FIELD MARKINGS

A. Submit shop drawings for approval of all field markings prior to fabrication.
The following sports will be tufted-in to the field in order of priority. See drawings for layout, sizing and color designations.
1. Football
2. Soccer
3. Field hockey

B. Balance of sports markings will be inlaid only as 'tick marks' as guidelines so the lines can be painted seasonally/ as needed.
1. Lacrosse

3.6 ADJUSTMENT AND CLEANING

A. Do not permit traffic over unprotected surface.
B. Contractor shall provide the labor, supplies, and equipment as necessary for final cleaning of surfaces and installed items.
C. All usable remnants of new material shall become the property of the Owner.
D. The Contractor shall keep the area clean throughout the project and clear of debris.
E. Surfaces, recesses, enclosures, and related spaces shall be cleaned as necessary to leave the work area in a clean, immaculate condition ready for immediate occupancy and use by the Owner.

3.7 PROTECTION

A. Protect installation throughout construction process until date of final completion.

END OF SECTION

Section 32 13 13
PEDESTRIAN CONCRETE PAVING

PART 1 GENERAL

1.0 RELATED DOCUMENTS

A. Division 00 – PROCUREMENT AND CONTRACTING REQUIREMENTS and applicable parts of Division 01 - GENERAL REQUIREMENTS, as listed in the Table of Contents, shall be included in and made a part of this Section.

1.1 DESCRIPTION OF WORK

A. Provide all equipment and materials and do all work necessary to construct the Portland cement concrete paving work, complete, as indicated on the Drawings and as specified. Portland cement concrete paving shall include but not be limited to: concrete walks, sidewalks, handicap ramps, service area pads, and detectable warning surfaces.

1.2 RELATED WORK

A. Examine Contract Documents for requirements that affect work of this Section. Other Specification Sections that directly relate to work of this Section include, but are not limited to:

1. Section 01 40 00, QUALITY REQUIREMENTS; Inspection and testing.
2. Section 31 20 00, EARTH MOVING; Establishment of subgrade elevations, subase and base course.
3. Section 03 30 01, CAST-IN-PLACE CONCRETE; Concrete for structures.
4. Section 07 92 00, JOINT SEALANTS; Sealing of expansion joints.
5. Section 32 12 16, ASPHALT; granite curbing.
6. Section 32 14 13, CONCRETE UNIT PAVING
7 Section 3214 40, GRANITE PAVING

1.3 REFERENCES

A. Comply with applicable requirements of the following standards. Where these standards conflict with other specified requirements, the most restrictive requirements shall govern.

1. American Concrete Institute (ACI):

301	Specifications for Structural Concrete for Buildings
305R	Hot Weather Concreting
306R	Cold Weather Concreting
325.9R	Guide for Construction of Concrete Pavements and Concrete Bases.

2. American Society for Testing and Materials (ASTM):

A 185	Welded Steel Wire Fabric for Concrete Reinforcement
A 615	Deformed and Plain Billet - Steel Bars for Concrete Reinforcement
C 33	Concrete Aggregates
C 94	Ready-Mixed Concrete
C 143	Slump of Portland Cement Concrete
C 150	Portland Cement
C 171	Sheet Materials for Curing Concrete
C 231	Air Content of Freshly Mixed Concrete by the Pressure Method
C 260	Air Entraining Admixtures for Concrete
C 309	Liquid Membrane-Forming Compounds for Curing Concrete
C 494	Chemical Admixtures for Concrete
C 920	Elastomeric Joint Sealants
C 962	Guide for Use of Elastomeric Joint Sealants
D 226	Asphalt-Saturated Organic Roofing Felt for Use in Membrane Waterproofing and Built-Up Roofing
D 1557	Moisture - Density Relations of Soils and Soil Aggregate Mixtures Using 10 lb. (4.54-kg) Rammer and 18-in. (457 mm) Drop
D 1752	Preformed Sponge Rubber and Cork Expansion Joint Fillers for Concrete Paving and Structural Construction
E 1980	Standard Practice for Calculating Solar Reflectance Index of Horizontal and Low-Sloped Opaque Surfaces

Appendix to Part 1191	Accessibility Guidelines for Buildings and Facilities

3. Commonwealth of Massachusetts Highway Department (MHD):

Specifications	Standard Specifications for Highways and Bridges

4. Corps of Engineers (COE):

CRD-C 621	Specification for Nonshrink Grout: Hardened State Volume Change

5. Federal Specifications (Fed Spec.):

TT-S-00227	Sealing Compound: Elastomeric Type, Multi-Component (For Calking, Sealing, and Glazing in Buildings and other Structures)

1.4 QUALITY ASSURANCE

A. Manufacturer Qualifications: Manufacturer of ready-mixed concrete products who complies with ASTM C 94/C 94M requirements for production facilities and equipment.

1. Manufacturer certified according to NRMCA's "Certification of Ready Mixed Concrete Production Facilities."

B. Testing Agency Qualifications: An independent agency qualified according to ASTM C 1077 and ASTM E 329 for testing indicated, as documented according to ASTM E 548.

1. Personnel conducting field tests shall be qualified as ACI Concrete Field Testing Technician, Grade 1, according to ACI CP-01 or an equivalent certification program.

C. ACI Publications: Unless otherwise specified, work and materials for construction of the Portland cement concrete paving shall conform to ACI 325.9R.

D. Work, materials, and color of the handicap ramp paving shall conform to applicable sections of Americans with Disabilities Act (ADA) Accessibility Guidelines for Buildings and Facilities.

E. Paving work, base course etc., shall be done only after excavation and construction work which might injure them have been completed. Damage caused during construction shall be repaired before acceptance.

F. Existing paving areas shall, if damaged or removed during course of this project, be repaired or replaced under this section of the specification. Workmanship and materials for such repair and replacement, except as otherwise noted, shall match as closely as possible those employed in existing work.

G. Pavement, base, or subbase shall not be placed on a muddy or frozen subgrade.

1.5 PRECONSTRUCTION MOCK-UPS

A. General

1. Schedule mock-up casting for acceptance 30 days prior to casting of concrete surfaces represented by the mockups.
2. Locate mock-up panels in non-public areas accepted by the Architect.
3. Continue to cast mock-ups until acceptable mock-ups area produced. Accepted mock-ups shall be the standard for color, texture, and workmanship for the work.
4. Mock-up sequence of forming, placing, form removal, curing, and finishing shall be reviewed and accepted by the Architect.
5. Mock-up formwork shall be inspected and accepted by the Architect before placing of concrete.
6. Use the same concrete mixes and placement procedures, accepted in mock-ups, in the final work, unless otherwise directed by the Architect.
7. Protect accepted mock-ups from damage until completion and acceptance of the work represented by the mock-up.
8. Remove mock-up panels from site at completion of project, as directed by the Architect.

B. Construct mock-up panels or areas as indicated to demonstrate the ability to cast concrete for concrete paving to achieve shape, color, jointing and textured finish required. Mock-ups shall include or meet the following requirements:

1. Provide full scale mock-up panels: plaza- 4’ x 8’ panel showing broom finish and jointing.
2. Provide mock-ups simulating actual design and execution conditions for concrete mix materials, reinforcement, formwork, placing sequence, form removal, curing, finishing, and methods and materials of stain removal and correction of defective work.
3. On mock-ups where directed by the Architect, provide minimum of three variation of mix color to be used in the repair of defective work, in order to determine acceptable color and texture match.
4. Demonstrate in the construction of the mock-up formwork the sealer material, form release agent, and curing materials and methods to be used.

C. Source of Materials. Utilize the same source, stock, or brand of concrete materials for each class or mix of concrete which is to be exposed. Do not interchange materials or mixes until an additional mock-up shows that uniformity in finish texture and color, as compared to original mock-up will be maintained. If necessary, obtain and stockpile materials in sufficient quantity to ensure continuity and uniformity.

1.6 SUBMITTALS

A. Description of Methods and Sequence of Placement. For each type of specially-finished concrete provide description of methods and sequence of placement.

B. Submit manufacturer's product data for the following including color options where applicable:

1. Form release agent.
2. Curing material
3. Preformed joint filler
4. Non-sag joint sealant.

C. Submit samples of the following:

1. Preformed joint filler.
2. Non-sag joint sealant.

D. Design Mixtures: For each concrete pavement mixture. Include alternate mixture designs when characteristics of materials, Project conditions, weather, test results, or other circumstances warrant adjustments.

E. Material Certificates: Signed by manufacturers certifying that each of the following materials complies with requirements:

1. Cementitious materials.
2. Steel reinforcement and reinforcement accessories.
3. Admixtures.
4. Curing compounds.
5. Bonding agent or epoxy adhesive.

1.7 TESTING AND INSPECTION

A. The Owner reserves the right to inspect and test paving and associated work in accordance with Section 01 40 00, QUALITY REQUIREMENTS.

PART 2 PRODUCTS

2.1 AGGREGATE BASE COURSE

A. Material for aggregate base course shall be a graded, granular, non-frost susceptible, free-draining material, consisting of either durable stone and coarse sand or of blast furnace slag, practically free from loam and clay, and which can be readily compacted to form a stable foundation.

1. Material shall conform to MHD Specifications Section M1.03.0 Type b, with less than 8% by weight passing No. 200 sieve.

2.2 STEEL REINFORCEMENT

A. Steel reinforcing bars shall conform to the following requirements:

1. Reinforcing Bars: ASTM A 615/A 615M, Grade 60 (Grade 420); deformed.
2. Galvanized Reinforcing Bars: ASTM A 767/A 767M, Class II zinc coated, hot-dip galvanized after fabrication and bending; with ASTM A 615/A 615M, Grade 60 (Grade 420) deformed bars.

B. Welded wire fabric reinforcement shall conform to the following applicable requirements. Fabric reinforcement shall be furnished in flat sheets, sized as indicated on the Drawings. Fabric reinforcement in rolls will not be permitted.

1. Plain-Steel Welded Wire Reinforcement: ASTM A 185, fabricated from as-drawn steel wire into flat sheets.

C. Joint Dowel Bars: Plain steel bars, ASTM A 615/A 615M, Grade 60 (Grade 420). Cut bars true to length with ends square and free of burrs.

D. Tie Bars: ASTM A 615/A 615M, Grade 60 (Grade 420), deformed.

E. Bar Supports: Bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening reinforcing bars, welded wire reinforcement, and dowels in place. Manufacture bar supports according to CRSI's "Manual of Standard Practice" from steel wire, plastic, or precast concrete of greater compressive strength than concrete, and as follows:

1. Equip wire bar supports with sand plates or horizontal runners where base material will not support chair legs.

2.3 PORTLAND CEMENT CONCRETE

A. Portland cement concrete for pavements and slabs shall be air-entrained type with a maximum water-cement ratio of 0.50 conforming to ACI 325.9R. Minimum compressive strengths at 28 days shall be as follows: Flexural strength with third point loading - 650 psi; compressive strength - 4000 psi.

1. Concrete shall be air-entrained type, conforming to ASTM C 94. Air content by volume shall be 6% $\pm$ 1%, and shall be tested in accordance with ASTM C 231.
2. Concrete slump shall be no less than 2 in. nor greater than 4 in., determined in accordance with ASTM C 143.
3. Cement shall be Portland cement, conforming to ASTM C 150, Type I or II. Only one color of cement, all of the same manufacturer, shall be used for the work.
4. Fine and coarse aggregates shall be recycled porcelain, concrete, stone, or other recycled content material conforming to requirements of mix design.
5. Concrete shall contain a water reducing agent to minimize cement and water content of the concrete mix at the specified slump. Water reducing agent shall conform to ASTM C 494.
6. No calcium chloride or admixtures containing calcium chloride shall be added to the concrete. No admixtures other than those specified shall be used in the concrete without the specific written permission of the Architect in each case.

2.4 CHEMICAL ADMIXTURES

A. Chemical Admixtures: Provide admixtures certified by manufacturer to be compatible with other admixtures and to contain not more than 0.1 percent water-soluble chloride ions by mass of cementitious material.

1. Water-Reducing Admixture: ASTM C 494/C 494M, Type A.
2. Retarding Admixture: ASTM C 494/C 494M, Type B.

2.5 CURING MATERIALS

A. Curing shall be by moist curing or by use of curing compound.

B. Absorptive Cover: AASHTO M 182, Class 2, burlap cloth made from jute or kenaf, weighing approximately 9 oz./sq. yd. (305 g/sq. m) dry.

C. Moisture-Retaining Cover: Curing paper shall be nonstaining, fiber reinforced laminated kraft bituminous product conforming to ASTM C 171. Four mil polyethylene sheeting may be substituted for curing paper.

D. Curing Compounds, Sealers, and coatings: Water-based.

1. Toxicity/IEQ: Zero VOC.

E. Water: Potable.

2.6 EXPANSION JOINTS

A. Unless otherwise indicated on the Drawings, expansion joints shall be located 30 ft. o.c., maximum and at all fixed, vertical faces.

B. Expansion joint filler shall be preformed, nonbituminous type joint filler conforming to ASTM D 1752, Type II, similar to Sealtight Cork Expansion Joint Filler, manufactured by W.R. Meadows, Inc., Elgin, IL 60120, or approved equal.

1. Premolded filler shall be one piece for the full depth and width of the joint leaving a sealant recess as indicated.
2. Use of multiple pieces of lesser dimensions to make up required depth and width of joint will not be permitted.
3. Except as otherwise noted on the Drawings, joint filler shall be 1/2 in. thick.

2.7 CONTROL JOINTS

A. Control joints indicated to be sawn shall be made by saw cutting concrete slab after concrete is finished and when the surface is stiff enough to support the weight of workmen without damage to the slab. Saw blade shall cut into slab at least 1 in., but in no case less than 25% of slab depth. Do not overcut at joints-see drawings for jointing pattern in plazas.

2.8 GROUT

A. Grout shall be mixed in the proportions of one part Portland cement to two parts sand, by volume. Only sufficient water shall be used to enable grout to barely hold its shape when squeezed into a ball in the hand. Sand for grout shall be "Fine Aggregate", conforming to ASTM C 33.

B. Nonshrink grout shall be pre-mixed non-shrinking, high strength grout. Compressive strength in 28 days shall be 5,000 psi minimum, but in no case less than the specified strength of the adjacent concrete. Manufacturer shall provide evidence that the material meets the requirements of the COE CRD-C 621 (558). Grout permanently exposed to view shall be nonoxidizing; metallic grout may be used in other locations.

1. Nonshrink grout shall be one of the following, or approved equal:

Manufacturer	Product
Gifford-Hill Co.	Supreme
Master Builders Co.	Embeco
U.S. Grout Corporation	Five Star Grout

2.9 SEALANT

A. Sealant for sealing of control joints and expansion joints in concrete walks shall be a two component polyurethane based sealant conforming to ASTM C 920 as specified in Section 07 92 00, JOINT SEALANTS.

2.10 BOND BREAKER

A. Bond breaker shall be asphalt felt conforming to ASTM D 226, Type I or 6 mil polyethylene sheeting.

PART 3 EXECUTION

3.1 PREPARATION OF SUBGRADE

A. Areas to be paved will be compacted and brought to subgrade elevation under Section 31 20 00, EARTH MOVING before work of this section is performed. Final fine grading, filling, and compaction of areas to receive paving, as required to form a firm, uniform, accurate, and unyielding subgrade at required elevations and to required lines, shall be done under this Section.

B. Existing subgrade material which will not readily compact as required shall be removed and replaced with satisfactory materials. Additional materials needed to bring subgrade to required line and grade and to replace unsuitable material removed shall be material conforming to this Section.

C. Subgrade of areas to be paved shall be recompacted as required to bring top 8 in. of material immediately below gravel base course to a compaction at optimum moisture of at least 95% of maximum density, as determined by ASTM D 1557. Subgrade compaction shall extend for a distance of at least 1 ft. beyond pavement edge.

1. Field testing shall be conducted to determine in-place density, accompanied by visual inspection of the compaction methods being used.

D. Excavation required in pavement subgrade shall be completed before fine grading and final compaction of subgrade are performed. Where excavation must be performed in completed subgrade, subbase, base, or pavement, subsequent backfill and compaction shall be performed as directed by the Architect as specified in Section 31 20 00, EARTH MOVING. Completed subgrade after filling such areas shall be uniformly and properly graded.

E. Areas being graded or compacted shall be kept shaped and drained during construction.

Ruts greater than or equal to 2 in. deep in subgrade, shall be graded out, reshaped as required, and recompacted before placing pavement.

F. Materials shall not be stored or stockpiled on subgrade.

G. Disposal of debris and other material excavated under this section, and material unsuitable for or in excess of requirements for completing work of this section shall be disposed of off-site.

H. Prepared subgrade will be inspected by the Architect. Subgrade shall be approved by the Architect before installation of gravel base course. Disturbance to subgrade caused by inspection procedures shall be repaired under this section of the specification.

3.2 AGGREGATE BASE COURSE

A. Aggregate base course for paving and the spreading, grading, and compaction methods employed shall conform to standard requirements for usual base course of this type for first class road work, and the following:

1. MHD Specifications Section 402, "Dense-Graded Crushed Stone for Sub-Base".

B. Width of base course shall be greater than or equal to the width of pavement surface, if continuous lateral support is provided during rolling, and shall extend at least 2 x base thickness beyond edge of the course above, if not so supported.

C. Aggregate material shall be applied in lifts less than or equal to 6 in. thick, compacted measure. Each lift shall be separately compacted to specified density, using a 6 ton smooth drum vibratory roller equivalent to a 6 ton static roller, or an approved equivalent. Smaller areas or areas impossible to reach with large drum rollers shall be compacted to specified density using a vibrating plate compactor.

1. Material shall be placed adjacent to wall, manhole, catch basin, and other structures only after they have been set to required grade and level.
2. Rolling shall begin at sides and progress to center of crowned areas, and shall begin on low side and progress toward high side of sloped areas. Rolling shall continue until material does not creep or wave ahead of roller wheels.
3. Surface irregularities which exceed 1/2 in. as measured by means of a 10 ft. long straightedge, shall be replaced and properly recompacted.

D. Base course shall be compacted at optimum moisture content to not less than 95% of maximum density as determined by ASTM D 1557.

E. Subgrade and base course shall be kept clean and uncontaminated. Less select materials shall not be permitted to become mixed with gravel. Materials spilled outside pavement lines shall be removed and area repaired.

F. Portions of subgrade or of construction above which become contaminated, softened, or dislodged by passing of traffic, or otherwise injured, shall be cleaned, replaced, or otherwise repaired to conform to the requirements of this specification before proceeding with next operation.

3.3 STEEL REINFORCEMENT

A. General: Comply with CRSI's "Manual of Standard Practice" for fabricating, placing, and supporting reinforcement.

B. Before being placed in position, reinforcing for reinforced concrete shall be thoroughly cleaned of loose mill and rust scale, dirt, ice, and other foreign material which may reduce the bond between the concrete and reinforcing. Where there is delay in placing concrete after reinforcement is in place, bars shall be reinspected and cleaned when necessary.

C. Any bar showing cracks after bending shall be discarded.

D. Unless otherwise indicated on the Drawings, reinforcing shall extend within 2 in. of formwork and expansion joints. Reinforcing shall continue through control joints. Adjacent sheets of fabric reinforcing shall lap 6 in.

E. After forms have been coated with form release agent, but before concrete is placed, reinforcing steel anchors shall be securely wired in the exact position called for, and shall be maintained in that position until concrete is placed and compacted. Chair bars and supports shall be provided in a number and arrangement satisfactory to the Architect.

F. Install welded wire reinforcement in lengths as long as practicable. Lap adjoining pieces at least one full mesh, and lace splices with wire. Offset laps of adjoining widths to prevent continuous laps in either direction.

3.4 PORTLAND CEMENT CONCRETE PAVING

A. Paving mix, equipment, methods of mixing and placing, and precautions to be observed as to weather, condition of base etc., shall meet the requirements of ACI 325.9R. Pavement shall be constructed in accordance with the Drawings.

B. The Architect shall be notified of concrete placement sufficiently in advance of start of operation to allow his representative to complete preliminary inspection of the work, including subgrade, forms, and reinforcing steel, if used.

C. Normal concrete placement procedures shall be followed. Concrete shall arrive at the jobsite so that no additional water will be required to produce the desired slump. When conditions develop that required addition of water to produce the desired slump, permission of the Architect must be obtained. The concrete shall be transported from the mixer to its place of deposit by a method that will prevent segregation or loss of material.

D. Work shall not be performed during rainy weather or when temperature is less than 40^{o} F. (4.4^{o} C).

E. Adjacent work, etc., shall be protected from stain and damage during entire operation. Damaged and stained areas shall be replaced or repaired to equal their original conditions.

F. Existing concrete, earth, and other water-permeable material against which new concrete is to be placed shall thoroughly damp when concrete is placed. There shall be no free water on surface.

G. Concrete which has set or partially set before placing shall not be employed. Re-tempering of concrete will not be permitted.

H. Concrete shall be thoroughly spaded and tamped to secure a solid and homogeneous mass, thoroughly worked around reinforcement and into corners of forms.

I. When joining fresh concrete to concrete which has attained full set, latter shall be cleaned of foreign matter, and mortar scum and laitance shall be removed by chipping and washing. Clean, roughened base surface shall be saturated with water, but shall have no free water on surface. A coat of 1:1 cement-sand grout, approximately 1/8 in. thick, shall be well scrubbed into thoroughly dampened concrete base. New concrete shall be placed immediately, before grout has dried or set.

J. At concrete slabs below mortared unit pavers (concrete and granite see Sections 321413 and 321440) the maximum deviation is slabs ½" from proposed elevation.

3.5 FINISHING

A. Concrete flatwork surfaces shall be screeded off, bullfloated, power or hand floated, troweled and finished true to line and grade, and free of hollows and bumps. Surface shall be dense, smooth, and at exact level and slope required.

1. Finished concrete surface for exposed concrete pavement shall be wood-floated and steel troweled to a smooth surface. Surface shall not deviate more than 1/8 in. in 10 ft.

B. Unless otherwise indicated, horizontal surfaces of concrete surfaces which will be exposed shall be given a medium broomed finish, with direction of grooves in concrete surface perpendicular to length of concrete band, slab, or pad. After concrete has set sufficiently to prevent coarse aggregate from being torn from surface, but before it has completely set, brooms shall be drawn across it to produce a pattern of small parallel grooves. Broomed surface shall be uniform, with no smooth, unduly rough or porous spots, or other irregularities. Coarse aggregate shall not be dislodged by brooming operation. Confirm direction of brooming with Landscape Architect prior to commencement.

D. Immediately following finishing operations, arrises at edges and both sides of expansion joints shall be rounded to a 1/4 in. radius. Control joints to be tooled shall be scored into slab surface with scoring tool. Adjacent edges of control joint shall at same time be finished to a 1/4 in. radius.

E. Where finishing is performed before end of curing period, concrete shall not be permitted to dry out, and shall be kept continuously moist from time of placing until end of curing period, or until curing membrane is applied.

3.6 CURING

A. It is essential that concrete be kept continuously damp from time of placement until end of specified curing period. It is equally essential that water not be added to surface during floating and troweling operations, and not earlier than 24 hours after concrete placement. Between finishing operations surface shall be protected from rapid drying by a covering of waterproofing paper. Surface shall be damp when the covering is placed over it, and shall be kept damp by means of a fog spray of water, applied as often as necessary to prevent drying, but not sooner than 24 hours after placing concrete. None of the water so applied shall be troweled or floated into surface.

B. Concrete surfaces shall be cured by completely covering with curing paper or application of a curing compound.

1. Concrete cured using waterproof paper shall be completely covered with paper with seams lapped and sealed with tape. Concrete surface shall not be allowed to become moistened between 24 and 36 hours after placing concrete. During curing period surface shall be checked frequently, and sprayed with water as often as necessary to prevent drying, but not earlier than 24 hours after placing concrete.
2. If concrete is cured with a curing compound, compound shall be applied at a rate of 200 sq. ft. per gallon, in two applications perpendicular to each other.
3. Curing period shall be seven days minimum.

3.8 EXPANSION JOINTS

A. Expansion joints (isolation joints) shall be 3/8 in. wide and shall be located 30 ft. o.c unless otherwise indicated on the Drawings and at places where pavement meets other vertical faces. Expansion joint shall be formed in the concrete to required width with preformed joint filler in place. Joint filler shall extend the full width and depth of the slab. Joint filler shall extend the full length of the expansion joint.
1. For concrete pavements, depth of joint filler shall be as required to form a 1-1/4 in. deep sealant and backer rod recess below finished concrete surface.

3.9 CONTROL JOINTS

A. Control joints indicated shall be sawn by using a diamond blade concrete power saw. Joint shall be made after concrete is finished and when the surface is stiff enough to support the weight of workmen without damage to the slab. Saw shall cut into slab at least 1 in., but in no case less than 25% of slab depth.
1. Saw cut joints shall be sawn flush to vertical surfaces.
2. Unless otherwise indicated on the Drawings, control joints in pedestrian pavements (sidewalks) shall be located 10 ft. o.c. maximum.

3.10 TACTILE WARNING SURFACE – See Section 323120 Site Furnishings for information and drawings for locations.

3.11 COLD WEATHER CONCRETING

A. Materials for concrete shall be heated when concrete is mixed, placed, or cured when the mean daily temperature is below 40^{O}F. or is excepted to fall to below 40^{O}F. within 72 hours, and the concrete after placing shall be protected by covering, heat, or both.

B. Details of handling and protecting of concrete during freezing weather shall be subject to the approval and direction of the Architect. Procedures shall be in accordance with provisions

of ACI 306R.

3.12 HOT WEATHER CONCRETING

A. Concrete just placed shall be protected from the direct rays of the sun and the forms and reinforcement just prior to placing shall be sprinkled with cold water. Every effort shall be made to minimize delays which will result in excessive mixing of the concrete after arrival on the job.

B. During periods of excessively hot weather (95^{O}F., or above), ingredients in the concrete shall be cooled insofar as possible and cold mixing water shall be used to maintain the temperature of the concrete at permissible levels all in accordance with the provisions of ACI 305. Any concrete with a temperature above 95^{O}F., when ready for placement will not be acceptable, and will be rejected.

C. Temperature records shall be maintained throughout the period of hot weather giving air temperature, general weather conditions (calm, windy, clear, cloudy, etc.) and relative humidity. Records shall include checks on temperature of concrete as delivered and after placing in forms. Data should be correlated with the progress of the work so that conditions surrounding the construction of any part of the structure can be ascertained.

3.13 SEALING OF JOINTS

A. Where indicated on the Drawings, expansion joints and control joints shall be sealed with joint sealant in accordance with the precautions specified in the Appendix of ASTM C 962, and as specified in Section 07 92 01, EXTERIOR JOINT SEALANTS.

3.14 FIELD QUALITY CONTROL

A. Testing Services: Testing of composite samples of fresh concrete obtained according to ASTM C 172 shall be performed according to the following requirements:

1. Testing Frequency: Obtain at least 1 composite sample for each 5000 sq. ft. or fraction thereof of each concrete mix placed each day.
   a. When frequency of testing will provide fewer than five compressive-strength tests for each concrete mixture, testing shall be conducted from at least five randomly selected batches or from each batch if fewer than five are used.
2. Slump: ASTM C 143/C 143M; one test at point of placement for each composite sample, but not less than one test for each day's pour of each concrete mix. Perform additional tests when concrete consistency appears to change.
3. Air Content: ASTM C 231, pressure method; one test for each composite sample, but not less than one test for each day's pour of each concrete mix.
4. Concrete Temperature: ASTM C 1064; one test hourly when air temperature is 40 deg F (4.4 deg C) and below and when 80 deg F (27 deg C) and above, and one test for each composite sample.
5. Compression Test Specimens: ASTM C 31/C 31M; cast and laboratory cure one set of three standard cylinder specimens for each composite sample.
6. Compressive-Strength Tests: ASTM C 39/C 39M; test 1 specimen at 7 days and 2 specimens at 28 days.
   a. A compressive-strength test shall be the average compressive strength from 2 specimens obtained from same composite sample and tested at 28 days.

B. Strength of each concrete mix will be satisfactory if average of any 3 consecutive compressive-strength tests equals or exceeds specified compressive strength and no compressive-strength test value falls below specified compressive strength by more than

500 psi (3.4 MPa).

C. Test results shall be reported in writing to Architect, concrete manufacturer, and Contractor within 48 hours of testing. Reports of compressive-strength tests shall contain Project identification name and number, date of concrete placement, name of concrete testing and inspecting agency, location of concrete batch in Work, design compressive strength at 28 days, concrete mixture proportions and materials, compressive breaking strength, and type of break for both 7- and 28-day tests.

D. Nondestructive Testing: Impact hammer, sonoscope, or other nondestructive device may be permitted by Architect but will not be used as sole basis for approval or rejection of concrete.

E. Additional Tests: Testing and inspecting agency shall make additional tests of concrete when test results indicate that slump, air entrainment, compressive strengths, or other requirements have not been met, as directed by Architect.

F. Remove and replace concrete pavement where test results indicate that it does not comply with specified requirements.

G. Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.

3.15 PROTECTION OF CONCRETE SURFACES

A. Concrete surfaces shall be protected from traffic or damage until surfaces have hardened sufficiently. If necessary 1/2 in. thick plywood sheets shall be used to protect the exposed surface.

B. Drill test cores, where directed by Architect, when necessary to determine magnitude of cracks or defective areas. Fill drilled core holes in satisfactory pavement areas with portland cement concrete bonded to pavement with epoxy adhesive.

3.16 CONSTRUCTION WASTE MANAGEMENT

A. Comply with the requirements of Division 01, GENERAL REQUIREMENTS, for removal and disposal of construction debris and waste.

1. Do not allow excavated materials to accumulate on-site.

END OF SECTION

Section 321413
CONCRETE UNIT PAVING

PART 1 GENERAL

1.0 RELATED DOCUMENTS

A. Division 00 – PROCUREMENT AND CONTRACTING REQUIREMENTS
Division 01 - GENERAL REQUIREMENTS, as listed in the Table of Contents, including but not limited to the following sections, shall be included in and made a part of this Section:
01 30 00 – SUBMITTALS
01 43 39 – MOCK-UPS
01 81 13 – SUSTAINABLE DESIGN REQUIREMENTS

1.1 DESCRIPTION OF WORK

A. The work includes furnishing all labor, materials, equipment, and supervision to construct the concrete unit paving, in accordance with the Drawings and Specifications.

1. Concrete unit pavers installed on a ~~mortar~~ ***sand*** (Add. #4) setting bed over a concrete base.

1.2 RELATED WORK

A. Examine Contract Documents for requirements that affect work of this Section. Other Specification Sections that directly relate to work of this Section include, but are not limited to:

1. Section 014320, QUALITY CONTROL AND TESTING SERVICES; Inspection and testing.
2. Section 033001, CAST-IN-PLACE CONCRETE – SITEWORK; Reinforced concrete base with vertical weep holes for unit pavers.
3. Section 07 92 01, EXTERIOR JOINT SEALANTS.

1.3 REFERENCES

A. Comply with applicable requirements of the following standards. Where these standards conflict with other specified requirements, the most restrictive requirement shall govern.

1. American Association of State Highway and Transportation Officials (AASHTO):

Specifications	Standard Specifications for Highway Bridges
M 43	Standard Size of Coarse Aggregate for Highway Construction

2. American Society for Testing and Materials (ASTM):

C 67	Sampling and Testing Brick and Structural Clay Tile
C 91	Masonry Cement
C 136	Sieve Analysis of Fine and Coarse Aggregates
C 144	Aggregate for Masonry Mortar
C 216	Facing Brick (Solid Masonry Units Made from Clay or Shale)
C 902	Pedestrian and Light Traffic Paving Brick
D 36	Softening Point of Bitumen (Ring-and-Ball Apparatus)
D 113	Ductility of Bituminous Materials
D 3381	Viscosity-Graded Asphalt Cement for Use in Pavement Construction.

3. Americans with Disabilities Act (ADA):

Appendix to Part 1191	Accessibility Guidelines for Buildings and Facilities

4. National Concrete Masonry Association (NCMA):

A-10	Solid Concrete Masonry Paving Units

5. State of New Hampshire Department of Transportation (NHDOT):

Specifications Bridge	Standard Specifications for Road and Construction

1.4 SUBMITTALS

A. Submit manufacturer's product data for each type of concrete paver.

B. Submit a minimum of three concrete pavers of each type and size required to Architect for approval. Samples shall exhibit the full color range of pavers to be provided.

C. Submit ~~mortar~~ ***sand setting*** (Add. #4) bed information to Architect for approval.

D. Submit joint sand information and sample for Architect approval.

E. Submit a sample of edge material, 12 in. length, with one bolt.

F. Test Report:

1. Test report of precast concrete paver shall be submitted.
2. Testing shall be done by an independent testing laboratory. Test procedures shall conform to ASTM C 936 methods, where applicable.
3. Test report shall indicate, as a minimum, the following:
   a. Compressive strength, psi.
   b. Absorption, 5 hr. submersion in cold water.
   c. Absorption, 24 hr. submersion in cold Water.
   d. Maximum saturation coefficient.
   e. Initial rate of absorption (suction).
   f. Abrasion index.
   g. Freeze-thaw.

1.5 IN-SITU MOCK-UP

A. Construct the initial 6' x 6' panel of concrete unit paving in a location selected with the architect consistent with dimensions and details for concrete unit paving as shown on the Drawings. This panel will serve as the project mockup for approval and, if approved, may remain as part of the final project. This in-situ mockup panel shall exhibit paving pattern, finish, color, direction, and required jointing and relationship to adjacent paving.
Sample panel shall be inspected by the Architect prior to any additional unit paving construction. If the original panel is not acceptable, remove and construct additional panels at no cost to the Owner until an acceptable panel is constructed. The acceptable panel shall become the standard for the entire job, and may be included as part of the final installation.

1. Schedule preconstruction meeting with Architect before construction mockup.
2. Notify Architect seven days in advance of dates and times when mockups will be constructed.
3. Demonstrate the proposed range of aesthetic effects and workmanship.
4. Obtain Architect's approval of mockups before starting paver installation.
5. Maintain mockups during construction in an undisturbed condition as a standard for judging the completed Work.
6. Demolish and remove rejected panels when directed.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Pavers shall be carefully packed and loaded for shipment and all necessary precautions taken against damage in transit and handling.

B. Aggregate materials shall be kept dry and free from soiling.

C. Pavers damaged in any manner will be rejected and replaced with new materials at no additional cost to the Owner.

PART 2 PRODUCTS

2.1 CONCRETE PAVERS – Note: Drawing detail is shown for paver thickness of 3", if 4" thick pavers are preferred by Owner setting detail will be modified.

A. Approved paver manufacturers, sizes and colors are:

1. Hanover Prest Concrete Pavers, hydraulically precast concrete pavers, manufactured by Hanover Architectural Products, Inc., Hanover, PA 17331, www.hanoverpavers.com or approved equal. Pavers shall be as follows:

   a. Sizes: Pavers shall be 4 in. x 8 in. x 3 in thickness. gauged.
   b. Color: 35% Charcoal/ 35 % Limestone/ 30% Matrix #M1025/T
   c. Finish: Tudor Finish.

2. Tectura Designs Expressions pavers by Wausau Tile Inc, PO Box 1520, Wausau, WI 54402-1520, p: 800.388.8729, www.tecturadesigns.com :

   a. Sizes: Pavers shall be 4 in. x 12 in. x 4 in thickness., gauged.
   b. Color: 35% HXP-110/ 35 % HXP-50/ 30% HXP-10
   c. Finish: Standard

3. Narrow Modular pavers by Stepstone Inc, 17025 So. Main Street, Gardena, CA p: 310.327.7474, www.stepstoneinc.com

   a. Sizes: Pavers shall be 3 in. x 9 in. x 4 in thickness., gauged.
   b. Color: 35% Porcelain 1813/ 35 % French Gray 1804/ 30% Agave 1812
   c. Finish: Light sand blast

B. Pavers shall be solid concrete unit pavers in sizes and textures indicated. Produced from a single homogenous mix (no lamination) containing laminin and possessing the following physical characteristics:

1. No efflorescence after 7 days exposure to water ASTM C-67
2. UV Resistant ASTM G 154
3. Absorption less than 4% ASTM C 936
4. Average compressive strength 8,000 psi ASTM C 936
5. Average absorption less than 5% ASTM C 936
6. Average Abrasion coefficient .0937 ASTM C 418
7. Static coefficient of friction Dry 1.08 Wet .85 ASTM C 1028
8. Stain resistant ASTM C 1378

2.2 SETTING BED ~~MORTAR~~ ***SAND*** (Add. #4)

~~A. Setting bed mortar shall be equal to "Laticrete 3701 Fortified Mortar Bed", a polymer fortified blend of carefully selected polymers, portland cement and graded aggregates, manufactured by Laticrete International, Inc., One LATICRETE Park North, Bethany, CT 06524-3423 USA 1.800.243.4788 · +1.203.393.0010, or approved equal. Mix with water according to manufacturer's instructions.~~

A. Sand shall be a clean, washed, uniformly well graded masonry sand with 100 percent passing No. 16 (1.18-mm) sieve and no more than 10 percent passing No. 200 (0.075-mm) sieve, conforming to ASTM C 144, except that the fineness modulus shall be 2.25+ 0.10. Sand shall be from a single source. Source of supply shall not be changed during course of job without written permission of the Architect. (Add. #4)

~~2.3 BOND COAT~~

~~A. High strength bond coat between concrete base slab and setting bed mortar, and between setting bed mortar and concrete unit paver shall be equal to "Laticrete 254 Platinum", one-step, polymer fortified, thin-set mortar bond coat, manufactured by Laticrete International, Inc., One LATICRETE Park North, Bethany, CT 06524-3423 USA · 1.800.243.4788 · +1.203.393.0010, or approved equal.~~

2.3 FILTER FABRIC

A. Filter fabric shall be a non-woven polypropylene fabric equal to Mirafi 140N, manufactured by Tencate, 365 South Holland Drive, Pendergrass, GA 30567; Tel 800 685 9990; Tel 706 693 2226; Fax 706 693 4400; www.mirafi.com, or approved equal.

2.4 SAND JOINT FILLER

A. Gradation for joint filler sand shall be as follows:

1. Sand shall be a clean, washed, uniformly well graded masonry sand with 100 percent passing No. 16 (1.18-mm) sieve and no more than 10 percent passing No. 200 (0.075-mm) sieve, conforming to ASTM C 144, except that the fineness modulus shall be 2.25+ 0.10. Sand shall be from a single source. Source of supply shall not be changed during course of job without written permission of the Architect.
2. Color of sand shall be uniform matching the paver in color, and shall be approved by the Architect.

2.5 PAVER RESTRAINT

A. Approved Products and manufacturers:

a. Permaloc AsphaltEdge, with 0.210 inch (5.33 mm) thick exposed top lip x 2.5" (63.5mm) high x 8 feet (2.44 meters) long, extruded aluminum, alloy 6005, T-5 hardness as manufactured by Permaloc Corporation, Holland MI 49424, telephone (800) 356-9660 or (616) 399-9600, or approved equal. Horizontal base to have upward facing angle profile designed to integrate restraint. Section shall have holes in base spaced 4 inches (102 mm) apart along its length to receive anchors.
b. Duralum aluminum paver restraint edging by JD Russell Company, PO Box 183471, Shelby Township, MI 48318 p: 586.254.8500; www.jdrussell.com;
c. Iron Edge by Border Concepts, 7621 Little Ave, Suite 426, Charlotte, NC 28226, p: 800.845.3343, www.borderconcepts.com.

B. Connection Method: Varies per manufacturer. General: Section ends shall splice together with horizontal 0.060 inch (1.52 mm) thick x 1 inch (25 mm) wide, or 0.530 inch (13.5 mm) wide for 1 inch (25 mm) high edging x 4 inches (102 mm) long aluminum sliding connector.

C. Anchors: 3/16 inch x 1-1/2 inches (4.8 mm x 38 mm) or longer Ardox concrete nail, or drive pin fastener equal to Hilti DX 40 powder actuated pin or Ramset Trakfast Automatic Fastening System pin.

D. Finish: Black. Paint finish shall comply with AAMA 2603 for electrostatically baked on paint.

2.6 WATER

A. Water shall be potable and shall be free of injurious contaminants.

PART 3 EXECUTION

3.1 ACCEPTABILITY OF BASE

A. Contractor shall examine the concrete base slab to determine its adequacy to receive concrete pavers and ~~mortar~~ ***sand*** (Add. #4) setting bed. Evidence of inadequate base shall be brought to the immediate attention of the Architect.

B. Start of work of this Section shall constitute acceptance of concrete base slab.

3.2 PREPARATION

~~A. Vacuum clean concrete substrates to remove dirt, dust, debris, and loose particles.~~

A. Drill 2" diameter holes through concrete base slab 36" o.c.

B. Vacuum clean concrete base slab and drilled holes to remove dirt, dust, debris, and loose particles.

C. Fill drilled holes with washed #8 stone. (Add. #4)

3.3 PAVER RESTRAINT

A. Locate border line of edging with string or other means to assure border straightness and curves as designed.

B. Edging Installation: Install base of edging resting on base and folding underneath paver:

1. Drive powder actuated nails through edge base to concrete.
2. Anchor each section end with anchor.
3. Concrete Base: Hilti DX A41 Fully Automatic Powder Actuated Tool is desirable where sufficient hold can be obtained. Provide 3/4 inches (19 mm) to 1 inches (25 mm) nail at 4 inches (102 mm) to 12 inches (305 mm) on center spacing with applicable charge recommended. Anchor into outer 1 inch (25 mm) of base of restraint edging and not less than 2.5 inches (63.5 mm) from edge of concrete.
4. Securely connect sections in accordance with manufacturer's instructions. Provide additional anchors at closer spacing as necessary to firmly secure edging for permanent intended use.

3.4 INSTALLATION, GENERAL

A. Do not use unit pavers with chips, cracks, voids, discolorations, and other defects that might be visible or cause staining in finished work.

B. Mix pavers from several pallets or cubes, as they are placed, to produce uniform blend of colors and textures.

C. Cut unit pavers with motor-driven masonry saw equipment to provide clean, sharp, unchipped edges. Cut units to provide pattern indicated and to fit adjoining work neatly. Use full units without cutting where possible. Hammer cutting is not acceptable.

D. Joint Pattern: As indicated on the Drawings.

E. Tolerances: Do not exceed 1/16-inch (1.6-mm) unit-to-unit offset from flush (lippage) nor 1/8 inch in 24 inches (3 mm in 600 mm) and 1/4 inch in 10 feet (6 mm in 3 m) from level, or indicated slope, for finished surface of paving.

F. Expansion and Control Joints: Provide for sealant-filled joints at locations and of widths indicated. Provide joint filler as backing for sealant-filled joints where indicated. Install joint filler before setting pavers. Sealant materials and installation are specified in Section 07 92 01, EXTERIOR JOINT SEALANTS.

G. Minimum Paver Dimensions:

1. Minimum dimensions for trimmed pavers are 3” in width and 4” in length. Avoid ‘wedges’ or small pieces of pavers. If required to meet minimum dimensions trim 3-4 course of adjacent pavers evenly. Any installed pavers not meeting minimum dimensions are to be removed and replaced.
2. Whenever possible use whole courses of pavers and align joint pattern with other site elements to achieve consistent jointing and minimize trimming.
3. Review paver layout and jointing patterns with architect in field prior to installation.

3.5 SETTING CONCRETE PAVERS – ~~MORTAR~~ ***SAND*** (Add. #4) BED

~~A. Saturate concrete subbase with clean water several hours before placing setting bed. Remove surface water about one hour before placing setting bed.~~

~~B. Apply cement-paste bond coat over surface of concrete subbase about 15 minutes before placing setting bed. Limit area of bond coat to avoid its drying out before placing setting bed. Do not exceed 1/16-inch (1.6-mm) thickness for bond coat.~~

~~C. Apply mortar bed over bond coat immediately after applying bond coat. Mortar setting shall be 3/4 in. thick, minimum. Spread and screed setting bed to uniform thickness at subgrade elevations required for accurate setting of pavers to finished grades indicated.~~

~~D. Mix and place only that amount of mortar bed that can be covered with pavers before initial set. Cut back, bevel edge, remove, and discard setting-bed material that has reached initial set before placing pavers.~~

~~E. Concrete pavers shall be neatly cut and fitted at all perimeters and closures to fit neatly and closely, with joints uniform in thickness. Pavers shall be cut with a water-cooled, cut-off wheel masonry saw using a diamond blade. Concrete pavers with chips, cracks, stains, or other defects which might be visible in the finished work shall not be used.~~

~~F. Wet concrete pavers before laying if the initial rate of absorption exceeds 30 g/30 sq. in. (30 g/194 sq. cm) per minute when tested per ASTM C 67. Allow units to absorb water so they are damp but not wet at the time of laying.~~

~~G. Place pavers before initial set of cement occurs. Immediately before placing pavers on setting bed, apply uniform 1/16-inch- (1.5-mm-) thick, slurry bond coat to bed or to back of each paver with a flat trowel.~~

~~H. Tamp or beat pavers with a wooden block or rubber mallet to obtain full contact with setting bed and to bring finished surfaces within indicated tolerances. Set each paver in a single operation before initial set of mortar; do not return to areas already set and disturb pavers for purposes of realigning finished surfaces or adjusting joints.~~

~~I. Spaced Joint Widths: Provide hand tight joints.~~

~~J. Exposed surfaces shall be kept free from mortar at all times. Excess mortar shall be immediately removed before latex modified mortar can set.~~

A. Lay filter fabric across entire concrete slab where pavers will be laid

B. Lay sand bed across area that can be laid that day and screed to required depth and level.

C. Concrete pavers shall be neatly cut and fitted at all perimeters and closures to fit neatly and closely, with joints uniform in thickness. Pavers shall be cut with a water-cooled, cut-off wheel masonry saw using a diamond blade. Concrete pavers with chips, cracks, stains, or other defects which might be visible in the finished work shall not be used.

D. Tamp or beat pavers with a wooden block or rubber mallet to obtain full contact with setting bed and to bring finished surfaces within indicated tolerances.

E. Spaced Joint Widths: Provide hand tight joints. (Add. #4)

3.5 JOINT TREATMENT - SAND

A. On a dry day, after pavers have been installed, joints of pavers shall be filled by sweeping dry sand into them. When joints are filled, paver surfaces shall be lightly misted with a fine spray of water to settle sand joint filler. Additional dry sand shall be added and swept into joints, repeating the process until joints are completely filled. Pavers shall then be swept clean and rinsed with a fine spray, careful not to dislodge joint filler.

3.6 CLEANING OF PAVED SURFACE

A. After completion of the concrete pavers, paved areas shall be thoroughly swept clean and surface shall be left unsoiled. Where required, surface shall be cleaned with water or an approved cleaner.

END OF SECTION

Section 32 14 10
GRANITE PAVING

PART 1 GENERAL

1.0 RELATED DOCUMENTS

A. Division 00 – PROCUREMENT AND CONTRACTING REQUIREMENTS
Division 01 - GENERAL REQUIREMENTS, as listed in the Table of Contents, including but not limited to the following sections, shall be included in and made a part of this Section:
01 30 00 – SUBMITTALS
01 43 39 – MOCK-UPS
01 81 13 – SUSTAINABLE DESIGN REQUIREMENTS

1.1 DESCRIPTION OF WORK

A. Provide all equipment and materials, and do all work necessary to construct the granite unit paving as indicated on the Drawings and as specified, including but not limited to:

1. Granite pavers installed on a ~~mortar~~ ***sand*** (Add. #4) setting bed over a cast-in-place concrete base.

1.2 RELATED WORK

A. Examine Contract Documents for requirements that affect work of this Section. Other Specification Sections that directly relate to work of this Section include, but are not limited to:

1. Section 033001, CAST-IN-PLACE CONCRETE - SITEWORK; Concrete base.
2. Section 079201, EXTERIOR JOINT SEALANTS; Sealing expansion joints.
3. Section 312000, EARTHWORK; Excavation, backfill, compaction and establishment of subgrade elevations.
4. Section 32 13 13, CONCRETE PAVING

1.3 REFERENCES

A. Comply with applicable requirements of the following standards. Where these standards conflict with other specified requirements, the most restrictive requirement shall govern.

1. American Association of State Highway and Transportation Officials (AASHTO):

Specifications	Standard Specifications for Highway Bridges
M 43	Standard Size of Coarse Aggregate for Highway Construction

2. American Society for Testing and Materials (ASTM):

C 67	Sampling and Testing Brick and Structural Clay Tile
C 91	Masonry Cement
C 97	Absorption and Bulk Specific Gravity of Natural Building Stone
C 136	Sieve Analysis of Fine and Coarse Aggregates
C 144	Aggregate for Masonry Mortar
C 150	Portland Cement
C 170	Compressive Strength of Dimension Stone
C 207	Hydrated Lime for Masonry Purposes
C 270	Mortar for Unit Masonry
C 880	Flexural Strength of Natural Building Stone

1.4 SUBMITTALS

A. Samples: Samples of stone pavers shall be "range samples" provided from the exact quarry stone pavers will be supplied from. Samples of the following shall be submitted:

Item	Quantity and Size
Granite Paver	Three required each size, 1' x 1' full thickness, specified color and finish.
~~Mortar Pointing Grout~~	~~Color chart, Cured sample, 2 x 2 in., color to be specified.~~
Granite Cobble	Three required, full size, thickness, color and finish as specified

B. Manufacturer's Product Data: Manufacturer's product data shall be submitted for the following items:

~~Mortar materials, including additives~~
~~Grout materials, including additives~~
Sand setting bed material
Filter fabric
Joint sand (Add. #4)

C. Shop Drawings: Shop drawings of granite pieces specified here in shall be submitted. Drawings shall indicate sizes, dimensions, layout, and finishes and relationship to adjacent items.

D. Contractor's Review: Before commencing work, submit written statement signed by the Contractor stating that the Contract Documents have been reviewed with a qualified representative of the granite supplier, and that he is in agreement that the selected materials and construction are proper, compatible, and adequate for the application shown.

E. Test Report: Submit reports from tests conforming to ASTM C 67 methods indicating:

1. Compressive strength, psi. (ASTM C 170)
2. Density, lbs./c.f. (ASTM C 97)
3. Absorption by weight, % (ASTM C 97)
4 Abrasion resistance (ASTM C 241)
5. Flexural strength psi, (MPa) (ASTM C 880)

1.5 IN-SITU MOCKUP

A. Construct the initial 6' x 6' panel of granite paving (for both dimensional granite pavers and cobble pavers) in a location selected with the architect consistent with dimensions and details for granite paving as shown on the Drawings. This panel will serve as the project mockup for approval and, if approved, may remain as part of the final project. This in-situ mockup panel shall exhibit granite pavers, grain and grain direction, and required jointing and relationship to adjacent paving.
Sample panel shall be inspected by the Architect prior to any additional granite paving construction. If the original panel is not acceptable, remove and construct additional panels at no cost to the Owner until an acceptable panel is constructed. The acceptable panel shall become the standard for the entire job, and may be included as part of the final installation.

1. Schedule preconstruction meeting with Architect before construction mockup.
2. Notify Architect seven days in advance of dates and times when mockups will be constructed.
3. Demonstrate the proposed range of aesthetic effects and workmanship.
4. Obtain Architect's approval of mockups before starting paver installation.
5. Maintain mockups during construction in an undisturbed condition as a standard for judging the completed Work.
6. Demolish and remove rejected panels when directed.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: An experienced installer who has completed unit paver installations similar in material, design, and extent to that indicated for this Project and whose work has resulted in construction with a record of successful in-service performance. Minimum 5 years' experience and three projects of same scale and value within the last three years. Provide three references for review.

B. Source Limitations: Obtain each type of unit paver, joint material, and setting material from one source with resources to provide materials and products of consistent quality in appearance and physical properties.

1. Granite shall be free of cracks, seams, starts or other defects which may impair its strength, durability or appearance. Color, texture and finish shall be within the range of samples approved by the Architect.

1.7 LAYOUT

A. The granite paving layout indicated on the Drawings is approximate. The final configuration of the paving will be determined in the field by the Architect.

1.8 DELIVERY, HANDLING, AND STORAGE

A. Granite shall be carefully packed and banded by the supplier for shipment. Following shipping granite shall be stored on wood skids or pallets, covered with non-staining, waterproof membrane and protected from the weather. Skids shall be placed and stacked in such a manner as to evenly distribute the weight of the granite materials and to prevent breakage, cracking, and damage to granite pieces. Granite materials shall be stored in such a manner as to allow air to circulate around the granite material. Granite shall not be permitted to be in direct contact with the ground any time during storage.

B. Granite damaged in any manner will be rejected and replaced with new materials at no additional cost to the Owner.

1.9 PROTECTION OF FINISHED SURFACES

A. Finished surfaces adjacent to the paving work shall be adequately protected from soiling, staining, and other damage.

~~1.10 PROJECT CONDITIONS~~

~~A. Cold Weather Protection:~~

~~1. Remove any ice or snow formed on stone or concrete bed by carefully applying heat until top surface is dry to touch.~~
~~2. Remove stone work determined to be damaged by freezing conditions.~~
~~3. Perform the following construction procedures while work is progressing:~~

~~Air Temperature~~	~~Procedures~~
~~40° - 32°F.~~	~~Heat sand to produce mortar temperatures between 40° and 120°F.~~
~~32° - 25°F.~~	~~Heat sand to produce mortar temperatures between 40° and 120°F. Maintain temperature of mortar on boards above freezing.~~
~~25° - 20°F.~~	~~Heat sand to produce mortar temperatures between 40° and 120°F. Maintain temperature of mortar on boards above freezing. Use wind breaks when wind is in excess of 15 mph.~~
~~20°F. - below~~	~~Heat sand to produce mortar temperatures between 40° and 120°F. Provide enclosures and auxiliary heat to maintain air temperature above 32°F. Do not lay units which have a surface temperature below 20°F.~~

~~4. Latex admixture shall be kept at 40°F. minimum.~~

~~B. Cold Weather Protection for Completed Stone Work:~~

~~Mean Daily Air Temperatures~~	~~Procedures~~
~~40° - 32°F.~~	~~Protect stone work from rain or snow for at least 24 hours by covering with weather-resistive membrane.~~
~~32° - 25°F.~~	~~Completely cover stone work with weather-resistive membrane for at least 24 hours.~~
~~25° - 20°F.~~	~~Completely cover stone work with insulating blankets or similar protection for at least 24 hours.~~
~~20°F. - below~~	~~Maintain stone work at temperature above 32°F. for 24 hours using enclosures and supplementary heat.~~

~~1. Do not use frozen materials or materials mixed or coated with ice or frost. Do not lower the freezing point of mortar by use of admixtures or antifreeze agents, and do not use calcium chloride in mortar or grout.~~
~~2. Do not build on frozen work; remove and replace stone work damaged by frost or freezing.~~
~~3. During all seasons, protect partially completed stone work against weather when work is not in progress.~~

PART 2 PRODUCTS

2.1 BASE SLABS

A. Cast-in-place concrete base: Refer to Section 033001, CAST-IN-PLACE CONCRETE – SITEWORK and Section 321313, CONCRETE PAVING.

2.2 GRANITE PAVERS

A. Approved granite pavers and manufacturers are:

a. Cold Spring Black, Rub and Sand finish all exposed surfaces supplied by Cold Spring Granite Co., Cold Spring, MN 56320,
b. Hanover Granite Paver Basalt black, thermal flamed finish by Hanover Architectural Products, 5000 Hanover Rd, Hanover, PA, 17331, p: 717-637-0500;
c. American Black, Cambrian Black or American Mist propane flamed, plasma flamed or waterjet finish by Polycor 76 rue Saint-Paul, Suite 100 Quebec City (Quebec) Canada G1K 3V9, p:1-418-692-4695, www.polycor.com;
d. Peribonka Gem 8 or thermal finish by Granicor, 300, rue Rotterdam, St-Augustin, Quebec, G3A 1T4 p: 1-418-878-3530 or other approved source.

B. Granite pavers shall be of specified sizes as follows:

1. 18 in. x 36 in. x 3 (or 4) in. pavers. (Note: thickness may be 4” if a 4” thick concrete paver is chosen for project). Concrete unit pavers and granite paver thickness shall match.
2. Over size pavers: 18 in. x 42 in. x 3 (or 4) in. Contractor to order 10% of pavers to be oversized required to address specific site conditions. These oversize pavers shall be cut in the field to required field measured dimensions.
3. Finishes listed above vary per manufacturer. General shall be sawn bottom; sawn sides; proprietary finish above per manufacturer, provide samples for approval.

C. With the exception of the oversize pavers, granite shall be cut to exact dimensions and radii required by the fabricator prior to shipment to the project site.

D. Granite pavers shall conform to the following requirements:

1. Absorption by weight shall not exceed 0.4 %
2. Compressive strength of not less than 19,000 psi.
3. Minimum density of 160 pcf.

2.3 SETTING BED ~~MORTAR~~ ***SAND*** (Add. #4)

~~A. Setting bed mortar shall be equal to "Laticrete 3701 Fortified Mortar Bed", a polymer fortified blend of carefully selected polymers, portland cement and graded aggregates, manufactured by Laticrete International, Inc., One LATICRETE Park North, Bethany, CT 06524-3423 USA ·1.800.243.4788 · +1.203.393.0010, or approved equal. Mix with water according to manufacturer's instructions.~~

A. Sand shall be a clean, washed, uniformly well graded masonry sand with 100 percent passing No. 16 (1.18-mm) sieve and no more than 10 percent passing No. 200 (0.075-mm) sieve, conforming to ASTM C 144, except that the fineness modulus shall be 2.25+ 0.10. Sand shall be from a single source. Source of supply shall not be changed during course of job without written permission of the Architect.

~~2.4 BOND COAT~~

~~A. High strength bond coat between concrete base slab and setting bed mortar, and between setting bed mortar and granite paver shall be equal to "Laticrete 254 Platinum", one-step, polymer fortified, thin-set mortar bond coat, manufactured by Laticrete International, Inc., One LATICRETE Park North, Bethany, CT 06524-3423 USA · 1.800.243.4788 +1.203.393.0010, or approved equal.~~

2.4 FILTER FABRIC

A. Filter fabric shall be a non-woven polypropylene fabric equal to Mirafi 140N, manufactured by Tencate, 365 South Holland Drive, Pendergrass, GA 30567; Tel 800 685 9990; Tel 706 693 2226; Fax 706 693 4400; www.mirafi.com, or approved equal.

~~2.5 MORTAR GROUT FOR POINTING~~

~~A. Sanded Grout: shall be 1500 Sanded Grout, a premium, factory prepared grout designed to be mixed with water. 1500 Sanded Grout is formulated from a blend of high strength portland cement, graded aggregates, polymers and color-fast pigments and provides a grout joint that is dense, hard and durable, manufactured by Laticrete International, Inc., One LATICRETE Park North, Bethany, CT 06524-3423 USA · 1.800.243.4788 · +1.203.393.0010, or approved equal.~~

~~1. Grout joint widths shall be a min of 1/4" and maximum of 3/8".~~
~~2. Color; will be selected by Architect, submit samples for approval.~~

2.5 Joint Filler – Polymeric Sand

A. Joint filler shall be:

1. Hanover Polymeric Sand for Paving Joints, manufactured by Hanover Architectural Products, Inc., Hanover, PA 17331, or approved equal. Provide the following type:

a. HP POLYMERIC SAND: high-performance mix made of the latest-generation of polymers; specially formulated for the filling of paver or slab joints in heavy-traffic areas [such as pool decks, sloped driveways, public ways, etc.; recommended for the replacement of existing joints; unrivalled effectiveness and durability]. Maximum width: 2.5 cm (1"); a larger joint width is acceptable where the pavers intersect. Minimum depth: 3 cm (1.25").

2. Techniseal HP NextGel Jointing Sand, manufactured by Techniseal, Candiac, Quebec J5R 6X1

3. Gator Supersand G2, manufactured by Alliance Designer Products Inc., Laval, Quebec H7L 6A1

B. Color will be selected by Architect.
(Add. #4)

2.6 GRANITE COBBLE PAVERS – SALVAGED OR NEW

A. Characteristics and Quality:

1. Units shall be sound stock, and free from defects impairing strength, durability or appearance, such as cracks, seams, starts, holes, flaws or imperfections which have been patched or filled.

2. Units shall be uniformly consistent in color, value, graining texture, and other features to the extent inherent in each stone type.

3. Units shall be clean, used or new, split-face cobbles, 4” deep, and with 4”x 8” face sizes.

4. Stone shall be cut to sizes, shapes, dimensions, and details shown on the drawings for each type and condition.

5. Exposed surfaces and edges of stone units shall be free from cracks, broken corners, chipped edges, scratches, or defects affecting appearances. No patching or hiding of defects will be permitted.

6. Shop Cutting, Drilling and Fitting: Include all cutting, drilling, and fitting of stone required to accommodate the work of other trades and to fit conditions on-site. In cutting and fitting, carefully cut and grind edges to a neat, tight, fit. Cutting shall be in such a manner so as not to impair strength or appearance.

2.7 GRANITE COBBLE SETTING BED

~~A. Sand Setting Bed Material: Provide clean, washed natural sand aggregate with material and grading in accordance with ASTM C-33.~~

A. Stone Dust Setting Bed Material: stone dust of decomposed granite or trap rock conforming to the gradation requirements of AASHTO M 43, No. 10, or "stone dust" minus 1/4 in. screenings. (ESBP #3)

B. Planting Soil Composition: As specified under Section 329300.

2.8 STONE DUST JOINT FILLER

A. Stone dust for filling joints between pavers shall be stone dust of decomposed granite or trap rock conforming to the gradation requirements of AASHTO M 43, No. 10, or "stone dust" minus 1/4 in. screenings. (ESBP #3)

~~2.8~~ ***2.9*** WATER
(ESBP #3)

A. Water shall be potable and shall be free of contaminants.

PART 3 EXECUTION

3.1 BASE

A. Contractor shall examine the cast-in-place concrete base slab to determine their adequacy to receive granite pavers and setting bed. Evidence of inadequate base shall be brought to the immediate attention of the Architect. Maximum deviation in slabs is ½" from proposed elevation.

B. Start of work of this Section shall constitute acceptance of cast-in-place concrete base slab.

3.2 PREPARATION

~~A. Clean cast-in-place concrete base slab to remove dirt, dust, debris, and loose particles.~~

~~B. Remove substances, from base slabs that could impair bond, including curing and sealing compounds, form oil, and laitance.~~

A. Drill 2" diameter holes through concrete base slab 36" o.c.

B. Vacuum clean concrete base slab and drilled holes to remove dirt, dust, debris, and loose particles.

C. Fill drilled holes with washed #8 stone. (Add. #4)

3.3 INSTALLATION, GENERAL

A. Do not use granite pavers with chips, cracks, voids, discolorations, and other defects that might be visible or cause staining in finished work.

B. Mix pavers from several pallets or cubes, as they are placed, to produce uniform blend of colors and textures.

C. Cut granite pavers with motor-driven masonry saw equipment to provide clean, sharp, unchipped edges. Cut units to provide pattern indicated and to fit adjoining work neatly. Use full units without cutting where possible. Hammer cutting is not acceptable.

D. Joint Pattern: As indicated on the Drawings in a running bond pattern. If necessary a staggered bond pattern may be acceptable in places in order to avoid slivers of pavers. Minimum joint offset to be 8" and minimum paver size to be 6" x 18". If required adjacent pavers can be trimmed to accommodate site conditions. Confirm these conditions with landscape architect prior to deviation from the standard running bond pattern.

E. Tolerances: Do not exceed 1/32-inch (0.8-mm) unit-to-unit offset from flush (lippage) nor 1/8 inch in 10 feet (3 mm in 3 m) from level, or indicated slope, for finished surface of paving.

3.4 PAVER SETTING ON ~~MORTAR~~ ***SAND*** (Add. #4) BED

A. All setting shall be done by competent stone setters under adequate supervision.

B. Stone units with chips, cracks, stains, or other defects which might be visible in the finished work shall not be used.

C. Before setting, stone shall be clean and free of dirt, and foreign matter on all sides. Stone shall be dry before setting.

D. Stone shall be set true to the required lines and grades. Joints shall be uniform in thickness. Expansion joints shall be 1/2 in. thick. Unless otherwise indicated on the Drawings all other joints shall be 3/8 in. thick. Direct bearing contact between stone pieces shall be prohibited.

E. Stone pavers shall be set on a ~~mortar~~ ***sand*** (Add. #4) setting bed over a prepared concrete base slab. All setting shall be done by competent masons under adequate supervision.

~~F. Bond coat shall be applied to concrete base slab using flat trowel. Thickness of bond coat shall be approximately 1/16 in.~~

~~G. Mortar bed shall be spread evenly over the troweled bond coat. Mortar setting shall be 1 in. thick, minimum. Bond coat shall then be applied to mortar bed using flat trowel to thickness of 1/16 in.~~

~~H. Before setting, the back of each stone shall be dampened and shall receive a slurry of mortar to ensure maximum contact with mortar bed. Each piece shall be carefully bedded in a full bed of mortar and tapped home to a full and solid bearing. Particular care shall be exercised to equalize bed and joint openings and eliminate the need for redressing of exposed surfaces.~~

F. Lay filter fabric across entire concrete slab where pavers will be laid

G. Lay sand bed across area that can be laid that day and screed to required depth and level.

~~I.~~ ***H.*** Stone pavers shall be set true to the required lines and grades in the pattern detailed on the Drawings. Stone pavers shall be neatly cut and fitted at all perimeters and closures to fit neatly and closely, with joints uniform in thickness. Pavers shall be cut with a water- cooled, cut-off wheel masonry saw using a diamond blade.

~~J. Exposed surfaces shall be kept free from mortar at all times. Excess mortar shall be immediately removed before latex modified mortar can set.~~

~~K. All joints except expansion joints shall be completely filled with mortar, then raked out to a depth equal to the width of the joint in a concave tool. Joints shall be brushed clean and~~

~~pointed with colored mortar to a concave joint. Mortar grout between stone pieces shall be uniform in appearance, texture, and color. After initial set of mortar, joints shall be finished by tooling with a rounded, non-staining jointer to produce a glassy-hard, polished, slightly, concave joint, free of drying cracks.~~

~~L. After pointing stone work shall be carefully cleaned, removing all dirt, excess mortar and stains. Expansion joints shall be cleaned of all mortar and left ready for sealing of joints under Section 079201, EXTERIOR JOINT SEALANTS.~~

~~M.~~ ***I.*** Upon completion of stone paving, surfaces shall be left in a clean, unsoiled condition, acceptable to the Architect.

J. Joint Treatment – Polymeric Sand

1. Surface must be completely dry.

2. Cover surface with product

3. Using a push broom, sweep product so as to fill joints completely down to their full depth; sweep surface clean of polymeric sand to avoid staining during compaction. Joints must be filled up to the bottom of the paver chamfer or at minimum 1/8" below the top of the pavers.

4. Compact surface at least twice with a plate vibrator and rubber protection mat. Repeat steps 1 through 3 until there is no significant settling after compaction.

5. Prior to wetting, surface must be free of polymeric sand; clean it with a fine bristle brush or a leaf blower.

6. Wetting must be performed gradually in at least three sprayings; each time, especially during the first spraying, be sure not to flood pavement or generate run-off, as this could wash out the binder, especially on sloped sites.

a. Use a very fine mist so that the water falls lightly on pavement without displacing polymeric sand; take care not to aim the jet directly on the surface.

b. First spraying: Dampen surface very lightly with a fine mist; this first spraying will stabilize polymeric sand on the surface and make it more absorbent for subsequent sprayings. Wait for 5 to 10 minutes.

c. Subsequent sprayings: Lightly spray surface in 5 to 10 minute intervals, so as to gradually moisten joints; repeat sprayings until joints are moistened down to the bottom, using a minimum amount of water; using a small screwdriver, check wetting progress in several spots by emptying a little section of polymeric sand down to the bottom of the joint.

7. Drying time is directly influenced by ambient humidity and temperature - at least 24 hours for pedestrian areas; - at least 48 hours is recommended for vehicular areas. NOTE: Drying time can be considerably less in dry climates

a. After application, if there is a risk of rain during drying time, protect the pavement with a tarp.

(Add. #4)

3.5 COBBLES: DRY SETTING ON ~~SAND~~ ***STONE DUST*** (ESBP #3) BED

A. Compact base course.

1. Provide a uniform bedding plane parallel to the finished pavement surface. The bed material shall be screeded to a surface tolerance of plus or minus 3/16-inch, giving a compacted thickness of 1 inch. The screeded course will be compacted with a light vibratory roller. The compacted bed material shall then be screeded again to a depth of 1/4-inch.

B. Paving cobbles shall be installed to fit together accurately with hand tightened joint widths as indicated on Drawings.

C. After a substantial area has been installed, a plate vibrator with soft protective pad shall be used to compact the paving stones into place and to vibrate the setting bed material up into the joints.

D. Joint Treatments:

a. If joint treatment installations are performed more than two (2) days after paver unit installation, or at such other times as conditions warrant, use a powered air blower to clean paving joints of debris before applying joint treatment.

b. For stone dust joints: Initial joint filler treatment shall be spread and broom swept over the installed pavers. Next, at least one pass of the plate vibrator shall be made to consolidate the joint material in the joints. Stone dust shall then be swept into the joints until joints are filled flush to the top of the paving stones. Sweep excess material clean from the paving surface.

3.6 ADJUST AND CLEAN

A. Remove and replace stone pieces which are broken, chipped, stained, or otherwise damaged. Remove and replace units which are misaligned or not to grade or do not match adjoining stone work. Provide new matching units, install as specified ~~and regrout to eliminate evidence of replacement~~. Repair defective and unsatisfactory joints as required to provide a neat, uniform appearance.

~~B. Exposed surfaces shall be kept free from mortar at all times. Any mortar smears shall be immediately removed with a clean sponge and clean water before latex modified mortar can set.~~

~~C. Clean stone work not less than five days after completion of work, using clean water and stiff-bristle brushes. Do not use wire brushes, acid type cleaning agents, or other cleaning compounds with caustic or harsh fillers.~~

B. After completion of the granite pavers, paved areas shall be thoroughly swept clean and surface shall be left unsoiled. Where required, surface shall be cleaned with water or an approved cleaner. (Add. #4)

END OF SECTION

Section 32 15 43
STABILIZED AGGREGATE PAVING

PART 1 GENERAL

1.0 RELATED DOCUMENTS

A. Division 00 – PROCUREMENT AND CONTRACTING REQUIREMENTS
Division 01 - GENERAL REQUIREMENTS, as listed in the Table of Contents, including but not limited to the following sections, shall be included in and made a part of this Section:
01 30 00 – SUBMITTALS
01 43 39 – MOCK-UPS
01 81 13 – SUSTAINABLE DESIGN REQUIREMENTS

1.1 DESCRIPTION OF WORK

A. Provide all equipment and materials, and do all work necessary to construct the aggregate (decomposed granite) paving with stabilizer material, including aggregate base and edging, as indicated on the Drawings and as specified.

1.2 RELATED WORK

A. Examine Contract Documents for requirements that affect work of this Section. Other Specification Sections that directly relate to work of this Section include, but are not limited to:

1. Section 31 20 00, EARTH MOVING; Establishment of subgrade elevation.

2. Section 32 93 00, TREES, PLANTS AND GROUNDCOVERS, Trees planted in Stabilized Aggregate Paving.

1.3 REFERENCES

A. Comply with applicable requirements of the following standards. Where these standards conflict with other specified requirements, the most restrictive requirement shall govern.

1. American Society for Testing and Materials (ASTM):

D 1557	Moisture-Density Relations of Soils and Soil Aggregate Mixtures Using 10-lb. (4.54-kg) Rammer and 18-in. (475-mm) Drop

2. Commonwealth of Massachusetts Highway Department (MHD):

Specifications	Standard Specifications for Highways and Bridges

1.4 SUBMITTALS

A. Samples: The following samples shall be submitted: Material

	Sample Size or Quantity
Decomposed granite	1 lb. (3 color options for color approval)

B. Manufacturer's Product Data: Manufacturer's product data shall be submitted for the following materials:

Stabilizer

C. Test results for stabilized crushed stone surfacing indicating compliance with ADA Requirements for accessibility and slip resistance.

1.5 QUALITY ASSURANCE

A. Crushed granite sample of sufficient quantity shall be submitted to stabilizer manufacturer for recommended blending proportions and procedures to be followed by crushed granite supplier. Blending operations shall be performed at crushed granite supplier facility, and provided to Contractor pre-blended in accordance with stabilizer manufacturer's recommendations.

B. Installer shall provide evidence to indicate successful experience in providing crushed granite surfacing containing stabilizer binder/additive or ability to follow installation instructions.

C. Installer shall provide documentation of at least three (3) installations similar in scale (all reference projects to be equal or greater than 75% of the total square footage of the project being bid on) using specified stabilizer solution material, completed over the past five (5) years. If Contractor is not able to meet experience qualifications, Contractor shall be required to have a representative from Stabilizer Solutions be present on site for pre-construction training, installation of mockup, and at least 50% of the project installation. Contractor shall be responsible for any and all costs associated with this requirement. If contractor is unable to meet these requirements a qualified replacement contractor will be located subject to all qualifications listed above and Owner approval.

1.6 PERFORMANCE REQUIREMENTS

A. Perform gradation of decomposed granite material or 3/8" or 1/4" minus crushed aggregate in accordance with ASTM C 136 – Method for Sieve Analysis for Fine and Course.

1.7 MOCK-UP

A. General

1. Schedule mock-up for acceptance 30 days prior to constructing decomposed granite surfaces represented by the mockups.
2. Locate mock-up panels in original location or non-public areas accepted by the Architect.

3. Continue to construct mock-ups until acceptable mock-up is produced. Accepted mock-up shall be the standard for color, texture, mix ratio, and workmanship for the work.
4. Use the same decomposed granite /stabilizer mix and placement procedure, accepted in mock-ups, in the final work, unless otherwise directed by the Architect.
5. Protect accepted mock-ups from damage until completion and acceptance of the work represented by the mock-up.
6. Leave accepted mockup panel in original location or remove mock-up panels from site at completion of project, as directed by the Architect.

B. Sample panel shall be 4 ft. x 4 ft. minimum.

C. Source of Materials. Utilize the same source, stock, or brand of stabilizer material for all decomposed granite surfacing. Do not interchange materials or mixes until an additional mock-up shows that uniformity in finish texture and color, as compared to original mock-up will be maintained. If necessary, obtain and stockpile materials in sufficient quantity to ensure continuity and uniformity.

1.8 PROJECT/SITE CONDITIONS

A. Field Measurements: Each bidder is required to visit the site of the Work to verify the existing conditions. No adjustments will be made to the Contract Sum for variations in the existing conditions.

1. Where surfacing is indicated to fit with other construction, verify dimensions of other construction by field measurements before proceeding with the work.

B. Environmental Limitations: Do not install decomposed granite or crushed 3/8” or 1/4" minus aggregate paving during rainy conditions or below 40 degrees Fahrenheit.

1.9 TESTING AND INSPECTION

A. The Owner reserves the right to test and inspect materials and construction of crushed stone surfacing in accordance with the requirements of Division 1 – General Requirements.

1.10 WARRANTY

A. Provide written warranty signed by stabilizer manufacturer, installer, and Contractor, agreeing to repair or replace all work of this section which exhibits defects in materials or workmanship. Warranty shall cover stabilizer, decomposed granite and aggregate base work. "Defects" is defined to include, but not limited to, differential settlement, ponding of water, abnormal aging or deterioration of stabilized paving system, and failure to perform as required.

1. Warranty Period: 90 days from date of Substantial Completion.
2. Contractor shall provide unconditional maintenance and repairs as required through the warranty period.

PART 2 - PRODUCTS

2.1 AGGREGATE BASE COURSE

A. Material for aggregate base course shall be a graded, granular, non-frost susceptible, free-draining material, consisting of either durable stone and coarse sand or of blast furnace slag, practically free from loam and clay, and which can be readily compacted to form a stable foundation.

1. Material shall be dense graded crushed stone conforming to MHD Specifications Section M2.01.7.

2.2 STONE DUST (DECOMPOSED GRANITE)

A. Decomposed granite or 3/8 in. or 1/4 in. crushed aggregate screenings.

1. Surfacing material shall be sand and crushed stone consisting of inert materials that are hard and durable, with stone free from surface coatings and deleterious materials. Gradation requirements shall be as follows:
2. Crushed Stone Sieve Analysis Percentage of weight Passing a Square Mesh AASHTO T11-82 and T2782.

Sieve Size	% Passing by Weight
3/8 in.	100
No. 4	90 - 100
No. 8	75 - 80
No. 16	55 - 65
No. 30	40 - 50
No. 50	25 - 35
No. 100	15 - 20
No. 200	10 - 15

B. Decomposed granite color will be selected by Architect.

2.3 STABILIZER

A. Approved product and manufacturers are:
   a. Stabilizer additive shall be "Stabilizer", a non-toxic, colorless, odorless, concentrated powder organic binder capable of binding crushed aggregate screenings, manufactured by Stabilizer Solutions, Inc., 33 South 28th Street, Phoenix, AZ 85034; Tel. 602-225-5900; 1-800-336-2468; Fax: 602-225-5902; E- mail: info@stabilizersolutions.com, or approved equal.
   b. Organic-lock by Envirobond Products, 2100 Bloor St. W, Suite 6191, Toronto, ON, M6S 5A5, p: (416) 628-3704, www.organic-lock.com
   c. Addaset Resin Bound Permeable Paving by Chameleon Ways, PO Box 387, Center Valley, PA, www.chameleonways.com, color TBD, submit sample for approval

1. Material shall be provided by supplier pre-mixed with stone dust (decomposed granite) material specified herein.

PART 3 - EXECUTION

3.1 GRADING

A. Areas to receive stone dust surfacing will be compacted and brought to subgrade elevation under Section 31 20 00, EARTH MOVING before work of this section is performed. Final fine grading, furnishing and installing aggregate base course, stabilizer, and stone dust surface and compaction of these materials as required to form a firm, uniform, accurate, and unyielding stone dust surface at required elevations and to required lines, shall be done under this Section.

B. Existing subgrade material which will not readily compact as required shall be removed and replaced with satisfactory materials. Additional materials needed to bring subgrade to required line and grade and to replace unsuitable material removed shall be material conforming to Section 31 20 00, EARTH MOVING.

C. Immediately prior to paving, subgrade below exterior pavements shall be rough graded as needed, and then scarified and recompacted. This process shall include scarifying the exposed subgrade to a depth of 9 inches, moisture conditioning the scarified soil to within -2 to +3 percent of the material's optimum, and compacting the scarified soil to at least 98% of standard Proctor density (ASTM D 698). Scarified soils which cannot be recompacted to this degree should be undercut and replaced with stable material. Subgrade compaction shall extend for a distance of at least 1 ft. beyond pavement edge.

1. Field testing shall be conducted to determine in-place density, accompanied by visual inspection of the compaction methods being used.

D. Excavation required in subgrade shall be completed before fine grading and final compaction of subgrade are performed. Where excavation must be performed in completed subgrade or gravel base, subsequent backfill and compaction shall be performed as directed by the Architect as specified in Section 31 20 00, EARTH MOVING. Completed subgrade after filling such areas shall be uniformly and properly graded.

E. Areas being graded or compacted shall be kept shaped and drained during construction. Ruts greater than or equal to 1 in. deep in subgrade, shall be graded out, reshaped as required, and recompacted before placing stone dust surfacing.

F. Materials shall not be stored or stockpiled on subgrade.

G. Disposal of debris and other material excavated and/or stripped under this section, and material unsuitable for or in excess of requirements for completing work of this section shall be disposed of off-site.

3.2 AGGREGATE BASE COURSE

A. Aggregate base course for paving and the spreading, grading, and compaction methods employed shall conform to standard requirements for usual base course of this type for first class road work, and the following:

1. MHD Specifications Section 405, "Gravel Base Course".

B. Compaction of aggregate base course shall be to 95% of maximum density as determined by ASTM D 1557, Method D. Stone greater than 2-1/2 in. shall be excluded from course.

C. Width of base course shall be greater than or equal to the width of pavement surface, if continuous lateral support is provided during rolling, and shall extend at least 2 x base thickness beyond edge of the course above, if not so supported.

D. Aggregate material shall be applied in lifts less than or equal to 6 in. thick, compacted measure. Each lift shall be separately compacted to specified density, using a 6 ton steel wheel roller or vibratory roller equivalent to a 6 ton static roller, or an approved equivalent.

1. Material shall be placed adjacent to wall, manhole, catch basin, and other structures only after they have been set to required grade and level.
2. Rolling shall begin at sides and progress to center of crowned areas, and shall begin on low side and progress toward high side of sloped areas. Rolling shall continue until material does not creep or wave ahead of roller wheels.
3. Surface irregularities which exceed 1/2 in. measured by means of a 10 ft. long straightedge shall be replaced and properly compacted.

E. Subgrade and base course shall be kept clean and uncontaminated. Less select materials shall not be permitted to become mixed with gravel. Materials spilled outside pavement lines shall be removed and area repaired.

F. Portions of subgrade or of construction above which become contaminated, softened, or dislodged by passing of traffic, or otherwise damaged, shall be cleaned, replaced, and otherwise repaired to conform to the requirements of this specification before proceeding with next operation.

3.3 STONE DUST (DECOMPOSED GRANITE) SURFACING

A. Stabilizer shall be provided thoroughly and unifomly pre-blended with decomposed granite by local supplier, at rate, and by method in strict accordance with manufacturer's printed instructions.

1. Blend 12 to 16-lbs (contact manufacturer for exact blend) of Stabilizer per 1-ton of decomposed granite or crushed aggregate screenings. It is critical that Stabilizer be thoroughly and uniformly mixed throughout decomposed granite or crushed aggregate screenings.
2. Bucket blending is not acceptable. Blending with a rake and or shovel is not acceptable.
3. Blend material dry.

B. Decomposed granite surfacing shall be done only after excavation and construction work which might injure it has been completed. Damage caused during construction shall be repaired before acceptance.

C. Decomposed granite surfacing shall be constructed on a compacted aggregate base or sand-based structural soil mix as indicated on the Drawings.

D. Pre-blended stabilized decomposed granite or crushed aggregate screenings shall be spread evenly over the base in 1-1/2 in. maximum lifts, rolled and compacted to 85% of maximum density as determined by ASTM D 1557. Final compacted thickness shal be 3 in.

1. Contractor shall wait a minimum of 24 hours after placing stabilized decomposed granite material prior to compaction. Longer periods may be required for material to adequately dry. Consult manufacturer to make determination.

E. Water shall be added to decomposed granite for full-depth moisture penetration prior to compacting.

1. Minimum 25 to 45-gallons of water per 1-ton must be applied to achieve saturation of stabilized pathway profile.
2. During water application randomly test for depth using a probing device, which reaches full depth.

F. Upon thorough moisture penetration, compact stabilized decomposed granite to 85% relative compaction with 2 to 4 ton durable drum roller or 1000 lb. single drum roller as required to achieve a dense, hard packed surface conforming to the finish grades indicated.

1. Do not use vibratory rollers or compactors.
2. Do not begin compaction for 12 hours after placement and up to 72 hours.
3. Contractor shall hand tamp areas adjacent to irrigation or plantings with 8 in. or 10 in. hand tamper.
4. If surface aggregate dries significantly quicker than subsurface material, lightly mist surface before compaction operations.

G. Variations in smoothness of finished stone dust surface shall be less than or equal to 1/4 in. when tested with a 10 ft. straightedge, applied both parallel to and at right angles to centerline of stone dust surface areas. Irregularities exceeding these amounts or which retain water on surface shall be corrected by removing defective work and replacing with new material conforming to this specification.

H. Crushed stone surface shall comply with ADA Requirements for slip resistance and accessibility, with a minimum static coefficient of friction of 0.6 for accessible routes and 0.8 for ramps, when tested in accordance with ASTM C1028.

I. Allow finished surface to dry completely before permitting use.

3.4 INSPECTION

A. Finished aggregate surfacing shall be smooth, uniform and solid. Cured and compacted aggregate shall be firm throughout profile with no spongy areas. Loose material shall not be present on the surface after installation, but may appear after use and according to environmental conditions. Aggregate shall remain stable underneath loose decomposed granite on top. Surfacing shall appear “natural” yet stable throughout. Any significant irregularities in surfacing shall be repaired to the uniformity of the entire installation.

3.5 MAINTENANCE

A. Remove debris, such as paper, grass clippings, leaves or other organic material by mechanically blowing or hand raking the surface as needed. Any plowing program required during winter months shall involve the use of a rubber baffle on the plow blade or wheels on the plow that lifts the blade 1/4" off the paving surface.

B. During the first year, a minor amount of loose aggregate will appear on the paving surface (1/16” to 1/4"). If this material exceeds a 1/4", redistribute the material over the entire surface. Water thoroughly to the depth of 1”. Compact with power roller of no less than 1000 lbs. This process should be repeated as needed.

C. If cracking occurs, simply sweep fines into the cracks, water thoroughly and hand tamp with an 8” – 10” hand tamp plate.

3.6 REPAIRS

A. Excavate damaged area to the depth of the stabilized aggregate and square off sidewalls.

B. If area is dry, moisten damaged portion lightly.

C. Pre-blend the dry required quantity of stabilizer powder with the proper quantity of aggregate in a concrete batch mixer.

D. Add water to the pre-blended aggregate and stabilizer. Thoroughly moisten mix with 25 to 45 gallons per 1 ton of pre-blended material or to approximately 10% moisture content.

E. Apply moistened, pre-blended aggregate to excavated area to finish grade.

F. Compact with an 8 in. to 10 in. hand tamper or 250 lb to 300 lb. roller. Keep traffic off areas for 12 to 48 hours after repair has been completed.

END OF SECTION

Section 32 18 16.12
RUBBER SAFETY SURFACING

PART 1 GENERAL

1.0 GENERAL PROVISIONS

A. Division 00 – PROCUREMENT AND CONTRACTING REQUIREMENTS
Division 01 - GENERAL REQUIREMENTS, as listed in the Table of Contents, including but not limited to the following sections, shall be included in and made a part of this Section:
01 30 00 – SUBMITTALS
01 43 39 – MOCK-UPS
01 81 13 – SUSTAINABLE DESIGN REQUIREMENTS

1.1 DESCRIPTION OF WORK

A. Provide all equipment and materials, and do all work necessary to furnish and install the poured in place (PIP) rubber safety surfacing, complete, as indicated on the Drawings and as specified.

1.2 RELATED WORK

A. Examine Contract Documents for requirements that affect Work of this Section.
Other Specification Sections that directly relate to Work of this Section include, but are not limited to:

1. Section 03 30 01, CAST-IN-PLACE CONCRETE - SITEWORK; Concrete base, ready to receive rubber safety surfacing.
2. Section 11 68 13, PLAYGROUND EQUIPMENT

1.3 REFERENCES

A. Comply with applicable requirements of the following standards. Where these standards conflict with other specified requirements, the most restrictive requirements shall govern.

1. American Society for Testing and Materials (ASTM):

D 412	Vulcanized Rubber and Thermoplastic Rubbers and Thermoplastic Elastomers-Tension.
D 624	Conventional Vulcanized Rubber and Thermoplastic Elastomers.

D 2047	Static Coefficient of Friction of Polish-Coated Floor Surfaces as Measured by the James Machine.
D 2859	Flammability of Finished Textile Floor Covering Materials.
E 303	Measuring Surface Frictional Properties Using the British Pendulum Tester.
F 1292	Impact Attenuation of Surface Systems Under and Around Playground Equipment.
F 1951	Determination of Accessibility of Surface Systems Under and Around Playground Equipment.

2. International Playground Equipment Manufacturer's Association (IPEMA)

1.4 SYSTEM DESCRIPTION

A. Performance Requirements: Provide a 2 layer rubber-urethane surfacing system which has been designed, manufactured and installed to meet the following criteria:

1. Shock Attenuation (ASTM F1292):
   a. Gmax: Less than 200.
   b. Head Injury Criteria: Less than 1000.

2. Flammability (ASTM D2859): Pass.

3. Tensile Strength (ASTM D412): 60 psi (413 kPa).

4. Tear Resistance (ASTM D624): 140%.

5. Water Permeability: 0.4 gal/yd2/second.

6. Accessibility: Comply with requirements of ASTM F1951.

1.5 SUBMITTALS

A. Certificate of qualifications of the surfacing installer.

B. Certified test data indicating that safety surface meets or exceeds the following:

1. Current Consumer Product Safety Commission (CPSC) guidelines issued in "A Handbook for Public Playground Safety" (latest edition) for a minimum fall height of 6 feet.

2. Current Americans with Disabilities Act Guidelines (ADAG).

3. Current ASTM F-1292 requirements.

C. Shop drawings of rubber safety surfacing indicating colors, dimensions, and layout of surfacing shall be submitted.

D. Manufacturer's product data, and catalogue cuts, shall be submitted for rubber safety surfacing system including certifications and other data as may be required to show compliance with Contract Documents.

E. Verification Samples: Submit 12 in. x 12 in. color samples of safety surfacing on 1/4 in. plywood backing or as manufacturer samples as many times as necessary to obtain Architect's approval.

F. Manufacturer's Review: Submit written statement, signed by safety surfacing installer stating that Drawings and Specifications have been reviewed by qualified representatives of materials manufacturer, and that they are in agreement that materials and system to be used for safety surfacing are proper and adequate for applications shown.

G. Substrate Acceptability: Submit a certified statement issued by manufacturer of safety surfacing materials and countersigned by applicator, attesting that areas and surfaces designated to receive safety surfacing have been inspected and found satisfactory for reception of Work covered under this Section; and are not in conflict with "Warranty" requirements. Application of materials will be construed as acceptance of surfaces.

H. Statement of Supervision: Upon completion of Work, submit a written statement signed by manufacturer stating that field supervision of manufacturer's representative was sufficient to insure proper application of materials, that Work was installed in accordance with Contract Documents, and that installation is acceptable to manufacturer.

I. Certification: Furnish certificate accompanying delivery of safety surface material indicating compliance with the Contract Documents.

1.6 QUALITY ASSURANCE

A. Safety surfacing work shall be performed by a firm approved and trained by the manufacturer of the rubber surfacing system with ten years' experience in installation of materials specified on comparable projects.

1. Certifications: Certification by manufacturer that installer is an approved applicator of the surfacing system

B. The safety surface manufacturer shall provide evidence indicating that the specified materials have been successfully utilized on work of similar scope to that shown and specified for this Project. The safety surface system examples cited shall have been completed and in use for five years without any evidence of failure.

C. The Owner reserves the right to retain an independent testing laboratory to test and inspect the work specified herein. The presence of the testing laboratory, nor any observations and testing performed by the laboratory shall relieve the Contractor of his responsibilities for the Work.

D. Contractor shall engage the manufacturer's representative to inspect the surface after preparation and monitor the application of the safety surface system upon the prepared surfaces of all pavement to receive safety surface system.

E. Installed safety surface shall meet or exceed CPSC performance guidelines with respect to the Critical Heights of the proposed in-place play equipment.

F. Material used in construction of the safety surface system shall be tested for conformance with requirements of ASTM F 1292, and shall be IPEMA Certified.

G. Material shall have a Class A fire rating.

H. Material shall be vandal resistant, firmly secured so that it cannot be pulled away from the playground surface.

1.7 MATERIAL TESTING

A. All safety surface material shall meet the latest suggested guidelines published in the "Handbook for Public Playground Safety" by The U.S. Consumer Product Safety Commission (C.P.S.C.), and The American Society for Testing and Materials (ASTM) as outlined below.

B. TESTS: Safety surfacing must meet the following test requirements and criteria:

1. Shock Absorbency: When tested in accordance with ASTM F 1292-09 (or latest issue), Test Method F355, Procedure C (Metal Headform), the surface shall not impart to the headform upon impact, a peak deceleration exceeding
200 times the acceleration due to gravity (200G's) and shall not exceed 1000
Head Injury Criteria (HIC).. Drop heights used in this test shall be the heights relevant to the proposed play structures used in conjunction with the safety surfacing areas indicated on the Drawings.

2. Weathering (Aging): After being subject to fifty (50) freeze-thaw cycles in accordance with ASTM C67, “Freezing and Thawing”, and after being subject to 200^{O}F for 7 days in accordance with ASTM D573, "Rubber Deterioration in an Air Oven", the same sample shall be re-tested in compliance with ASTM F1292-09 at 72^{O}F only. A peak deceleration reading not exceeding 200G's shall be maintained. HIC testing is not required for re-testing.

3. Slip Resistance: Wet dynamic reading shall not be less than 40 when tested in accordance with ASTM E 303, using the British Portable Skid Resistance Tester.

4. Flammability: Minimum critical radiant flux of 0.22 Watts/CM^{2} when tested in accordance with ASTM E 648.

C. IN-FIELD TESTING: Testing conducted in the field on actual installed safety surfacing at locations determined by the material manufacturer’s representative shall attest to the composition and thickness used, the drop height used, and the supporting certified test data showing that the installed system meets or exceeds the test requirements of this specification.

1.8 WARRANTY

A. Provide a written warranty stating that work executed under this Section will be free from defects of materials and workmanship for a period of (5) five years from date of Substantial Completion, and that material breakdown and unraveling will be remedied on written notice at no additional cost to Owner. The warranty shall be in writing and shall be signed by the Contractor and safety surface materials manufacturer. Warranty shall include removal and replacement of materials as required to repair safety surfacing, at no cost to Owner.

1. Warranty Period: 7 years from date of completion of work

B. Manufacturer’s warranty is in addition to, and not a limitation of, other rights Owner may have under contract documents.

C. Proper drainage is critical to the longevity of the PlayBound Poured-in-Place surfacing system. Inadequate drainage will cause premature breakdown of the poured system in affected areas; and void the warranty.

1.9 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Deliver materials in manufacturer's original, unopened containers or bundles fully identified with trade name and name of manufacturer, container weight, and safety precautions, type, grade, date of manufacture, class, lot number, and other qualifying information.

B. Store materials in original tightly sealed containers or unopened packages. Materials shall be stored out of weather, off the ground, in dry area, in compliance with manufacturer's maximum storage temperature range.

1. Store materials protected from exposure to harmful environmental conditions and at a minimum temperature of 40 degrees F (4 degrees C) and a maximum temperature of 90 degrees F (32 degrees C).

1.10 JOB CONDITIONS

A. Maintain manufacturer's current installation instructions at the job site at all times for safety surface material to be used on the Project.

B. Maintain material storage area at minimum 60^{o}F, but not above 90^{o}F for 48 hours prior to application.

C. Proceed with work of this section only after substrate construction and penetrating work have been completed.

D. Environmental Requirements: Install surfacing system when minimum ambient temperature is 40 degrees F (1 degree C) and maximum ambient temperature is 90 degrees F (32 degrees C). Do not install in steady or heavy rain, or otherwise inclement weather.

E. Comply with manufacturer's recommendations for application and curing under specific climatic conditions.

F. Coordinate application of safety surfacing with work of other trades.

1.11 PROTECTION

A. Protect the safety surface from damage, resulting from spillage, dripping, and dropping of materials. Prevent materials from entering and clogging drains. Repair, restore or replace work which is soiled or damaged in connection with the performance of the work.

PART 2 - PRODUCTS

2.1 SAFETY SURFACE SYSTEM

A. Rubber safety surfacing shall be "Playbound Poured-In-Place System", poured- in - place cushioned play surface, manufactured by Surface America, Williamsville, NY 14231, Telephone: (800) 999-0555, (716) 632-8413; Fax: (716) 632-8324; E-mail: info@surfaceamerica.com; website: http://www.surfaceamerica.com.; Poured in Place Rubber by GameTime, a Playcore company, www.gametime.com, (800) 235-2440, Tot turf Supreme Poured Rubber Surfacing by Totturf.com, 2414 W 12th St., Tempe, AZ, 85281, p: 800.858.0519, www.totturf.com or approved equal.

1. Primer: Urethane primer.

2. Base Mat (Cushion Course): shall be a monolithic poured in place cushioned pad, made from a field-mix blend of 100% post-consumer recycled styrene buttadiene rubber (SBR), (ground into 3/8 in. shredded strands with less than 4% dust), and a polyurethane binder.

   a. Thickness: See detail in drawings but thickness shall be determined based on critical fall heights of final playground equipment selection in accordance with ASTM F1292. Basemat thickness may be different at various locations on the playground site and is to be coordinated with Drawings and final play equipment.

   b. Formulation Components: Blend of strand and granular material.

3. Top Surface (Wearing Course): shall be a monolithic poured-in-place top surface made from a blend of UV stable recycled post-industrial ethylene propylene diene monomer (EPDM) colored rubber particles measuring 1 to 3 mm and an aromatic or aliphatic urethane binder (depending on color selections).

   a. Thickness: Nominal 1/2" (12.7 mm), minimum 3/8" (9.5 mm), maximum 3/4" (18.5 mm).

      1. Tensile strength shall be 200 psi.

      2. Elongation at break shall be 145%.

      3. Material shall meet a Class 1 fire rating.

      4. Shore hardness shall be 50/55.

      5. Meet Taper Abrasive Test of 0.1.

   b. Up to four (4) color(s) will be selected by Architect from manufacturer's standard range in equal proportions.

   c. Dry Static Coefficient of Friction (ASTM D2047): 1.0.

   d. Wet Static Coefficient of Friction (ASTM D2047): 0.9.

   e. Dry Skid Resistance (ASTM E303): 89.

   f. Wet Skid Resistance (ASTM E303): 57.

   g. Colors as shown on Drawings to match based on final chosen manufacturer

2.2 MIXES

A. Required mix proportions by weight:

1. Basemat: 16+% urethane (as ratio: 14% urethane divided by 86% rubber). 14% urethane, 86% rubber (based on entire rubber & urethane mix).

2. Top Surface: 22% urethane (ratio: 18% urethane divided by 82% rubber). 18% urethane, 82% rubber (based on entire rubber & urethane mix).

2.3 FLEXIBLE RUBBER EDGING

A. Where rubber surfacing meets lawn a flexible rubber L-shaped curb will be installed to provide the edge of the rubber surfacing. The edge should be a flush condition between rubber surfacing and lawn. Rubber curbing shall follow the edge per the Drawings and be joined together with a rubber adhesive.

B. Acceptable products and manufacturers are: or approved equal
1. FlexEdge Rubber L-Curb by SportsEdge.com p:800-334-6057, www.sportsedge.com

PART 3 - EXECUTION

3.1 GENERAL

A. The entire safety surfacing system shall be applied under the observation of the material manufacturer's representative.

3.2 INSPECTION AND SURFACE PREPARATION

A. Final Surface Inspection: Prior to application of safety surface system, the concrete base surface shall be flooded with water and allowed to drain. Any depressions thereupon holding water deeper than 1/16 in. shall be patched and leveled in accordance with recommendations of the manufacturer of the safety surfacing material specified hereinafter. Start of rubber safety surfacing application shall constitute acceptance of the concrete base surface to receive safety surfacing.

1. Proper drainage is critical to the longevity of the PlayBound Poured-in-Place surfacing system. Inadequate drainage will cause premature breakdown of the poured system in affected areas and void the warranty.

B. Where safety surface system is being applied over new concrete, a minimum of 30 days shall be allowed between the installation of paving, patches, and safety surface system to ensure full curing of the concrete paving. If manufacturer's recommendations differ from that specified above, manufacturer's recommendations shall govern.

C. Surface Preparation: Using a brush or short nap roller, apply primer to the substrate perimeter and any adjacent vertical barriers such as playground equipment support legs, curbs or slabs that will contact the surfacing system at the rate of 300 ft2/gal (7.5 m2/L).

3.3 SAFETY SURFACING

A. Prior to applying rubber safety surfacing system, adjacent work shall be completed including substrate preparation, fencing, playground equipment installation and other relevant work and approved by the Architect.

B. Application of the rubber safety surfacing shall occur only after the concrete surface has been thoroughly prepared, leveled, cleaned and dried in accordance with manufacturer's recommendations. The safety surface material shall be applied in strict accordance with manufacturer's printed instructions.

C. Basemat Installation:

1. Using screeds and hand trowels, install the basemat at a consistent density of 29 pounds, 1 ounce per cubic foot (466 kg/m3) to the specified thickness.
2. Allow basemat to cure for sufficient time so that indentations are not left in the basemat from applicator foot traffic or equipment.
3. Do not allow foot traffic or use of the basemat surface until it is sufficiently cured.

D. Primer Application: Using a brush or short nap roller, apply primer to the basemat perimeter and any adjacent vertical barriers such as playground equipment support legs, curbs or slabs that will contact the surfacing system at the rate of 300 ft2/gal (7.5 m2/L).

E Top Surface Installation:

1. Using a hand trowel, install top surface at a consistent density of 58 pounds, 9 ounces per cubic foot (938 kg/m3) to a nominal thickness of 1/2" (12.7 mm).
2. Allow top surface to cure for a minimum of 48 hours.
3. At the end of the minimum curing period, verify that the top surface is sufficiently dry and firm to allow foot traffic and use without damage to the surface.
4. Do not allow foot traffic or use of the surface until it is sufficiently cured.

F. In all cases, manufacturer's directions for achieving maximum wearability and resilience shall be strictly adhered to.

G. Flexible rubber edging to be installed per manufacturer’s instructions and details as shown.

3.4 CLEAN UP AND PROTECTION

A. Contractor shall remove all containers and surplus materials leaving the site in a clean and orderly condition acceptable to the Architect.

B. Protect the installed rubber surface from damage resulting from subsequent construction activity on the site.

END OF SECTION

Section 32 31 13 ***A*** (Final Bid Package)
CHAIN LINK FENCE AND GATE

PART 1 GENERAL

1.0 RELATED DOCUMENTS

Division 00 – PROCUREMENT AND CONTRACTING REQUIREMENTS
Division 01 - GENERAL REQUIREMENTS, as listed in the Table of Contents, including but not limited to the following sections, shall be included in and made a part of this Section:

01 30 00 – SUBMITTALS
01 43 39 – MOCK-UPS
01 81 13 – SUSTAINABLE DESIGN REQUIREMENTS

.

1.1 DESCRIPTION OF WORK

A. Provide all equipment and materials, and do all work necessary to construct the chain link fence and gate, as indicated on the Drawings and as specified.

1.2 RELATED WORK

A. Carefully examine all of the Contract Documents for requirements which affect the work of this Section. Other specification sections which directly relate to the work of this section include, but are not limited to the following:

1. Section 31 21 00, EARTHWORK
2. Section 03 30 01, CAST IN PLACE CONCRETE - SITEWORK

1.3 REFERENCES

A. Comply with applicable requirements of the following standards. Where these standards conflict with other specified requirements, the most restrictive requirement shall govern.

1. American Society for Testing and Materials (ASTM):

A 53	Pipe, Steel, Black and Hot-Dipped Zinc-Coated Welded and Seamless
A 90	Weight of Coating on Zinc-Coated (Galvanized) Iron or Steel Articles
A 123	Zinc (Hot-Galvanized) Coatings on Products Fabricated from Rolled, Pressed, and Forged Steel Shapes, Plates, Bars, and Strip
A 153	Zinc-Coating (Hot-Dip) on Iron and Steel Hardware
A 385	High-Quality Zinc Coatings (Hot-Dip)

A 392	Zinc-Coated Steel Chain-Link Fence Fabric
A 569 Rolled	Steel, Carbon (0.15 Maximum Percent) Hot-
	Sheet and Strip, Commercial Quality
B 6	Zinc (Slab Zinc)
F 567	Installation of Chain-Link Fence
F 668	Poly (Vinyl Chloride)(PVC)-Coated Steel Chain- Link Fence Fabric

2. Chain Link Fence Manufacturers Institute

(CLFMI): Manual	Product
Manual	

1.4 QUALITY ASSURANCE

A. Galvanized steel chain link fencing shall be manufactured in accordance with the requirements of the CLFMI Manual. Fence manufacturer shall be a CLFMI member.

B. Fence manufacturer shall have at least ten years of experience in the manufacture of galvanized steel chain link fencing.

1.5 SUBMITTALS

A. Information and Review Submittals: Submit the following under provisions of Section 01 33 00 - SUBMITTAL PROCEDURES:

B. Product Data: For each type of product indicated. Include technical data and tested physical and performance properties.
1. Each fence fabric type
2. Each size of pipe
3. Each type of hardware and fitting
4. Gates, including latch
5. Manufacturer’s vinyl coating system
6. The fence contractor shall provide the fence manufacturer's notarized certification to the Owner’s Representative that the vinyl-coated chain link fabric is warranted by the manufacturer for a minimum of 15 years against rust and corrosion.

C. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work. Show accessories, hardware, gate operation, and operational clearances.
   1. Provide a complete and detailed layout showing all chain link fence post locations.
   2. Submit a complete schedule of all chain link fencing and gates indicating locations of all post and fabric types on the project.

D. Samples: Prior to ordering the below listed materials, submit samples to the Owner's Representative for approval. Samples shall be representative of designated items. Do not order materials until Owner's Representative's approval has been obtained. Delivered materials shall closely match the approved samples.
   1. One square foot of each chain link fabric type.
   2. One sample of each size of post tops
   3. One 12-inch length of each size of pipe
   4. One sample of each type of hardware and fitting

E. Construct a representative fence section sample with gate on-site for each size and type of chain link fence construction. Samples shall be constructed prior to the installation of all chain link fencing and as part of the proposed finish work to facilitate comparisons during construction. The samples shall demonstrate the typical installation of fence posts and footings, framework, vinyl coatings, hardware fittings and miscellaneous materials. The accepted sample, upon approval, shall be maintained as the standard of minimal quality for approval of all proposed chain link fence work required for the project. Unacceptable sample sections shall immediately be removed from the site.

PART 2 PRODUCTS

2.1 PVC COATED FENCE FABRIC

A. Polyvinyl Chloride (PVC) Coated Fabric: Fence fabric shall be zinc coated in accordance with ASTM A392 Class-1 or aluminum-coated in accordance with ASTM F668 Class-2a. The color of the fabric shall be black and in accordance with ASTM F934.

B. Fabric shall be woven into a 2 in. mesh of 9 finished gauge (0.148 in.) galvanized wire with a minimum breaking strength of 1290 lb. in accordance with ASTM F 668, Class 2b.

C. Fabric around tennis courts shall be woven into a 1 in. mesh of 9 finished gauge (0.148 in.) galvanized wire with a minimum breaking strength of 1290 lb. in accordance with ASTM F 668, Class 2b. and shall be 10' height.

2.2 CHAIN LINK FENCE POSTS, HARDWARE, AND FITTINGS - GENERAL

A. Fittings shall be of best quality malleable iron casting, wrought iron forgings, or pressed steel and provided with pin connections. Equipment shall be designed to carry 100% overload.

1. Malleable iron castings shall be hot-dipped galvanized in accordance with ASTM A 153.
2. Wrought iron forgings or pressed steel fitting and appurtenances shall be hot-dipped galvanized in accordance with ASTM A 123.
3. Fence hardware coatings shall match fence fabric coating.

B. Piping for posts and rails shall be the following:

1. Piping shall be Schedule 40 hot-dip galvanized steel pipe, conforming to ASTM A 53.
   a. Zinc used for coating shall conform to ASTM B 6, High Grade and Special High Grade Zinc. Minimum average zinc coating shall be 1.8 oz./sq. ft. meeting ASTM F 1083 for standard weight (Schedule 40) galvanized pipe.

C. Galvanized items shall be galvanized in accordance with ASTM A 123, A 153, or A 385, as applicable.

D. Bolts which are installed 6 ft. or less above grade shall not protrude more than 1/4 in. beyond the nut after tightening. Rough edges shall be filed smooth to the satisfaction of the Architect. Peen ends of all bolts after tightening.

2.3 POSTS

A. Line post shall be 2.375 in. O.D., Schedule 40 pipe weighing 3.65 lb./ft.

B. End and corner posts shall be 2.875 in. O.D. Schedule 40 pipe weighing 5.79 lb./ft.

C. Gate Posts - (Gate leaf Single Width): All gate posts shall be of sufficient strength so that the total deflection of the gate frame and the gate post at the end of the gate leaf shall not exceed the lesser of 2% of the gate leaf width or 4 in.

1. Up to 6 ft. width: Shall be 2.875 in. O.D., Schedule 40 pipe weighing 5.79 lb./ft.
2. Over 6 ft. width up to and including 12 ft. width: Shall be 4.0 in. O.D., Schedule 40 pipe weighing 9.10 lb./ft. (at tennis courts)

2.4 CHAIN LINK RAILS AND POST BRACES

A. Bottom rail and mid-rail, and post braces shall be 1-5/8 in. O.D. Schedule 40 pipe weighing 2.27 lb./ft.

B. Truss braces: Fence shall have a brace rail of 1-5/8 in. O.D. between each terminal post and the next adjacent line post. Each brace rail shall have attachments for a 5/16 in. vinyl coated truss rod and turnbuckle attachment.

C. Top rail shall be 1-5/8 in. O.D., Schedule 40 pipe weighing 2.27 lb./ft.

2.5 CHAIN LINK FENCE GATES AND GATE FRAMES

A. Fabrication: Assemble gate frames by welding connections. Use same fabric as for fence, unless otherwise indicated. Install fabric with stretcher bars at edges, (and tie wire at top and bottom edges, if stretcher is not used). Attach stretcher bars to gate frame at not more than 15 in. o.c. Attach hardware with rivets or by other means which will provide security against removal or breakage. Gate height at tennis courts to match existing or be 6'-8" height. All other heights to match existing fence heights or as shown in drawings.

1. Single and Double Swinging Gate and Hardware: Swing gates and hardware shall be manufactured to meet the requirements of ASTM F900. Unless indicate otherwise, and to meet ADA requirements, the minimum clear opening for all single gates (as measure with gate perpendicular to framework) shall be 36 inches.

    a. Hinges. Industrial butt hinges, size and material as required for the gate size. Non-lift-off type, offset to permit 90 degree gate opening. Provide one pair of hinges for each leaf, gates eight feet and taller in nominal height shall have three hinges per leaf. Spot-weld or bolt to post and paint (non polymer coated), to prevent rotational movement.

    b. Latch (for both single and double gates). Pressed steel, industrial series gate latch, straight fork type, provide latch catch for double gates, designed to permit operation from either side of gate, with padlock eye as integral part of latch catch. Provide two latch and catch for double gates. All gates shall be equipped with one owner approved gate stop.

2. Sleeves if required for fence shall be galvanized steel pipe conforming to ASTM F1043 sizing as required to accommodate posts.

3. Wire ties for fastening fabric to top, bottom, middle and brace rails shall be #15 wire, black "band it" ties, or approved equal, spaced at 12" on center to form a secure connection.

2.6 STRETCHER BARS

A. Stretcher bars shall not be less than 3/16 in. x 3/4 in. and be full height of the fabric with which they are being used.

1. Provide stretcher bars for each gate, end, corner and pull post.

B. Stretcher bar bands and clips shall be heavy pressed steel, or malleable iron. At square post provide special design clips.

C. Attachment bolts for bands shall be 5/16 in. x 1-1/2 in. galvanized carriage bolts with nuts, to match fence.

2.7 CAPS

A. Posts shall have caps which shall be designed to exclude water from post. Caps shall have holes suitable for the through passage of the top rail where necessary.

2.8 TENSION AND TIE WIRE

A. Tension wire shall be 7 gauge galvanized wire. Fabric shall be attached to the tension wire at intervals of 24 in. with tie wire.

B. Tie Wires, Clips, and Fasteners: According to ASTM F 626.

C. Hot-Dip Galvanized Steel: 0.148-inch- (3.76-mm) diameter wire; galvanized coating thickness matching coating thickness of chain-link fence fabric.

2.9 GALVANIZED PAINT

A. Cold galvanized paint for field touch-up shall be one of the following:

Product	Manufacturer
Galvicon	Galvicon Corporation
Zinc Shield	Stanley Chemical Division of the Stanley Works

2.10 CONCRETE

A. Concrete shall be air-entrained type, conforming to Section 033000, CAST-IN-PLACE CONCRETE

PART 3 EXECUTION

3.1 INSTALLATION

A. Chain link fence installation shall conform to ASTM F 567, except as modified below.

B. Line posts shall be placed at not more than 10 ft. on center, or as indicated on Drawings.

C. Fence shall be 4, 6 or 10 ft. height, from finish grade to top rail, of length and layout as indicated on Drawings. Fencing at Tennis courts will be matching current height (minimum of 10' ht).

D. Install fabric on security side of fence. Wire fabric shall be attached to frame, and tightly stretched such that it is flat, in uniform tension with no bulges or warping of fence or gate after pulling force is released. Ties shall be spaced at 15 in. on horizontal rails and braces, and 12 in. on posts. Bend ends of wire to minimize hazard to person or clothing. Set selvage at 1-1/2 in. below top of rail as indicated on the Drawings. Top of fence shall approximately follow grade and shall have no abrupt changes in slope. Height of fence shall be constant.

1. Fasteners: Install nuts for tension band and hardware bolts on side of fence opposite fabric side.
2. Bolts: Used in the construction of fence shall be thoroughly peened.

E. Tension Wire: Provide tension line at bottom of fabric and at top (if top rail is not specified). Install tension wires before stretching fabric and tie to each post with ties or clips. Attach to fabric with hog rings 24 in. o.c.

F. Stretcher Bars: Extend through fabric and secure to end, corner, pull and gate posts with bands or clips spaced not over 15 in. o.c.

3.2 GATES

A. Install gates plumb, level, and secure for full opening without interference.

B. Gate dimension is the center to center spacing of gate posts.

C. Gates shall work freely and shall have adequate clearance of the bottom. Adjust for smooth operation.

3.3 FOUNDATIONS

A. General: Unless otherwise indicated on the Drawings, footing diameter shall be four times the largest cross section of the post. The depth shall be as indicated on the Drawings.

B. Concrete shall be crowned at top to shed water.

C. Post hole footings shall be allowed to cured 72 hours prior to any additional work.

3.4 POSTS

A. Layout:

1. End, corner and pull post: Provide at each termination and change in horizontal or vertical direction of 30 degrees or more.
2. Line Posts: Space uniformly at approximately 10 feet on center.

B. Concrete Set Posts for site enclosure fence: (Corner, End and Pull Posts) Drill holes (after final grading) in firm, undisturbed or compacted soil. Holes shall have a diameter equal to four times the diameter of the post, and depths approximately 6 in. deeper than post bottom. Excavate deeper as required for adequate support in soft and loose soils, and for posts with heavy lateral loads.

1. Set post not less than 35 in. below surface when in firm, undisturbed soil.
2. Place concrete around posts in a continuous pour, tamp for consolidation. Trowel finish tops of footings, and slope or dome to direct water away from posts, except at walks.
3. Gate posts and hardware: Set keepers, stops, sleeves and other accessories into concrete.

C. Posts set in cast in place walls or perimeter curb at sports field : (Corner, End and Pull Posts) Core cast in place concrete to accept post per detail and fill with non-shrink grout to secure post

3.5 BRACING AND FRAMING

A. Bracing: Install horizontal pipe brace at mid height for fences 6 ft. and over, on each side of corner posts and at gate, end, and pull posts. Firmly attach with proper fittings. Install diagonal tension rods at these points. Install braces so posts are plumb when diagonal rod is under proper tension.

B. Top Rail:

1. Random length, averaging not less than 18 feet.
2. Pressed steel sleeve joints, for rigid connections and expansion/contraction.

3.6 TOUCH UP

A. Following installation, scratches and marred spots in galvanized surfaces shall be power wire brushed and painted with a cold-applied galvanized paint at a rate of 2.0 oz. zinc per sq. ft. of surface.
B. Inspect all fencing following installation to check for proper tension, stability, structural integrity and gate function, and adjust, repair or replace as required to establish proper function prior to final review and acceptance.

END OF SECTION

Section 32 31 13 B
LOWER FIELD CHAIN LINK FENCES, GATES, AND BACKSTOP

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. The General provisions of the Contract, including General and Supplementary General Conditions, and Division 1 General Requirements and Division 01 General Requirements, apply to work specified in this section.

B. Carefully examine all of the Contract Documents for requirements which affect the work of this Section. The exact scope of work of this section cannot be determined without a thorough review of all Specification Sections and other Contract Documents.

C. Refer to Drawings for further definition of location, extent, and details of work described in this Section.

D. Cooperate and coordinate with other trades in executing work as described in this Section.

E. Where referred to, Standard Specifications, Recommendations of Technical Societies, and/or Manufacturer's Associations, plus Codes of Federal, State, and Local Agencies shall include all amendments current as of date of issue of these Specifications.

F. In all cases when conflicts exists between information contained in this Section and in other parts of the Contract Documents, the Contractor shall assume (for budgeting purposes) that the most expensive solution is required, until notified otherwise.

G. In all cases, when a question exists to the level of quality required for a product and/or installation, the highest quality is required.

1.2 SCOPE OF WORK

A. Provide engineering and design, fabrication and materials, freight, installation, all labor, materials, equipment, and services necessary for, and incidental to, the installation of chain link fence, gates, and backstop as shown on the Drawings and as specified herein.

B. Work shall include all excavation and concrete footings.

C. Top of footings shall be coordinated with adjacent structures.

1.3 DESCRIPTION

B. The Contractor shall provide all labor, materials, equipment, and services necessary for, and incidental to, the installation of chain link fence and gates, as shown on the Drawings and as specified herein.

1.4 QUALITY ASSURANCE

A. Comply with standards of the Chain Link Fence Manufacturer's Institute.

B. Provide steel fence and related gates as a complete system produced by a single manufacturer,

including necessary erection accessories, fittings and fastenings.

C. Comply with ASTM A-120 for requirements of Schedule 40 piping. All piping shall be hot dipped galvanized inside and out.

D. Height of fence shall be measured from the top of concrete footing to the top of post.

1.5 SUBMITTALS

A. Shop Drawings: Show application to project, include gates.

B. Product Data: Manufacturer's catalog cuts, with printed specifications, and installation instructions.

PART 2 - PRODUCTS

2.1 STEEL

A. End Posts, Corner Posts, and Pull Posts:
1. 51" Foul Territory Fencing: 3.50" O.D. Pipe (Sch 40)
2. 75" Outfield Fencing at Non-Wall Locations: 3.50" OD Pipe (Sch 40)
3. 8' Outfield Fencing at Wall Locations: 4.00" OD Pipe (Sch 40)
4. 8' Fencing at Ends of Bullpens: 3.5" OD Pipe (Sch 40)
5. 24 Foot Backstop Fencing: 6.625" O.D. Pipe (Sch 40)

B. Line Post:
1. 51" Foul Territory Fencing: 2.875" O.D. Pipe (Sch 40)
2. 75" Outfield Fencing at Non-Wall Locations: 2.875" OD Pipe (Sch 40)
3. 8' Outfield Fencing at Wall Locations: 3.500" OD Pipe (Sch 40)
4. 8' Fencing at Ends of Bullpens: 3.5" OD Pipe (Sch 40)
5. 24 Foot Backstop Fencing: 6.625" O.D. Pipe (Sch 40)
6. Dugout Structure Enclosure Fencing 1.90" OD Pipe (Sch 40)

C. Top, Bottom and Mid- Rails for all fence systems and all heights where top, bottom and mid-rails are indicated on drawings:
1. 1.90" OD Pipe (Sch 40)

D. Brace Rails:

1. Brace Rails: 1.90" OD Pipe (Sch 40) (cross and middle rail)
2. Vertical Closure: 1.90" OD Pipe (Sch 40)
3. Non-Access Barrier Wings at Wall: 1.90" OD Pipe (Sch 40)

2.2 STEEL FABRIC

A. One-piece widths for fence heights up to 12'-0".

B. Fabric for all fencing: Chain link, No. 9 gauge galvanized steel core, 2 inch mesh for all fencing. Measured prior to application of coating.

C. Fabric for first 8 feet of backstop: Chain link, No. 6 gauge galvanized steel core, 2 inch mesh for all fencing. Measured prior to application of coating.

D. Selvage: Top and bottom knuckled.

E. All fabric shall be black vinyl coated. Gauge of fabric shall be measured prior to application of coating.

2.3 SWING GATE POSTS

A. End posts:
1. 48” Fencing: 3.50" OD Pipe (Sch 40) at 4 foot gate
2. 48” Fencing 4.00” OD Pipe (Sch 40) at double panel gates
3. 72” Fencing 4.00" OD Pipe (Sch 40) at 4 foot gate
4. 72” Fencing 4.00” OD Pipe (Sch 40) at double panel gates

2.4 SWING GATE FRAMES

A. Perimeter Framing:
1. 1.90” OD Pipe (Sch 40) Welded

B. Interior Framing:
1. 1.90" OD Pipe (Sch 40) Welded

C. Assemble gate frames by welded connections. When width of gate leaf exceeds 10 feet, install mid-distance vertical tubing of the same size and weight as frame members. When either horizontal or vertical bracing is not required, provide truss rods as cross bracing to prevent sag or twist.

D. Horizontal bid bracing shall be used on all gates.

2.5 GATE HARDWARE

A. All gates shall be equipped with hot-dipped galvanized steel hinges and latch with provisions for padlocking.

B. Double gates and single gates with leaf width 10 feet and greater shall be equipped with a drop bar and gate hold backs.

C. Hinges shall be cast steel hinges capable of 180 degree opening. Set screw shall be installed to lock each hinge to the gate post. **Box type hinges are not acceptable unless offset type**.

2.6 MISCELLANEOUS MATERIALS AND ACCESSORIES

A. Rails and Post Braces:
1. Schedule 40 Steel Tubing: 1.90 inches OD, Sch 40; hot dipped galvanized.

B. Post Tops: Steel, wrought iron, or malleable iron.

C. Stretcher Bars: One piece equal to full height of fabric, minimum cross-section 3/16 inch x 3/4 inch. Black color

D. Metal Bands (for stretcher bars): Steel, wrought iron, or malleable iron, to secure stretcher bars to end, corner, pull and gate posts. Black color.

E. Wire Ties:
1. For tying fabric to line posts, rails and braces: 9 gauge **steel**. Black color.
2. For tying fabric to tension wire: 11 gauge **steel** hog rings. Black Color

3. Spacing shall not exceed 12” at top and bottom railings.

F. Truss Rods: 3/8 inch diameter. Black color

G. Tension Wire: 7 gauge coiled spring steel wire. Black color

H. Angle Beams, I Beams and Steel Shapes: ASTM A-36. Black color

I. Bolts and Nuts: ASTM A-307, Grade A. Bolts shall be sized to allow ½” of bolt to extend beyond the face of the post or pipe. Black color

J. Top caps for top rails shall have smooth ring of square shapes without any projections. Black color.

K. End caps and corner post caps shall be low profile type without vertical projections. Black color

L. Concrete: 3,000 psi concrete.

2.7 FINISHES

Steel Framework:
1. Pipe: Galvanized in accordance with ASTM A-120, 1.0 oz. zinc per sq. ft. and 10 mils minimum coating of black polyvinyl chloride (PVC) meeting federal specification RR-F-101/3C.

M. Fabric:
1. Fencing: Heavy Galvanized: 2.0 ounces zinc per sq. ft. complying with ASTM A-392.
2. Fencing: Vinyl coated (black).

N. Fence and Gate Hardware, Miscellaneous Materials, Accessories:
1. Wire Ties: Galvanized Finish, ASTM A-90 2.0 oz. zinc per sq. ft. Vinyl coated (black)
2. Hardware and Other Miscellaneous Items: Hot-dipped Galvanized Finish, ASTM A-153. Black coated finish.
3. Angle Beams, I Beams, and Steel Shapes: Galvanized in accordance with ASTM A-123, 2.0 oz zinc per sq. ft. Black coated finish.

O. Tension Wire:
1. Aluminized Finish: ASTM A-585 Class 2, 0.30 oz. per sq. ft.

PART 3 - EXECUTION

3.1 PREPARATION

A. Coordinate fence and gate installation with completion of finished grading including top soiling, and paving.

B. Clear and grade along fence line as required to eliminate growth interfering with alignment.

3.2 INSTALLATION

A. Space posts equidistant in the fence line with a maximum of 8 feet on center where feasible.

B. In instances where 8 foot post separation must be increased due to the presence of underground structures and utilities, Adjust spacing to add an additional posts to avoid the conflict. The Contractor shall locate all potential conflicts prior to layout of fencing.

C. Concrete Slab Installations: Core holes into concrete slabs to a depth of 3 times the diameter of the post. Cores shall have a diameter of 2 times the pipe diameter. Grout with non-shrink grout 6,000 psi.

D. Earth: Excavate holes as indicated for fence and gate posts. Center and plumb sona tube or approved equal round form in hole. Excavations for posts must have vertical sides or must have a taper that is wider at the bottom that at the top to prevent frost action lifting the post.

E. Plumb and align posts. Vibrate or tamp concrete for consolidation. Finish top surface of concrete in a dome shape above ground to shed water. Do not attach fabric to posts until concrete has cured a minimum of 7 days.

F. Locate corner posts at corners and at changes in direction. Use pull posts at all abrupt changes in grade and at intervals no greater than 500 feet. On runs over 500 feet, space pull posts evenly between corner or end posts. On long curves, space pull posts so that the strain of the fence will not bend the line posts.

G. Install top rail continuously through post caps or extension arms, bending to radius for curved runs. Install expansion couplings as recommended by fencing manufacturers.

H. Install bottom and intermediate rails in one piece between posts and flush with post on fabric side using special offset fittings where necessary.

I. Diagonally brace corner posts, pull posts, and terminal posts to adjacent line posts with truss rods and turnbuckles.

J. Attach fabric to security side of fence. Maintain clearances as indicated. Thread stretcher bars through fabric using one bar for each gate and end post and two for each corner and pull post. Pull fabric tight so that the maximum deflection of fabric is 2 inches when a 30 pound pull is exerted perpendicular to the center of a panel. Maintain tension by securing stretcher bars to posts with metal bands spaced 15 inches oc. Fasten fabric to steel framework with wire ties spaced 12 inches oc for line posts and 18 inches oc for rails and braces. Bend back wire ends to prevent injury. Tighten stretcher bar bands, wire ties, and other fasteners securely.

K. Install fabric so that the top selvage is inline with the spring line of the top post. No part of the selvage shall extend above this point.

L. Position bolts for securing metal bands and hardware so nuts are located opposite the fabric side of fence and outside the playing field. Tighten nuts and score excess threads.

M. Secure post tops, extension arms, and caps with one-way cadmium plated steel screws.

N. Install gates plumb and level and adjust for full opening without interference. Install ground-set items in concrete for anchorage, as recommended by fence manufacturer. Adjust hardware for smooth operation and lubricate where necessary.

O. Eliminate any sharp edges at tie wire and bolts.

P. Bolts shall not extend more than 3/8” beyond face of nut.

Q. Restore disturbed ground areas to original condition. Top soil and seed to match adjacent areas.

R. Fence fabric shall be attached on all four (4) sides by means of tension bars and bands or ties on gates.

S. Fence fabric on gate panels shall be attached on all four sides by tension bar system.

END OF SECTION 32 31 13 B

Section 32 31 15
METAL FENCE AND GATE

PART 1 GENERAL

1.0 RELATED DOCUMENTS

Division 00 – PROCUREMENT AND CONTRACTING REQUIREMENTS
Division 01 - GENERAL REQUIREMENTS, as listed in the Table of Contents, including but not limited to the following sections, shall be included in and made a part of this Section:

01 30 00 – SUBMITTALS
01 43 39 – MOCK-UPS
01 81 13 – SUSTAINABLE DESIGN REQUIREMENTS

1.1 DESCRIPTION OF WORK

A. Provide all equipment and materials, and do all work necessary to construct the metal fence and gates at children's play areas (F2A, G2A), metal fence and gate at north access drive (F2B, G2B), utility screen fence and gate at automotive service area (F4,G7) and vehicular swing gate at north access drive (G5), as indicated on the Drawings and as specified herein.

1.2 RELATED WORK

A. Examine Contract Documents for requirements that affect work of this Section. Other Specification Sections that directly relate to work of this Section include, but are not limited to:

1. Section 033000, CAST-IN-PLACE CONCRETE

1.3 REFERENCES

A. Comply with applicable requirements of the following standards. Where these standards conflict with other specified requirements, the most restrictive requirement shall govern.

1. American Society for Testing and Materials (ASTM):

A 185	Steel Welded Wire fabric, Plain for Concrete Reinforcement
A653/A653M	Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy Coated (Galvannealed) by the Hot-Dip Process.
ASTM B117	Practice for Operating Salt-Spray (Fog) Apparatus.
ASTM D523	Test Method for Specular Gloss.
ASTM D714	Test Method for Evaluating Degree of Blistering in Paint.
ASTM D822	Practice for Conducting Tests on Paint and Related Coatings and Materials using Filtered Open-Flame Carbon-Arc Light and Water Exposure Apparatus.

ASTM D1654	Test Method for Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments.
ASTM D2244	Test Method for Calculation of Color Differences from Instrumentally Measured Color Coordinates.
ASTM D2794	Test Method for Resistance of Organic Coatings to the Effects of Rapid Deformation (Impact).
ASTM D3359	Test Method for Measuring Adhesion by Tape Test.

A 36	Structural Steel
A 53	Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless
A 123	Zinc (Hot-Galvanized) Coatings on Products Fabricated from Rolled, Pressed and Forged Steel Shapes, Plates, Bars, and Strip
A 153	Zinc Coating (Hot-Dip) on Iron and Steel Hardware
A 385	High-Quality Zinc Coatings (Hot-Dip)
A 386	Zinc Coating (Hot-Dip) on Assembled Steel Products
A 501	Hot-Formed Welded and Seamless Carbon Steel Structural tubing

2. American Welding Society (AWS):

D1.1	Structural Welding Code – Steel

3. Steel Structures Painting Council (SSPC):

SP 6	Commercial Blast Cleaning

1.4 SUBMITTALS

A. Shop Drawings: Provide large scale shop drawings for fabrication, installation and erection of all parts of the work. Provide plans, elevations and details for all fences, railings, gates and guardrails in this section. These drawings shall show sizes and thicknesses of all members, types of materials, methods of connection and assembly, complete dimensions, clearances, anchorage, relationship to surrounding work by other trades, shop paint and protective coatings, and other pertinent details of fabrication and installation.

B. Sample Panels:

1. Submit samples of all fence materials to be furnished under this Section in a 2 ft. x 2 ft. fully assembled fence panel, unless otherwise requested by Architect.
2. Submit samples of all gate materials to be furnished under this Section in a 2 ft. x 2 ft. fully assembled gate, unless otherwise requested by Architect.
3. Each assembled section shall exhibit specified post, picket and rail components, hardware, fittings, hinges, post and picket top treatment, color and finish.
4. Architect will review submitted sample panels and, if not acceptable, reserve the right to request additional panels at no cost to the Owner. Contractor shall provide additional panels until Architect approves. Approved panels shall remain in Architect's possession, and become the standard for measuring acceptance of completed fence and gate installations.

C. Product Data: Submit manufacturer's printed product data, specifications, standard details, installation instructions, use limitations and recommendations for each material used. Provide certifications that materials and systems comply with specified requirements.

1. Fence and gate posts, and fittings.
2. Gates and hardware.
3. Guardrail panels, fasteners and posts

D. Qualification Data: For Installer.

E. Do not order materials or begin fabrication until Architect's approval of submittals has been obtained.

F. Field Measurements: Take all necessary field measurements before preparation of shop drawings and fabrication. Do not delay progress of the job. If field measurements are not possible prior to fabrication, allow for field cutting and fitting.

G. Initial Selection Samples: Submit samples showing complete range of colors, textures, and finishes available for each material used.

H. Verification Samples: Submit representative samples of each material that is to be exposed in the completed work. Show full color ranges and finish variations expected. Provide samples having minimum size of 144 sq. in.

I. Calculations: Provide professionally prepared calculations and certification of the performance of this work. Indicate how design requirements for loading and other performance criteria have been satisfied.

1.5 QUALITY ASSURANCE

A. The Contractor shall provide laborers and supervisors who are thoroughly familiar with the type of construction involved and materials and techniques specified.

1.6 SPECIAL WARRANTY

A. Provide manufacturer's standard limited warranty that its ornamental metal fence and gate system is free from defects in material and workmanship including cracking, peeling, blistering and corroding for a period of 12 years from the date of purchase.

1.7 PRODUCT HANDLING AND STORAGE

A. Materials shall be carefully handled and stored under cover in manner to prevent deformation and damage to the materials and to shop finishes, and to prevent rusting and the accumulation of foreign matter on the metal work. All such work shall be repaired and cleaned before erection.

1.8 MOCKUP

A. Exterior Pedestrian Guardrails:

1. Construct a 6 ft. long mockup section on specified concrete support structure before start of any guardrail work. Sample section shall exhibit proposed pickets, posts, rails, connections, cutouts, frames, and workmanship.
2. Sample section shall be inspected by the Architect. If the sample is not acceptable, construct additional panels, at no additional cost to the Owner, until an acceptable panel is constructed. Accepted panel; shall become the standard for the entire job and shall remain undisturbed until Substantial Completion.

1.9 GENERAL REQUIREMENTS

A. The Contractor shall verify all measurements and shall take all field measurements necessary before fabrication. Welding to or on structural steel shall be in accordance with AWS D1.1/D1.1M. Items specified to be galvanized, when practicable and not indicated otherwise, shall be hot-dip galvanized after fabrication. Galvanizing shall be in accordance with ASTM A 123/A 123M, ASTM A 653/A 653M, or ASTM A 924/A 924M, as applicable. Exposed fastenings shall be compatible materials, shall generally match in color and finish, and shall harmonize with the material to which fastenings are applied. Materials and parts necessary to complete each item, even though such work is not definitely shown or specified, shall be included. Poor matching of holes for fasteners shall be cause for rejection. Fastenings shall be concealed where practicable. Thickness of metal and details of assembly and supports shall provide strength and stiffness. Joints exposed to the weather shall be formed to exclude water.

1.10 WORKMANSHIP

A. Handrail and guardrail work shall be well formed to shape and size, with sharp lines and angles and true curves. Drilling and punching shall produce clean true lines and surfaces. Welding shall be continuous along the entire area of contact. Exposed connections of work in place shall not be tack welded. Exposed welds shall be ground smooth. Exposed surfaces of work in place shall have a smooth finish, and unless otherwise approved, exposed riveting shall be flush. Where tight fits are required, joints shall be milled. Corner joints shall be coped or mitered, well formed, and in true alignment. Work shall be accurately set to established lines and elevations and securely fastened in place. Installation shall be in accordance with manufacturer's installation instructions and approved drawings, cuts, and details.

1.11 PERFORMANCE REQUIREMENTS

A. General: Provide installed handrail and guardrail assemblies complying with following structural performances, unless otherwise indicated:

1. Live Loads shall not be less than the minimum required by applicable building codes.

2. Design shall incorporate safety factors as required by the applicable building codes.
3. Design and construction shall be as such to assure that under the required design live loads there shall be no failure of any member, deflection of not more than L/240 of length of any member, and without permanent deformation of any member or fastener.

B. Minimum Structural Performances: Provide installed handrail and guardrail assemblies complying with following minimum structural performances, unless otherwise indicated:

1. Handrails:
   a. Uniform load of 50 lbf/ ft. (0.73 kN/m) applied in any direction.
   b. Concentrated load of 200 lbf (0.89 kN) applied in any direction.
   c. Uniform and concentrated loads need not be assumed to act concurrently.

2. Top Rails of Guards:
   a. Uniform load of 50 lbf/ ft. (0.73 kN/m) applied in any direction
   b. Concentrated load of 200 lbf (0.89 kN) applied in any direction.
   c. Uniform and concentrated loads need not be assumed to act concurrently.

1.12 QUALITY ASSURANCE

A. Source: For each material type required for the work of this section, provide primary materials which are the product of one manufacturer. Provide secondary or accessory materials which are acceptable to the manufacturers of the primary materials.

B. Engineering: Provide services of Professional Engineer, registered in the Commonwealth of Massachusetts, to design and certify that work of this Section meets or exceeds performance requirements specified.

1.13 ANCHORAGE

A. Anchorage shall be provided as shown and where necessary for fastening fences and gates securely in place. All posts to be secured per manufacturers specifications.

1.14 DISSIMILAR MATERIALS

A. Where dissimilar metals are in contact, or where aluminum is in contact with concrete, mortar, masonry, wet or pressure-treated wood, or absorptive materials subject to wetting, the surfaces shall be protected with a coat of bituminous paint or asphalt varnish.

PART 2 PRODUCTS

2.1 FENCE STYLE

A. Type F2A and F2B as shown on Drawings: Fence panels: Fabricated from pre-galvanized panels to create an open grille pattern; Top and bottom of panels shall have no vertical extension beyond the last top or bottom horizontal wire creating a clean, flush finish.

1. Fence manufacturers are:

   a. Omega Architectural by Omega II Fence Systems, 1735 St-Elzear Blvd. West, Laval (Quebec) Canada H7L 3N6, p: 1.800.836.6342, www.omegafence.com

b. Metalco Fence & Railing Systems Inc. – Amego System
3050 Sirius Ave, STE. 104, Las Vegas, NV 8910, p: 1.800.708.2526
www.fence-system.com

c. The American Fence Company – Woven and Welded Wire Fence System
7722 F Street, Omaha, NE 68127, p: 402.896.6722,
www.theamericanfencecompany.com

(Final Bid Package)

2. Panels as indicated: 6 GA vertical and horizontal wire pre-galvanized steel polyester powder coated wire, mesh opening 1.97" x 6" on center with reinforced bends top, middle and bottom
3. Panel height: 48".
4. Panel width: 7'-9" unless otherwise indicated on the Drawings.
5. Fence panel and post color for F2A: RAL 5003-S Blue, F2B: galvanized steel, no color (confirm color with Owner prior to ordering)
6. Include manufacturer's gate Omega II Fence style for playground area to match fence height and color.

B. Type F4 as shown on Drawings:

1. Fence manufacturers are:
   a. Ametco Shadow 100 Louvered Fence Panel, Electro-forged welded steel fencing. Design horizontal 1-31/32" x 1/16" formed main bar, 5/32" round cross bar forming a 1-13/16" x 5-7/32" mesh. Galvanized to ASTM 123 weighs 3.50 lbs. per Sq.Ft. flat horizontal, round vertical bars.
   b. The American Fence Company – Louvered Panel Screen Fence System
   7722 F Street, Omaha, NE 68127, p: 402.896.6722,
   www.theamericanfencecompany.com
   c. Omega 80 Orsogril by Omega II Fence Systems, 1735 St-Elzear Blvd. West, Laval (Quebec) Canada H7L 3N6, p: 1.800.836.6342, www.omegafence.com
   (Final Bid Package)
2. View blocking 100%
3. Hot-dipped galvanized finish
4. Height : 6'
5. Installation: mount posts in sonotubes per manufacturer's instructions. Submit shop drawing for approval.

C. Posts as per manufacturer

1. Size: 2" x 2" square posts
2. Length: As indicated.
3. Cap: square caps with universal brackets

2.2 GATES

A. Type G2A and G2B as shown on Drawings: Fabricated from pre-galvanized panels to create an open grille pattern; Top and bottom of panels shall have no vertical extension beyond the last top or bottom horizontal wire creating a clean, flush finish.
1. Fence manufacturers are:
   a. Fence by Omega Architectural by Omega II Fence Systems, 1735 St-Elzear

Blvd. West, Laval (Quebec) Canada H7L 3N6, p: 1.800.836.6342, www.omegafence.com

b. Metalco Fence & Railing Systems Inc. – Amego System 3050 Sirius Ave, STE. 104, Las Vegas, NV 8910, p: 1.800.708.2526 www.fence-system.com

c. The American Fence Company – Woven and Welded Wire Fence System 7722 F Street, Omaha, NE 68127, p: 402.896.6722, www.theamericanfencecompany.com

(Final Bid Package)

2. Infill panels as indicated: 6 GA vertical and horizontal wire pre-galvanized steel polyester powder coated wire, mesh opening 1.97" x 6" on center with reinforced bends top, middle and bottom
3. Panel height: 48".
4. Gate width as indicated on the Drawings.
5. Gate panel and post color for G2A: RAL 5003-S Blue, G2B (gate): galvanized steel, no color (confirm colors with Owner prior to ordering)
6. Equip gates with manufacturer's standard hardware as required for complete functional operation.
   a. Type: Hinged swinging self-closing and self-latching single gates with optional locks. Quantity as shown
   b. Construction: Welded frame fabricated from steel tubing of size and dimensions recommended by manufacturer, with open mesh steel panels to match fencing material.

6. Hardware:
   a. Hinges: Size and type as determined by manufacturer, to be self-closing. Provide 2 hinges for each leaf up to 6 feet [1829 mm] high and 1 additional hinge for each additional 24 inches [610 mm] in height or fraction thereof.
   b. Latch: self-latching from manufacturer, submit shop drawing information for approval.
   c. Posts: 3"

B. Type G5 shall City of Worcester Standard Vehicular Gate as shown in the drawings. Galvanized steel finish at dimensions shown.

C. Type G7: Gate at Service Area

1. Infill Panel Manufactureres:
   a. Ametco Shadow 100 Fence System, electro-forged welded steel fencing. consisting of modular open grille fencing panels fabricated by welding flat steel bars and rods, supported by steel posts and gates and gate hardware; manufactured by Ametco® Manufacturing Corporation, P.O. Box 1210, Willoughby, Ohio 44096; Telephone: 800-362-1360, www.Ametco®.com.
   b. The American Fence Company – Louvered Panel Screen Fence System 7722 F Street, Omaha, NE 68127, p: 402.896.6722, www.theamericanfencecompany.com
   c. Omega 80 Orsogril by Omega II Fence Systems, 1735 St-Elzear Blvd. West, Laval (Quebec) Canada H7L 3N6, p: 1.800.836.6342, www.omegafence.com

   (Final Bid Package)

2. Gate: Double Swing gate with tube frame, padlock slidebolt and padlock cane bolt. Provided by Ametco Shadow 100 by Ametco Manufacturing or approved equal. Dimensions as shown on Drawings.

2.3 COATINGS

A. Zinc coating: (Omega)

1. The wire meshes are coated with 0.5 oz./sq.ft. (150 g/m^2) zinc, conforms to ASTM A
2. The fence posts, the swing gate frame and the posts are zinc coated (galvalume process) with a minimum of 0.9 oz/sq.ft. (275 g/m^2) as per ASTM A653 G90.

B. Polyester surface coating to be minimum 4 mils applied by an electrostatic method. Coating shall cover all surfaces of the wire and post sections. Coating shall be capable of withstanding the following tests:

1. Mechanical adhesion test as per ASTMD 3359 (1990) - Method B.
2. Shock resistance tests as per ASTM D 2794 (1990).
3. Salt spray testing with a min. of 1,000 hrs without red rust appearance, as per ASTM B 117 (1990).
4. Humidity resistance in a weather meter chamber as per ASTM D 2247 (1988).
5. Exposure to ultraviolet light with exposure of 1000 hours using apparatus Type E and 63°C as per ASTM D1499
6. Color TBD

2.4 KEYING AND LOCK CYLINDERS (at all gates)

A. Provide interchangeable core cylinders, removable by use of special key, for all locking devices on this project. Provide temporary cores during construction. Remove and replace temporary cores when directed

B. Comply with Owner's instructions for keying of Project. Provide grandmaster key system unless otherwise indicated.

C. Metals: Provide cylinders and keys from stainless steel, brass, or nickel silver.

D. Provide three keys for each lock, five master keys, and five grand master keys. Provide one blank key for each lock.

E. Provide three additional cores, keyed only into this system.

2.5 SETTING MATERIAL

A. Concrete: Minimum 28-day compressive strength of 4000 psi (20 MPa).

2.6 FASTENERS AND ANCHORS

A. Provide all anchors, bolts, sockets, sleeves, and other parts required for securing each item of work of this Section to the construction. Furnish required inserts and sleeves for installation in concrete under Section 033000, CAST-IN-PLACE CONCRETE.

B. Exposed fastenings shall be of the same material and finish as the metal to which applied, unless otherwise noted.

C. Welding rods shall conform to AWS Standards and the recommendation of the welding rod

manufacturer. Welding of steel shall conform to AWS D1.1.

2.7 GROUT

A. Epoxy Grout: Provide non-shrink, non-metallic, non-corrosive epoxy grout conforming to the following requirements:

1. Grout shall be manufactured specifically for use in supporting heavy loads.
2. Shrinkage at 28 days: None (0.00 shrinkage when tested in accordance with ASTMC827modified procedure) with a minimum effective bearing area (EBA) of 95 percent coverage of the tested base plate.
3. Compressive strength, minimum: 10,000 psi at seven days, when tested in accordance with ASTM C579.
4. Initial setting time: Approximately one hour at 70 degrees F.
5. Provide flowable consistency as necessary for the particular application.
6. Epoxy grouts which are volatile and which give off noxious fumes are not acceptable.

2.8 FINISHES

A. Galvanizing: Hot-dip galvanize items as indicated to comply with applicable standard listed below:

1. ASTM A 123/A 123M, for galvanizing steel and iron products.
2. ASTM A 153/A 153M, for galvanizing steel and iron hardware.

B. Preparation for Shop Priming: Prepare uncoated ferrous-metal surfaces to comply with minimum requirements indicated below for SSPC surface preparation specifications and environmental exposure conditions of installed metal fabrications:

1. Exteriors and Items Indicated to Receive Zinc-Rich Primer: SSPC-SP 6/NACE No. 3, "Commercial Blast Cleaning."

2.9 HOT DIP GALVANIZING

A. Hot-Dip Galvanizing: Provide coating for iron and steel fabrications applied by the hot-dip process, Duragalv® by Duncan Galvanizing, or approved equal. Comply with ASTM A 123 for fabricated products and ASTM A 153 for hardware. Provide thickness of galvanizing specified in referenced standards. The galvanizing bath shall contain special high grade zinc, nickel, and other earthly materials.

B. Galvanizing shall exhibit a rugosity (smoothness) not greater than 4 rug (16-20 microns of variation) when measured by a profilometer over a 1 inch straight line on the surface of architectural and structural elements that are less than 24 pounds per running foot. Profilometer shall be capable of operating in 1 micron increments.

2.11 ELECTROLYTIC SEPARATION

A. Coating for electrolytic separation between steel and concrete and grout shall be a high-build coal tar epoxy providing one coat protection for steel and concrete in a variety of

chemical, immersion and underground conditions, manufactured by Tnemec Company, Inc., 6800 Corporate drive, Kansas City, MO 64120-1372; Tel. 816-483-3400; Kop-Coat Inc, 436 Seventh Avenue, Pittsburgh, PA 15219-1818; 1/412/227-2700, parent company RPM, International 2628 Pearl Road - P.O. Box 777 - Medina, Ohio 44258; Phone: 330.273.5090 - Fax: 330.225.8743; Carboline Company, 2150 Schuetz Road, St. Louis, MO 63146; Phone: 800-848-4645 or 314-644-1000; FAX: 314-644-4617, or approved equal.

PART 3 EXECUTION

3.1 EXAMINATION

A. Verify areas to receive fencing are completed to final grades and elevations.

B. Ensure property lines and legal boundaries of work are clearly established.

3.2 PREPARATION

A. Prior to fabrication, field verify required dimensions.

B. Cast concrete footings in accordance with Section 033000, Cast-in-Place Concrete as detailed on Drawings and approved shop drawings.

C. Provide setting holes for embedment of fence posts. Core drill existing concrete footings for embedment of fence posts. Hole shall be 2 inches [51 mm] minimum greater than post width.

3.3 INSTALLATION

A. Install fencing in accordance with manufacturer's installation instructions and approved shop drawings.

B. Install fence posts plumb and level in concrete and grouting solid. Temporarily brace fence posts with 2 by 4 wood supports until set.

C. Do not installed bent, bowed, or otherwise damaged panels. Remove damaged components from site and replace.

D. Secure fence panels with standard stainless steel bolts to fence posts prior to setting posts in footings.

E. Gates:

1. Install gates and adjust hardware for smooth operation.
2. Provide concrete center foundation depth and drop rod retainers at center of double swinging gate openings.
3. After installation, test gate. Open and close a minimum of five times. Correct deficiencies and adjust.

F. Touch-up damaged finish with paint supplied by manufacturer and matching original coating.

3.4 FABRICATION AND WORKMANSHIP

A. Metal surfaces shall be clean and free from mill scale, flake, rust and rust pitting; well-formed and finished to shape and size, true to details with straight, sharp lines and angles and smooth surfaces. Curved work shall be to true radii. Exposed sheared edges shall be eased.

B. Weld all permanent connections unless otherwise indicated. Weld shall be continuous on all exposed surfaces and where required for strength on concealed surfaces. Exposed welds shall be ground flush and smooth, with voids filled with metallic filling compound. Tack-welding will not be permitted unless specifically called for. Do not use screws or bolts where they can be avoided. Where used, heads shall be countersunk, screwed up tight and threads nicked to prevent loosening.

C. Fastenings shall be concealed where practical. Thickness of metal and details of assembly and supports shall provide required strength and stiffness. Joints exposed to weather shall be formed to exclude water.

D. Do all cutting, punching, drilling, and tapping required for attachment of hardware and of work of other Sections where so indicated or where directions for same are given prior to, or with approval of, shop drawings.

E. Live loads: Refer to Paragraph 1.12. Factor of safety shall not be less than 2-1/2 to 1.

3.5 COATINGS

A. Galvanizing:

1. Ferrous metal under this Section for exterior use shall be hot-dip galvanized, including all bolts, nuts, washers, and other related ferrous metal items used therewith.
2. Hot-dip galvanizing process shall comply with ASTM A 123, A 153, A 385, and A 386, as applicable. After galvanizing, processed items shall be straightened to remove all warpage and distortion caused by the process.
3. Furnish to the Contractor, with copy to Architect, a certified statement that galvanizing complies fully with this Specification.

3.6 INSTALLATION - GENERAL

A. Materials shall be carefully handled and stored under cover in manner to prevent deformation and damage to the materials and to shop finishes, and to prevent rusting and the accumulation of foreign matter on the metal work. All such work shall be repaired and cleaned prior to erection.

B. Work shall be erected square, plumb, and true, accurately fitted, and with tight joints and intersections. All anchors, inserts and other members to be set into concrete or masonry shall be furnished loose by this trade to be built-into concrete and masonry by those trades as the work progresses. Later cutting or drilling shall be avoided wherever possible.

C. Metal work shall be rigidly braced and secured to surrounding construction, and shall be tight and free of rattle, vibration, or noticeable deflection after installation.

D. Where members, other than expansion bolts or inserts, are fastened into concrete, set such members in proprietary-type expanding grout manufactured specifically for such purpose, used strictly in accordance with manufacturer's directions. Holes to receive members shall be formed with galvanized sheet metal sleeves, expanded polystyrene foam, or other approved method to provide at least 1/2 in. clearance around entire perimeter. At exposed applications, hold expanding grout back 1/2 in. from finish surface and fill voids with Portland cement grout to match color and texture of surrounding concrete surface.

E. Electrolytic Isolation: Where dissimilar metals are to come into contact with one another, isolate by application of a heavy coating of bituminous paint on contact surfaces in addition to shop coat specified above. Do not permit the bituminous paint in any way to remain on surfaces to be exposed or to receive sealant.

3.7 ADJUSTING

A. Gate: Adjust gate to operate smoothly, easily, and quietly, free of binding, warp, excessive deflection, distortion, nonalignment, misplacement, disruption, or malfunction, throughout entire operational range. Confirm that latches and locks engage accurately and securely without forcing or binding.

B. Lubricate hardware and other moving parts.

3.8 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's personnel to adjust, operate, and maintain gates.

3.9 ACCESSORIES

A. Install post caps and other accessories to complete fence.

3.10 CLEANING

A. Clean up debris and unused material, and remove from site.

END OF SECTION

Section 32 32 23

SEGMENTAL RETAINING WALLS

PART 1 – GENERAL

1.1 DESCRIPTION

A. Work includes furnishing and installing precast modular concrete retaining walls to the lines and grades designated on the Contract Drawings and as directed by the Architect/Engineer. Also included is furnishing and installing appurtenant materials required for construction of the retaining wall as shown on the Contract Drawings.

1.2 REFERENCE STANDARDS

A. Segmental Retaining Wall Units

1. ASTM C 140 – Sampling and Testing Concrete Masonry Units
2. ACTM C 90 – Hollow Load-Bearing Concrete Masonry Units
3. ASTM C 145 – Solid Load-Bearing Concrete Masonry Units

B. Geosynthetic Reinforcement

1. ASTM D 4595 – Tensile Properties of Geotextiles by the Wide-Width Strip Method.
2. ASTM D 5262 – Test Method for Evaluating the Unconfined Creep Behavior of Geosynthetics
3. GRI: GG1 – Single Rib Geogrid Tensile Strength
4. GRI: GG5 – Geogrid Pullout

C. Soils

1. ASTM D 698 – Moisture-Density Relationship for Soils, Standard Method
2. ASTM D 422 – Gradation of Soils
3. ASTM 4318 – Atterberg Limits of Soil

D. Drainage Pipe

1. ASTM D1248 – Specification for Corrugated Plastic Pipe

E. Where specifications and reference documents conflict, the Architect/Engineer shall make the final determination of applicable document.

1.3 SUBMITTALS

A. Material Submittals: The Contractor shall submit manufacturers' certifications two weeks prior to start of work stating that the units and geosynthetic reinforcement meet the requirements of Section 2 of this specification.

B. Design Submittal: The Contractor shall submit two sets of detailed design calculations and construction drawings for approval at least three weeks prior to the beginning of wall construction. All calculations and drawings shall be prepared and sealed by a professional Civil Engineer experienced in wall design and licensed in the state of Massachusetts.

1.4 DELIVERY, STORAGE AND, HANDLING

A. Contractor shall check materials upon delivery to assure that specified type and grade of materials have been received and proper color and texture of units have been received.

B. Contractor shall prevent excessive mud, wet concrete, epoxies, and like materials which may affix themselves, from coming in contact with materials.

C. Contractor shall store and handle materials in accordance with manufacturer's recommendations.

D. Contractor shall protect materials from damage. Damaged materials shall not be incorporated into the retaining wall.

PART 2 – MATERIALS

2.1 SEGMENTAL RETAINING WALL UNITS

A. Units shall be machine formed, Portland Cement precast concrete blocks specifically designed for retaining wall applications.

B. Large block units shall be Redi-Rock Limestone blocks or approved equal.

C. Small block units for interior landscape walls shall be Unilock Siena Stone with a natural finish or approved equal.

D. Segmental retaining wall units for the lower field area shall be provided by one of the manufacturers listed below:

1. VersaLok Brute 8" Height
2. Key Stone Broadstone 8" Height
3. Anchor Vertica Pro 8" Height
4. Rockwood Classic 8" Height
5. Techo Bloc G-Force 8" Height

E. Units for the lower field area shall be solid concrete blocks measuring 18" to 24" in width, 8" in height and 16" to 20" in depth. Blocks shall be formed with a rear face width that is 1" to 4" narrower than the front face with uniform angles on each side. Blocks shall be capable for close to vertical face stacking with the maximum step-back per block of less than ½".

F. The layout of segmental retaining walls in the lower field area is based on Versalok 'Mosaic Block'. Subject to compliance with requirements, provide the named product or a comparable product.

G. Units for the lower field area shall not differ more than + 1/8 inch from that specified, as measured in accordance with ASTM C140.

H. Units that comply with requirements for freeze-thaw durability.

(Final Bid Package)

I. Unit faces shall be of straight geometry ***and segmental retaining wall units shall be solid through the full depth of the unit.***

(Final Bid Package)

J. Units shall be manufactured in accordance with ASTM C 90, C 140, and C 145, as applicable.

K. ***Minimum peak shear strength between lower wall units shall be tested according to NCMA SRWU-2.***

L. ***Minimum peak connection strength between units and soil reinforcement shall be tested according to NCMA SRWU-1.***

(Final Bid Package)

M. Units shall be solid through the full depth of the unit.

N. Units shall be capable of being erected with the horizontal gap between adjacent units not exceeding 1/8 inch.

O. ***Units for the lower field area shall be capable of being erected with a variable bond configuration, between ¼ to ¾ bond***.

(Final Bid Package)

P. For any corners shown on the construction plans, units shall be capable of providing overlap of units on each successive course so that walls meeting at corner are interlocked and continuous. Units that require corners to be mitered shall not be allowed.

Q. Units for the lower field area shall interlock with courses above and below by means of integral lugs pins or through integral interlocking forming shapes. Both solid blocks or hollow cores filled with drainage fill are acceptable. Segmental retaining wall units shall be interlocked with connection pins, designed to allow for vertical and setback configurations.

R. Provide corner units, end units, and other shapes as needed to produce segmental retaining walls of dimensions and profiles indicated and to provide texture on exposed surfaces.

(Final Bid Package)

S. Units shall be capable of providing a split face, textured surface for all vertical surfaces that will be exposed after completion of wall, including any exposed sides and backs of units.

T. Units shall be sound and free of cracks or other defects that would interfere with the proper placing of the unit or significantly impair the strength or permanence of the structure. Cracking or excessive chipping is grounds for rejection. Units showing cracks longer than 1/2" shall not be used within the wall. Units showing chips shall not be used within the wall. ***Any cracks or chips observed during construction shall fall within the guidelines outlined in ASTM c 1372.***

(Final Bid Package)

U. Concrete used to manufacture units shall have a minimum 28 days compressive strength of 3,000 psi and a maximum moisture absorption rate, by weight, of 8% as determined in

accordance with ASTM C 140. ***Compressive strength test specimens shall conform to the saw-cut coupon provisions of ASTM c 140.***

(Final Bid Package)

V. Units' shall be interlocking and provide a vertical wall or a near vertical wall with maximum setback of 1 horizontally in 16 vertically.

W. Segmental retaining wall units for the lower field shall have a depth (front face to rear) -to-height ratio of 2.25:1, minimum.

X. Block system for the lower field area shall be suitable for installing on a concrete mud-slab footing. Block shall also be suitable for connecting too and capping with a reinforced concrete walk/slab surface.

(Final Bid Package)

2.2 SEGMENTAL RETAINING WALL UNIT CONNECTION PINS ***AND CLIPS***

A. Units shall be interlocked with connection pins **or clips** or other structurally acceptable methods. The pins shall consist of ***nondegradable*** glass-reinforced nylon made for the expressed use with the units supplied.

(Final Bid Package)

2.3 GEOSYNTHETIC REINFORCEMENT

A. When required, geosynthetic reinforcement shall consist of geogrids or geotextiles manufactured as a soil reinforcement element. The manufacturers/suppliers of the geosynthetic reinforcement shall have demonstrated construction of similar size and types of segmental retaining walls on previous projects. ***Soil reinforcement materials for the lower field area shall be provided by one of the following manufactures:***

1. Civil Engineering Fabrics; a division of BP Amoco Chemicals.
2. Colbond Geosynthetics.
3. HUESKER, Inc.
4. TC Mirafi.
5. TENAX Corporation.
6. Versa-Lok Retaining Wall Systems; a division of Kiltie Corp.

(Final Bid Package)

B. The type, strength, and placement location of the reinforcing geosynthetic shall be as determined by the Civil Engineer, as shown on the approved shop drawings.

C. ***Geosynthetic reinforcement shall meet the requirements for geotextiles as defined in Section 31 20 00 Earth Moving.*** (Final Bid Package)

2.4 LEVELING PAD

Material for leveling pad shall consist of compacted gravel and shall be a minimum of 6 inches in depth. Lean concrete with a strength of 200-300 psi and three inches thick maximum may also be used as a leveling pad material. The leveling pad should extend laterally at least a distance of 6 inches from the toe and heel of the lowermost unit.

Leveling pad base material shall meet the gradation requirements as defined in Section 31 20 00 Earth Moving. (Final Bid Package)

2.5 DRAINAGE AGGREGATE

A. Drainage aggregate shall be angular, clean stone or granular fill meeting the following gradation of ¾-inch crushed stone as defined in Section 31 20 00 Earth Moving.

2.6 SOIL FILL

A. Reinforced and nonreinforced soil fill shall meet the gradation requirements for structural fill as defined in Section 31 20 00 Earth Moving. (Final Bid Package)

2.7 DRAINAGE PIPE

A. The drainage collection pipe shall be a perforated or slotted HDPE pipe, as specified in Section 33 40 00 Storm Drainage Utilities.

PART 3 – EXECUTION

3.1 DESIGN

A. The design provided by the Contractor and prepared by the manufacturer and Civil Engineer shall consider the internal and local stability of the soil mass and shall be prepared in accordance with acceptable engineering practice, specifications, and applicable code requirements. The design shall consider all loading conditions, including live loads of vehicles, guardrail, and temporary loading imposed during construction. Geotechnical investigations shall be made by the wall designer and the wall system shall be designed for a total settlement not to exceed one-inch.

3.2 EXCAVATION

A. Contractor shall excavate to the lines and grades shown on the Contract Drawings. Contractor shall take precautions to minimize over-excavation. Over-excavation shall be filled with compacted gravel at the Contractor's expense.

B. Contractor shall verify location of existing structures and utilities prior to excavation. Contractor shall ensure all surrounding structures and surfaces are protected from the effects of wall excavation. Excavation support, if required, is the responsibility of the Contractor.

3.3 FOUNDATION PREPARATION

A. Following the excavation, the foundation soil shall be examined by the wall designer to ensure actual foundation soil strength meets or exceeds the assumed design bearing strength. Soils not meeting the required strength shall be removed and replaced with gravel, as directed by the Engineer.

B. Foundation soil shall be proofrolled and compacted to 95% standard Proctor density and inspected by the Engineer prior to placement of leveling pad materials.

3.4 LEVELING PAD CONSTRUCTION

A. Leveling pad shall be placed as shown on the approved shop drawings with a minimum thickness of 6 inches. The leveling pad should extend laterally at least a distance of 6 inches from the toe and heel of the lowermost unit.

B. Soil leveling pad material shall be compacted to provide a firm, level bearing surface on which to place the first course of units. Well-graded sand can be used to smooth the top 1/2 to 1/4 inch of the leveling pad. Compaction will be with mechanical plate compactors to achieve 95% of maximum standard Proctor density (ASTM D 698).

3.5 MODULAR PRECAST CONCRETE UNIT INSTALLATION

A. All units shall be installed at the proper elevation and orientation as shown on the wall elevations and details on the Contract Drawings, shop drawings, and as directed by the Engineer. The units shall be installed in general accordance with the manufacturer's recommendations.

B. First course of units shall be placed on the leveling pad. The units shall be leveled side-to-side, front-to-rear and with adjacent units, and aligned to ensure complete contact with the leveling pad. The first course is the most important to ensure accurate and acceptable results. No gaps shall be left between the front of adjacent units. Alignment shall be maintained by means of a string line or offset from baseline to the back of the units.

C. Clean all excess debris from top of units and install next course.

D. Insert two connection pins through pin holes of each upper course unit into receiving slots in lower course units. Pins shall be fully seated in the pin slot below. Push units forward to remove any looseness in the unit-to-unit connection and then check alignment. Check level and alignment of the units.

E. Layout of corners shall be installed in accordance with the shop drawings and in general accordance with manufacturer's installation guidelines. Walls meeting at corners shall be interlocked by overlapping successive courses so corners are continuous.

F. Repeat procedures to extent of wall height.

3.6 GEOSYNTHETIC REINFORCEMENT PLACEMENT

A. If required, all geosynthetic reinforcement shall be installed at the proper elevation and orientation as shown on the shop drawings and as directed by the Engineer.

B. At the elevations shown on the shop drawings, the geosynthetic reinforcement shall be laid horizontally on compacted gravel and on top of the concrete units. Embedment of the geosynthetic in the units shall be consistent with manufacturer's recommendations. Correct orientation of the geosynthetic reinforcement shall be verified by the Contractor to be in accordance with the geosynthetic manufacturer's recommendations. The highest strength direction of the geosynthetic must be perpendicular to the wall face.

C. Geosynthetic reinforcement layers shall be one continuous piece for their entire embedment length. Overlap of the geosynthetic in the design strength direction (perpendicular to the wall face) shall not be permitted.

D. Tracked construction equipment shall not be operated directly on the geosynthetic reinforcement. A minimum of 6 inches of backfill is required prior to operation of tracked vehicles over the geosynthetic. Turning should be kept to a minimum. Rubber-tired equipment may pass over the geosynthetic reinforcement at slow speeds (less than 5 mph).

E. The geosynthetic reinforcement shall be in tension and free of wrinkles prior to placement of soil fill. The nominal tension shall be applied to the reinforcement and secured in place with staples, stakes or by hand tensioning until reinforcement is covered by six inches of fill.

3.7 DRAINAGE MATERIALS

A. Drainage aggregate shall be installed to the line, grades, and sections shown on the shop drawings. Drainage fill shall be placed to the minimum thickness shown on the Contract Drawings between and behind units.

B. Drainage collection pipes shall be installed to maintain gravity flow of water outside the reinforced soil zone, as indicated on the Contract Drawings.

3.8 BACKFILL PLACEMENT

A. The gravel backfill shall be placed as shown in the construction plans in the maximum compacted lift thickness of 10 inches and shall be compacted to a minimum of 95% of standard Proctor density (ASTM D 698) at a moisture content within 2% of optimum. The backfill shall be placed and spread in such a manner as to eliminate wrinkles or movement of the geosynthetic reinforcement and the units.

B. Only hand-operated compaction equipment shall be allowed within 3 feet of the front of the wall face. Compaction within the 3 feet behind the wall face shall be achieved by at least three (4) passes of a lightweight mechanical tamper, plate, or roller.

C. At the end of each day's operation, the Contractor shall slope the last level of backfill away from the wall facing to direct water runoff away from the wall face.

D. At completion of wall construction, backfill shall be placed level with final top of wall elevation. If final grading, paving, landscaping, and/or storm drainage installation adjacent to the wall is not placed immediately after wall completion, temporary surface drainage shall be provided to ensure water runoff is not directed at the wall nor allowed to collect or pond behind the wall until final construction adjacent to the wall is completed.

3.9 WALL CAPS

A. Caps shall be properly aligned and installed along the top of the wall.

B. Caps shall overhang the top course of units by 3/4 to 1 inch. Slight variation in overhang is allowed to correct alignment at the top of the wall.

C. Caps for the lower field area shall have smooth top surfaces without holes or lugs. Provide cast stone threads for stairs. Cap units shall be 3.5” to 4.0” in height and 12” to 16” in depth.

(Final Bid Package)

3.10 CONSTRUCTION ADJACENT TO COMPLETED WALL

A. The Contractor is responsible for ensuring that construction adjacent to the wall by others does not disturb the wall or place temporary construction loads on the wall that exceed design loads, including loads such as water pressure, temporary grades, or equipment loading. Heavy paving or grading equipment shall be kept a minimum of three feet behind the back of the wall face. Care should be taken by the Contractor to ensure water runoff is directed away from the wall structure until final grading and surface drainage collection systems are completed.

End of Section

Section 32 80 00
IRRIGATION SYSTEM

PART 1 GENERAL

1.0 RELATED DOCUMENTS

Division 00 – PROCUREMENT AND CONTRACTING REQUIREMENTS
Division 01 - GENERAL REQUIREMENTS, as listed in the Table of Contents, including but not limited to the following sections, shall be included in and made a part of this Section:

01 30 00 – SUBMITTALS
01 43 39 – MOCK-UPS
01 81 13 – SUSTAINABLE DESIGN REQUIREMENTS

1.1 DESCRIPTION OF WORK

A. This is a Design/Build Specification: The Contractor is responsible for the design and engineering of the entire irrigation system including sizing all piping, calculating system hydraulics, testing, and all other work required for a complete operable system and for providing the specified guarantees. Design and install irrigation system in compliance with ASIC Standards. The system is required to provide a 30% reduction in water use (from a typical system) by employing smart technology sensors within the design. This requirement needs to be met for project LEED certification.

B. Contractor to provide documentation of water reduction calculations per LEED guidelines.

C. Contractor to provide supply line for irrigation system from water supply at the required PSI (80 at source, 50-60 at system) and GPM (50).

D. The completed and proper construction of the landscape irrigation system including, but not limited to:

1. All piping and conduit, including mains, laterals, fittings, connections, tees, risers, clamps, and swing joints.
2. All control, gate, globe, pressure reducing, quick coupling and other valves; including valve boxes, markers, connections, operators smart technology sensors and other accessories.
3. All rotating and stationary spray sprinkler head; including proper nozzles and all other appurtenances and accessories for proper operations.
4. Connections of piping to the supply sources, including backflow preventer.
5. All excavation, sitework, relocation or replacement of utilities, backfill and restoration of all disturbed areas.
6. Provide complete and operable system for irrigation of the areas shown on the drawings. Provide all items obviously necessary and requisite for the proper irrigation of the project.
7. Adjust head location, type and size, and any other system components to comply with the requirements of landscaping as actually installed, at no cost to the Owner except for, when authorized in writing, such adjustments which will be compensated at an agreed upon price.
8. Supply, deliver, store, and protect all equipment and materials including pipe and fittings, sprinkler heads, valves, controllers, wire, and all other component parts necessary for the installation of a fully automatic irrigation system. Adequate security of materials on site shall be provided by the Contractor at all times at his expense.

E. On-Site Conditions

1. Inspection of the Site: The Contractor shall acquaint himself with all on-site conditions. Should utilities be found during excavations, the Contractor shall promptly notify the Owner for instruction as to further action. Failure to do so will make the Contractor liable for any and all damage thereto arising from his operations subsequent to discovery of such utilities.
2. Protection of Property: The Contractor shall be responsible for the preservation and protection of all site conditions to remain from damage due to this work. In the event damage does occur, all damage shall be completely repaired to its original condition at no additional cost to the Owner.
3. Trenching: All trenching or other work under the leaf canopy of any and all trees shall be done by hand or by other methods so that no branches or root systems are damaged in any way.
   a. Trenching around existing plant material shall be done by hand so as to minimize root disturbance.
   b. Buildings, walks, walls, and other property shall be protected from damage. Open ditches left exposed shall be flagged and barricaded by the Contractor by approved means. The Contractor shall restore disturbed areas to their original condition.
4. Protection and Repair of Underground Utilities: The Contractor shall be responsible for requesting the proper utility company to stake the exact location of any underground lines including but not limited to electric, gas, telephone service, water, and cable.
   a. The Contractor shall take whatever precautions are necessary to protect these underground lines from damage. In the event damage does occur, all damage shall be completely repaired to its original condition, at no additional cost to the Owner.

1.2 RELATED WORK

A. Carefully examine all of the Contract Documents for requirements which affect the work of this Section. Other specification sections which directly relate to the work of this section include, but are not limited to the following:

1. Section 31 20 00, EARTH MOVING
2. Section 32 13 13 CONCRETE PAVING
3. Section 32 91 13.16 MULCH
4. Section 32 91 19, LANDSCAPE GRADING
5. Section 32 92 00, LAWNS AND GRASSES
6. Section 32 93 00, TREES, PLANTS, AND GROUND COVERS
7. Section 03 30 01, CAST-IN-PLACE CONCRETE - SITEWORK

1.3 REFERENCES

A. Comply with applicable requirements of the following standards. Where these standards conflict with other specified requirements, the most restrictive requirements shall govern.

1. American National Standards Institute (ANSI):

B16.26	Cast Copper Alloy Fittings for Flared Copper Tubes

2. American Society of Irrigation Consultants (ASIC):

Standards	Minimum Standards for Landscape Irrigation

3. American Society for Testing and Materials (ASTM):

B 88	Seamless Copper Water Tube
D 1785	Poly (Vinyl Chloride)(PVC) Plastic Pipe, Schedules 40, 80, and 120
D 2239	Polyethylene (PE) Plastic Pipe (SLPR - PR) Based On Controlled Diameter.
D 2241	Poly(Vinyl Chloride) (PVC) Plastic Pipe (SDR-PR)
D 2464	Threaded Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80
D 2466	Poly (Vinyl Chloride)(PVC) Plastic Pipe Fittings, Schedule 40
F 690	Underground Installation of Thermoplastic Pressure Piping Irrigation Systems

1.4 SUBMITTALS

A. Submit a complete system design including but not limited to: materials list indicating name of manufacturer, with model numbers of proposed irrigation system equipment and accessories, piping diagram showing sizes and zone valves in relationship to existing system, planting material and hard surficial site elements. Show proposed water connection, control box location, and backflow preventer to be reviewed by Owner and Architect.

B. After completion of installation, furnish complete as-built drawings showing locations of all sprinkler heads, valves, drains, and piping to scale, with dimensions where required or necessary.

C. Owner's/Operator's Manual.

1.5 LAWS, CODES, AND ORDINANCES

A. Irrigation system shall be installed in accordance with the latest laws, ordinances, rules, and regulations of all local, state, and federal authorities having jurisdiction.

1.6 WARRANTY

A. The Contractor will be held strictly responsible for all parts of his work. If failure in the irrigation system or appurtenances develop within one (1) year from the date of final approval and acceptance of the work, the Contractor will be required to replace all faulty materials at his full expense.

B. Labor and materials to fulfill the requirements of this warranty shall be furnished by the Contractor at no additional cost to the Owner. All labor shall include premium time to correct any faulty material or workmanship.

C. Extended Maintenance Agreement: The Contractor shall provide an extended maintenance agreement to include all manufacturer-recommended services and maintenance related to annual fall winterization and spring startup of the irrigation system. The extended maintenance agreement shall extend for a period of three (3) years from the date of substantial completion and shall include all labor and materials required to perform the required maintenance service. (Add. #3)

1.7 QUALITY ASSURANCE

A. All applicable ANSI, AWWA, and ASTM Standards and Specifications, and all applicable building codes and other public agencies having jurisdiction upon the work.

B. Protection of Existing Plants and Site Conditions: The Contractor shall take necessary precautions to protect site conditions to remain. Should damages be incurred, this Contractor shall repair the damage to its original condition at his own expense. Any disruption, destruction, or disturbance of any existing plant, tree, shrub, or turf, or any structure shall by completely restored to the satisfaction of the Owner, solely at the Contractor's expense.

C. Permits and Fees: Obtain all permits and pay required fees to any governmental agency having jurisdiction over the work. Inspection required by local ordinances during the course of construction shall be arranged as required. On completion of the work, satisfactory evidence shall be furnished to Architect to show that all work has been installed in accordance with the ordinances and code requirements.

D. The Contractor shall provide full coverage in all irrigated areas and shall be responsible for additional heads and components as required, installed at his own cost.

E. On-Site Observation: At any time during the installation of the irrigation system by the Contractor, the Owner or Architect may visit the site to observe work underway. Upon request, the Contractor shall be required to uncover specified work as directed by the Owner or Architect without compensation. Should the material, workmanship or method of installation not meet the standards specified herein, the Contractor shall replace the work at his own expense.

F. Workmanship: All work shall be installed by skilled personnel, proficient in the trades required, in a neat, orderly, and responsible manner with recognized standards of workmanship. The Contractor shall have had minimum 5 years' experience and demonstrated ability in the installation of sprinkler irrigation systems of this type. At least three projects of equal size or value within the last 3 years. Provide three references for review.

PART 2 PRODUCTS

2.1 PIPE AND FITTINGS

A. Polyvinyl chloride (PVC) plastic pipe shall be continuously and permanently marked with the following information: Manufacturer's name, pipe size, type of pipe and material, SDR number, ASTM number, and the NSF (National Sanitation Foundation) seal.

B. Main Lines (irrigation line on the supply side of the system up to the zone control valves).

1. Pipe 4 in. diameter and less shall be Schedule 40 polyvinyl chloride (PVC) plastic pipe 1120 or 1220, NSF approved, conforming to ASTM D 1785.
2. Pipe larger than 4 in. diameter shall be polyvinyl chloride (PVC) plastic pipe, SDR 21, 1120 or 1220, conforming to ASTM D 2241, with a minimum pressure rating of 200 psi.
3. Plastic pipe fittings shall be polyvinyl chloride (PVC) molded fittings manufactured of the same material as the pipe and shall be suitable for solvent weld or slip joint ringtite seal (Schedule 40) conforming to ASTM D 2466, or threaded connections (Schedule 80) conforming to ASTM D 2464.
4. Slipfitting socket taper shall be sized so that a dry unsoftened pipe end conforming to these specifications can be inserted no more than halfway into the socket. Plastic saddle and flange fittings shall not be used. Only Schedule 80 pipe may be threaded.

C. Lateral Lines (irrigation lines on the sprinkler head side of the system from the control valves to the sprinkler heads).

1. Pipe 2 in. diameter and less shall be polyethylene (PE) pipe, SIDR 9, Class 160, Type III, Grade 3, Class C conforming to ASTM D 2239, with a minimum pressure rating (PR) of 160 psi.
2. Pipe larger than 2 in. diameter shall be polyvinyl chloride (PVC) plastic pipe, SDR 26 conforming to ASTM D 2241, with a minimum pressure rating (PR) of 160 psi.
3. Polyethylene pipe fittings shall be insert PVC or nylon type fitting recommended by pipe manufacturer. Fittings shall conform to NSF Standards, supplied by Harvard, Liverpool, NY, or approved equal. Joints 1-1/4 in. and greater shall be double clamped with stainless steel clamps.

D. Copper tubing: Hard, straight lengths of domestic manufacture only Type "K" conforming to ASTM B 88. No copper tube of foreign extrusion or thin wall copper tubing shall be used.

1. Where necessary, joints shall be made with cast brass three-part compression coupling or flared tube fittings conforming to ANSI B16.26.

E. Sleeves

1. For Control Wires: Schedule 40 PVC pipe or Schedule 40 galvanized steel pipe.
2. For Water Lines: Schedule 40 PVC or Schedule 40 galvanized steel pipe.
3. Sleeve size shall be at least twice the diameter of the pipe line.

F. Adapters

1. All adapters shall be provided as required by the manufacturer, and are required to construct the proposed system.

2.2 WARNING AND DETECTOR TAPE

A. Detector tape for identification of irrigation main locations shall be manufactured by Reef Industries, Inc., Houston, TX 77275-0218, or approved equal. Detector tape shall consist of a solid aluminum foil core running the full length and width of the tape and encased in a protective, high visibility, color coded inert plastic jacket.
1. Color of tape shall be "Safety Precaution Blue."
2. Tape shall be imprinted with the following legend: "Caution Buried Irrigation Line Below".

2.3 SPRINKLERS AND RISER ASSEMBLY **(Lawn areas and trees)**

A. Sprinklers: Manufacturer's standard sprinklers designed for uniform coverage over entire spray area indicated, at available water pressure. **General - Provide Spray Heads in lawn and Bubblers at trees.**

1. Flush, Surface Sprinklers: Fixed pattern, with screw-type flow adjustment.
2. Bubblers (At Trees): Fixed pattern, with screw-type flow adjustment.
3. Pop-up, Spray Sprinklers: Fixed pattern, with screw-type flow adjustment and stainless-steel retraction spring.
4. Pop-up, Rotary, Spray Sprinklers: Gear drive, full-circle and adjustable part-circle types.
5. Pop-up, Rotary, Impact Sprinklers: Impact drive, full-circle and part-circle types.

2.4 DRIP SYSTEM COMPONENTS **(Ground Cover and Shrub Beds)**

A. Dripperline and Integral Dripperline Components: The dripperline shall be Techline CV or Techline pressure compensating dripperline or 8mm Techlite non-pressure compensated dripperline as manufactured by Netafim Irrigation, Inc. Dripper flow rate and spacing shall be as indicated on drawings.

1. Techline CV/Techline/8mm Techlite Fittings: All Techline CV/Techline/8mm Techlite connections shall be made with approved Techline CV/Techline/8mm Techlite insert fittings.
2. Soil Staples: All on-surface/under mulch Techline CV/Techline/8mm Techlite installations shall be held in place with Techline Soil Staples spaced evenly every 3’ - 5’ on center, and with two staples on each change of location.
3. Line Flushing Valves: All Techline/Techlite systems shall be installed with Netafim Automatic Line Flushing Valves. Techline CV zones do not require an automatic line flushing valve but must have a manual flushing port(s) in the position that an automatic flush valve would be positioned.
4. Air/Vacuum Relief Valves: Each independent Techline subsurface irrigation zone shall be installed with an Air/Vacuum Relief Valve at the zone’s highest point(s). Techline CV zones do not require an Air/Vacuum Relief Valve.
5. Pressure Regulator: A pressure regulator shall be installed at each zone valve or on the main line to ensure operating pressures do not exceed system requirements. The pressure regulator shall be a Netafim Pressure Regulator.
6. Disc Filter: A disc filter shall be installed at each zone valve or on the main line to ensure proper filtration. The filter shall be a Netafim Disc Filter.
7. Reduced Pressure or other Backflow Prevention Units: Reduced pressure backflow prevention units or any unit as required by local codes shall be provided as indicated on drawings and shall comply with local codes.

2.5 SOIL MOISTURE SENSOR

A. Soil moisture sensor shall sense soil moisture status by measuring the conductivity of a soil volume between two stainless steel probes. This is to include smart technology for the 30% reduction in water use versus a traditional irrigation system. Moisture sensor device shall interrupt programmed irrigation cycles until the soil moisture matrix potential has reached a predetermined state. Soil moisture sensor shall be "Baseline Watertec S100" Soil Moisture Sensor, manufactured by Baseline LLC, 2700 E Lanark St. Ste. 100, Meridian, ID 83642 USA; Tel. Day Time Voice (208) 323-1634; Fax (208) 323-1834; Toll Free (866) 294-5847, or approved equal.

1. Soil moisture sensor shall be electrically isolated from other electrical potentials, and be wired from the sensor controller to the probes with water tight materials and connections.

2.6 AUTOMATIC REMOTE CONTROL VALVE AND BOX

A. Automatic remote control valves shall be pressure regulating electric remote control valves. Valve size shall not be less than the size of the lateral served.

B. Each remote control valve shall have a valve box.

1. Valve box shall be impact resistant cycolac plastic with locking cover, similar to those manufactured by Ametek, Sheboygan, WI 53081. Cover color shall be green.

C. Remote control valve tags shall be yellow with thermofused numbers.

2.7 GATE VALVE AND BOX

A. Gate valves 2 in. and smaller shall be cast iron body, bronze mounted with non-rising stem and working pressure rating of 200 psi.

B. Gate valves larger than 2 in. shall be mechanical joint or flanged cast iron with non-rising stem and working pressure rating of 200 psi.

C. Gate valves for above grade or pit use shall be supplied with wheel handles.

D. Gate valve for underground use shall be supplied with 2 in. square operating nut.

E. Each gate valve shall have a valve box.

1. Valve box shall be impact resistant cycolac plastic with locking cover, similar to those manufactured by Ametek, Sheboygan, WI 53081. Cover color shall be green.

2.8 DRAIN VALVE AND BOX

A. Drain valves shall be all bronze construction manual angle valves installed at low points in system.

B. Each drain valve shall have a valve box.

1. Valve box shall be impact resistant cycolac plastic with locking cover, similar to those manufactured by Ametek, Sheboygan, WI 53081. Cover color shall be green.

2.9 CONTROL AND GROUND WIRE

A. Control and ground wiring shall be minimum Type "UF", #12 wire, 600 volt, solid copper, single conductor wire with PVC insulation and shall bear UL approval for direct underground burial feeder cable.

B. A minimum of one extra wire for each direction of run to last valve shall be supplied. Extra wire shall be a fugitive color, loop at each valve.

C. Wire types, connectors, splices, and installation procedures shall conform to applicable local codes.

D. Multi conductor cable will not be acceptable.

E. Wire splices shall be made with "scotch lock connectors" or "snip snap caps" (per title connectors) or other approved method.

2.10 QUICK COUPLING VALVES

A. Quick coupling valves shall be 1 in. heavy duty brass construction one-piece body design, with locking rubber cover. Furnish to the Owner the following additional items: three hollow coupler keys and three swivel hose ell adapters.

1. For use on systems using non-potable water, locking rubber cover shall have molded-in warnings of "DO NOT DRINK" in English and Spanish

B. Each quick coupling valve shall have a valve box.

1. Valve box shall be impact resistant cycolac plastic with locking cover, similar to those manufactured by Ametek, Sheboygan, WI 53081. Cover color shall be green.

2.11 HOSE BIB FAUCET

A. Bib Faucet shall be flush type, anti-freezing Lock-Lid Hose Box, Model V475LL with locking lid and vacuum breaker, manufactured by Murdock, Inc., Cincinnati, OH 45204, or approved equal.

2.12 BACKFLOW PREVENTER

A. Backflow preventer shall be required at all cross-connections between irrigation system and potable water.

B. Backflow preventer, based upon prevailing local codes, shall be of the following type:

1. Double check valve backflow preventer

2.13 AUTOMATIC CONTROLLER

A. All system controllers shall meet the EPA's Water Sense Requirements as described: (https://www.epa.gov/watersense/irrigation-controllers). Controller to be of a high performance hybrid type that combines electro- mechanical and micro-electronic circuitry, weatherproof and locking type, capable of fully automatic, semi-automatic, and manual operation of irrigation system design, including integration of rain sensor and software to allow remote operation of system. Controller shall be Rain Bird Series, or approved equal.

B. Controller shall be UL listed and tested.

C. ~~Location of controller unit and type of mounting will be selected by the Architect.~~ ***Controller unit will be located in the boiler room adjacent to BFP. Refer to plumbing drawings. Type of mounting will be selected by the architect.*** (Add. #3)

D. Controller shall be equipped with a valve output lightning/electrical surge protection kit.

E. Exterior Controller Enclosure: NEMA 250, Type 4, weatherproof, with locking cover and 2 matching keys; include provision for grounding.

1. Material: Stainless-steel.
2. Mounting: Surface type for wall mounting.

2.14 THRUST BLOCKS

A. Concrete for thrust blocks shall be 2500 psi, minimum, air-entrained concrete.

PART 3 EXECUTION

3.1 GENERAL

A. Coordinate all installation/repair work with landscape planting work, especially fine grading, and soil preparation for planting areas per Section 32 91 19, LANDSCAPE GRADING, Section 32 92 00, LAWNS AND GRASSES, and Section 32 93 00, TREES, PLANTS AND GROUND COVERS.

B. Excavation required for the installation of the irrigation system shall conform to ASTM F 690.

3.2 PIPE, CONTROL VALVE, AND CONTROL WIRE INSTALLATION

A. Plastic pipe shall be delivered to the site in manufacturer's packaging, stacked in such a manner as to provide adequate protection from compression and deformation of the pipe ends. Pipe shall be protected from exposure to direct sunlight.

B. Pipe interior shall be thoroughly cleaned of all dirt or foreign matter before lowering pipe into trenches. Pipe interiors shall be kept clean during pipe installation by plugs or other approved methods. Piping shall not be installed in water or mud. Ends of pipe shall be securely closed when work is not in progress to prevent water and foreign matter from entering the lines.

C. PVC pipe shall be cut with a hand saw or hack saw with the assistance of a square in sawing vise, or other manner to ensure a square cut. Burrs at cut ends shall be removed prior to installation so that a smooth unobstructed flow will be obtained.

D. Installation of plastic pipe shall conform strictly to manufacturer's recommendations and to ASTM F 690.

1. Metallic fittings shall not be supported by PVC pipe. Metallic fittings shall be supported by a concrete block or cradle.
2. When damaged, plastic pipe shall be replaced by cutting out entire damaged area and replacing with same Schedule, Class, and type of pipe, or heavier, at no additional cost. Plastic pipe shall be thoroughly dry when this replacement is made.

E. Snake pipe in trench from side to side to allow for expansion and contraction.

F. Threaded Joints for Plastic Pipes:

1. Use Teflon tape on the threaded PVC fittings except where Marlex fittings are used.
2. Use strap-type friction wrench only: Do not use metal-jawed wrench.
3. When connection is plastic to metal, male adapters shall be used. Male adapter shall be hand tightened, plus one turn with a strap wrench. Joint compound shall be Teflon tape or equal upon approval.

G. Threaded Joints for Galvanized Steel Pipes:

1. Factory-made nipples shall be used wherever possible. Field-cut threads in pipes will be permitted only where absolutely necessary and approved by Architect; when field threading, cut threads accurately on axis with sharp dies.
2. Use pipe joint compound or Teflon tape to male threads only.

H. Joints for Polyethylene Pipes:

1. Double-clamp all connections 1-1/4 in. diameter and greater.
2. Make all connections between polyethylene pipes and metal valves or pipes with threaded fittings using male adapters.

I. Connections between plastic pipe and metal valves or steel pipe shall be made with threaded fittings using plastic toe nipples or shall be made with adapters and a nonhardening pipe compound applied to male threads.

J. Solvent weld joints shall be made according to manufacturer's instructions. Joints shall be tight and inseparable. Joints shall be allowed to cure 24 hours at temperatures over 40^{O}F. before testing.

1. Solvent shall be compatible with plastic material of heads, pipe, and fittings.

K. Remote control valve shall be installed in a valve box with a locking lid.

1. Clearance between the highest part of the valve and the bottom of the valve box lid shall be 2 in., minimum, and 4 in., maximum. The lid shall not rest on any part of the valve.
2. Clearance between the top of the piping and the bottom of the valve box or the valve box knock-outs shall be 2 in., minimum. Valve box shall not rest on piping.
3. Clearance between the valve body and the sides of the valve box shall be 3 in., minimum.

L. Control wire splices shall be made at electric valve locations. Make no splices between the controller and the remote control valve. Lay to the side of pipeline. Provide looped slack at valves and snake wires in trench to allow for contraction. Tie wires in bundles at 10 ft.

intervals. Control wires crossing under pavements shall be installed in conduit.

1. Install a minimum of one extra control wire to the control valve located the greatest distance from the controller in each direction and label each end.
2. Install tag to valve wire before making final connection.
3. Separate color coding of control wires by satellite if required.

3.3 INSTALLATION OF SPRINKLER HEADS

A. After irrigation piping and risers are in place and connected, and prior to installation of sprinkler heads, the control valves shall be opened and a full head of water used to flush out the system. Sprinkler heads shall be installed only after flushing of the system has been completed.

B. Sprinklers shall be set plumb and perpendicular to finish grade.

C. Sprinklers and valve box covers adjacent to walls, curbs, and other paved areas, shall be set to finish grade unless otherwise noted on Drawings.

3.4 INSTALLATION OF DRIP SYSTEM

A. Dripperline Installation:

1. Install all dripperline as indicated on drawings. Use only Teflon tape on all threaded connections.
2. Clamp Techline/Techlite fittings with Oetiker clamps when operating pressure exceeds specific dripperline fitting requirements.
3. When installing Techline CV, Techline, or 8mm Techlite dripperlines on-surface, install soil staples as listed below:
   a. One staple every three (3') feet and two (2) staples on each change of direction (tee, elbow, or cross).
4. Cap or plug all openings as soon as lines have been installed to prevent the intrusion of materials that would obstruct the pipe. Leave in place until removal is necessary for completion of installation.
5. Thoroughly flush all water lines before installing valves.

3.5 GATE VALVES

A. Install isolation and branch gate valves directly on main as required.

B. Where gate valves isolate branch mains of a smaller size, size valve to largest main and add reducing fittings downstream of valves.

C. Install valve and valve box to finish grade as indicated on the Drawings.

3.6 HOSE BIB FAUCET

A. Bib faucets shall be installed at locations indicated on the Drawings, in accordance with manufacturer's printed instructions.

3.7 TESTING AND COMPLETION

A. Flushing:

1. After all piping, valves, sprinkler bodies, pipe lines and risers are in place and connected, but prior to installation of sprinkler internals, open the control valves and flush out the system under a full head of water.
2. Sprinkler internals, flush caps and riser nozzles shall be installed only after flushing of the system has been accomplished to the full satisfaction of the Owner's Representative.
3. Contractor shall be responsible for flushing the entire system after installation is complete and will be responsible for any clogged nozzles for thirty (30) days after substantial completion of this portion of the landscape irrigation system.

B. Irrigation system shall be tested for leakage prior to backfilling of piping. Leakage test shall be at 100 psi pressure at furthest point of system being tested for a minimum period of one hour. System is acceptable if no leakage or loss of pressure occurs.

C. When the irrigation system is completed, perform a coverage test in the presence of the Architect to determine if the coverage of water for all areas is completely adequate. All valves, and the alignment and coverage of all sprinkler heads shall be adjusted, prior to final inspection, for required coverage. Correct inadequacies of coverage as directed by Architect.

D. All testing shall be at the expense of the Contractor.

E. Instruct Owner's designated personnel in proper operation of irrigation system, including programming controller; valves; adjustment of sprinkler heads.

3.8 BACKFILL AND COMPACTING

A. After system is operating and required tests and inspections have been made, backfill excavations and trenches with clean soil, free of debris.

B. Backfill for all trenches, regardless of the type of pipe covered, shall be compacted to minimum 95% density under pavements, 85% under planted areas.

C. Dress off all areas to finish grades.

3.9 PRESSURE SETTING

A. Prior to final inspection Contractor shall adjust each remote control valve to an agreed operating pressure by installing temporary pressure gauge on schrader valve and making necessary adjustments while valve is operating.

3.10 SEASONAL SHUTDOWN

A. At the end of the first irrigation season, the system shall be fully drained by use of compressed air (25 CFM or larger; do not exceed 50 psi) and shutdown for the season.

B. Electro-Mechanical Controllers: A.C. power shall remain on at the controller and place the manual/automatic switch into the manual position.

C. Solid State Control Systems: Winterize in accordance with manufacturer's printed instructions for geographic area.

D. Instruct Owner's designated personnel in proper seasonal shutdown procedures.

3.11 SEASONAL START UP

A. Prior to the start of the second irrigation season, the system shall be restarted, checked, and repaired. This start up procedure shall include but not be limited to:

1. Testing of all system components, (valves, heads, controllers, quick coupling valves, piping, etc.) for proper working order.
2. Adjustments, repair, or replacement of all system components that are not in proper working order.
3. Instruction of Owner's designated personnel in proper seasonal start up procedures.

END OF SECTION

Section 32 80 13
SPORTS FIELD IRRIGATION SYSTEM

PART 1 GENERAL

1.1 GENERAL PROVISIONS

A. The General provisions of the Contract, including General and Supplementary General Conditions, and Division 1 General Requirements and Division 01 General Requirements, apply to work specified in this section.

B. Carefully examine all of the Contract Documents for requirements which affect the work of this Section. The exact scope of work of this section cannot be determined without a thorough review of all Specification Sections and other Contract Documents.

C. Refer to Drawings for further definition of location, extent, and details of work described in this Section.

D. Cooperate and coordinate with other trades in executing work as described in this Section.

E. Where referred to, Standard Specifications, Recommendations of Technical Societies, and/or Manufacturer's Associations, plus Codes of Federal, State, and Local Agencies shall include all amendments current as of date of issue of these Specifications.

F. In all cases when conflicts exists between information contained in this Section and in other parts of the Contract Documents, the Contractor shall assume (for budgeting purposes) that the most expensive solution is required, until notified otherwise.

G. In all cases, when a question exists to the level of quality required for a product and/or installation, the highest quality is required.

1.2 SCOPE

A. This is a Design Build Irrigation Project intended to cover irrigation for the Lower Field Baseball and Sport Field area. The ball field shall be controlled by means of a single multi-zone 48 zone controller located in a control box (location to be determined by the Owner). The Contractor shall supply and provide detailed design and all products, materials, labor, equipment, and coordination necessary for, complete installation of the irrigation system as depicted in the Contract Drawings, manufacturer recommendations and guidelines, and or as specified herein.

B. The Contractor shall install the control cabinet, mounting posts and foundation as part of the Work. He shall also install install the controller in the cabinet, which will be connected to the panle by the Electirical Subcontractor.

1. The electrical component of the control cabinate shall be installed and connected by the Electirical Subcontractor. These electrical component shall include the panel and a duplex gfi receptacle. The well pump controller shall be provided by the well subcontractor and installed and connected by the Electirical Subcontractor.

C. The methods, materials, and systems specified herein are required for installation, placement, and supplying of new systems, products and materials. All systems, materials and products specified are intended to be "new" systems, materials and products and not used or salvaged

items, unless otherwise indicated herein. Irigation compeneonts shall be obtained from a single manufacturer.

D. The work of this Section consists of designing, providing, installing an underground irrigation system, start-up, Owner operation review, first winterization shutdown, first spring start-up as shown and specified. The work includes:

1. Automatic irrigation system including piping, fittings, quick couples at each mound and backstop, backflow protection as required by State Regulations, blow off valves and system draining methods, and accessories for the new soccer sports field.
2. Connect into the provided site service water main to accommodate required capacity of irrigation mains, zone valves and valves.
3. Testing.
4. Excavating and backfilling irrigation work.
5. Start-up, shut-down and Owner's orientation program.

E. The work covered in this section may be affected by requirements of the future well development Work

F. The Contractor is responsible for the purchase and installation of all fixed items, and providing all non-fixed items.

1.3 DEFINITIONS

A. Most terms used within the documents are industry standard. Certain words or phrases shall be understood to have specific meanings as follows:
1. Provide: Furnish and install, completely connected up, tested and in operable condition.
2. Furnish: Purchase and deliver to a specific location within the building or site.
3. Install: With respect to equipment furnished by others, install means to receive, unpack, move into position, mount and connect, and test, including removal of packaging materials.

1.4 RELATED WORK SPECIFIED IN OTHER SECTIONS:

A. The following related work is to be performed under designated sections.
1. 329020 – Natural Field Sports Surfacing
2. 329040 – Athletic Field Seeding
3. 321210 – Concrete Pavement

1.5 CODES AND STANDARDS

A. The following standards apply to this section:
1. “Massachusetts Highway Department Standard Specifications for Highways and Bridges.”
2. “Standard Specifications for Highway Materials and Methods of Sampling and Testing, American Association of State Highway and Transportation Officials (AASHTO).”
3. National Collegiate Athletic Association (NCAA)
4. American Society of Testing and Material (ASTM)
5. National Federation of State High Schools (NFSH)
6. All local and State codes.
7. National Fire Protection Association, (NFPA): National Electrical code.
8. American Society for Testing and Materials, (ASTM).
9. National Sanitation Foundation, (NSF).
10. The Irrigation Association, (IA).

1.6 SUBMITTALS

A. Provide all necessary data and information to determine compliance with requirements at this section. In cases where product or system substitutions are proposed submit a comparison of specified products to the substitute.

B. Product Data: drawings including standard printed specifications and diagrams.

C. Shop drawings including drawings depicting installation directions and dimensions for all sports equipment.

1. Provide signed statement by contractor indicating that they have read and fully understand the instructions and requirements. Statement shall indicate that the Contractor fully understands the requirements outlined herein and is especially aware of the quality control and acceptance requirements.

D. Submit the following specific information and materials:

1. Complete design of the irrigation system including layout, head type, nozzle, spray adjustment, etc.
2. Complete analysis of coverage including timing changes at each zone to assure uniform application.
3. Operation manual

E. General: Submit the following in accordance with the Conditions of Contract and Division 1 Specification Sections.

F. Submit manufacturer's product data and installation instructions for each of the system components including but not limited to sprinklers, electric valves, manual valves, quick coupling valves, valve boxes, controllers, pipe, fittings, wire, wire connectors, etc.

G. Upon irrigation system acceptance, submit five (5) copies of written operating and maintenance instructions, including winterization procedure. Provide format and contents as directed by the Engineer.

H. Record Drawings:

1. The Contractor shall provide and keep up to date a complete set of "AS Built" record set of prints which shall be corrected as the work progresses, and show every change from the original drawings and specifications and the actual "As Built" dimensions and kinds of equipment. This set of drawings shall be kept on site and shall be used only as a record set.
2. These drawings shall also serve as progress sheets, and the Contractor shall make neat and legible annotations thereon as the work proceeds, showing the work as actually installed. These drawings shall be available at all times for inspection and shall be kept in the Contractor's mobile office on location at all times for inspection.
3. Record drawings shall show the location of all sprinklers, valve boxes, valve markers, controllers, pipe, wire trenches, multiple wire splice boxes, sensors and all pertinent material buried and not visible to the eye. Record drawings shall indicate dimensions from two permanent points of easily identifiable nature, if possible, such as sprinkler heads, permanent markers, concrete pads, corner of buildings, large caliper trees, etc.

I. Material safety data sheets on all products, as necessary.

J. Statement of the presents of toxic and or hazardous materials. Any toxic and or hazardous material exceeding 100 ppm shall be included in this list.

1.7 QUALITY ASSURANCE

A. The Contractor shall only accept bids from those Vendors that have been pre-approved, identified as approved equal, or that indicate their products meet the specifications.

B. All work shall be performed by one (1) Contractor, with proven experience in this scope of work. Contractor shall have previously installed at least three (3) similar size, type and quality vertically-drained natural turf systems in the last five (5) years. Two (2) of the three (3) installations must be college level installations meeting NCAA rules and regulations.

C. Installer's shall be selected by the Owner and have qualifications that include a minimum of five (5) years' experience installing irrigation systems of comparable size. The irrigation system contractor shall have an installation crew consisting of a minimum of three (3) persons who each have a minimum of three years' experience installing irrigation systems.

1. The contractor shall be located within 3 hours driving distance from the project.
2. The contractor shall be able to demonstrate his ability to perform emergency or warranty repair work within a minimum of 24 hours' notice from the city. The contractor shall have a dedicated service department independent from his installation crews.
3. The contractor must provide a list of the last 3 projects done within the last 2 years that are of similar size and complexity. Name, address and phone numbers shall be included.

1.8 GUARANTEE

A. Keep work in good repair and condition without expense to Owner in regards to defects in workmanship or materials for a period of not less than two (2) years from date of Substantial Completion.

B. Products to be warranted for a period of not less than two (2) years from date of Substantial Completion.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Deliver packaged materials in containers showing weight, analysis and name of manufacturer. Protect materials from deterioration during delivery, and while stored at site.

B. Provide statement of irrigation system operation prior to scheduling of seeding or of delivery of sod to site.

C. Deliver irrigation system components in manufacturer's original undamaged and unopened containers with labels intact and legible.

D. Deliver plastic piping in bundles, packaged to provide adequate protection of pipe ends.

E. Store and handle materials to prevent damage and deterioration.

F. Provide secure, locked storage for valves, and similar components that cannot be immediately replaced, to prevent installation delays.

1.10 PROJECT CONDITIONS

A. Known underground and surface utility lines are indicated on other drawings. Utility Contractor shall contact local utilities before excavation. It is the contractor's responsibility to locate all above and below ground utilities before excavation.

B. Protect existing trees, plants, lawns, and other features designated to remain as part of the final landscape work.

C. Promptly repair damage to adjacent facilities caused by irrigation system work operations. The cost of repairs shall be at the Contractor's expense.

D. Irrigation system layout is diagrammatic. Exact locations of piping, sprinkler heads, valves, and other components shall be established by the Contractor in the field at the time of installation.

1. Space sprinkler components as indicated on the drawings.
2. Minor adjustments in system layout may be necessary to clear existing and proposed fixed obstructions. Final system layout shall be acceptable to the Engineer.
3. Nozzles are to be installed to give best head to head coverage possible within the range of the selected head.

E. Cutting And Patching:

1. Cut through concrete and masonry for conduits with core drills. Jack hammers are not permitted.
2. Materials and finishes for patching shall match existing cut surface materials and finish. Exercise special care to provide patching at openings in exterior walls water tight.
3. Methods and materials used for cutting and patching shall be acceptable to the Engineer.

1.11 COORDINATION

A. Coordinate work of this Section with that of other trades, under this and other Contracts with the Owner, affecting or affected by this work, and cooperate with the other trades as is necessary to assure the steady progress of work.

B. Before proceeding with installation work, inspect all project conditions and all work of other trades to assure that all such conditions and work are suitable to satisfactorily receive the work of this Section and notify the Engineer in writing of any which are not. Do not proceed further until corrective work has been completed or waived.

C. Do not interrupt existing services without Owner's approval. Schedule interruptions in advance, according to Owner's instructions. Interruptions shall be scheduled at such times of day and work so that they have minimal impact on Owner's operations.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Manufacturers: Acceptable manufactuers include Toro, Hunter Industries, and Rain Bird.

B. Manufacturers products shall conform to the specifications and shall be deemed acceptable by the Engineer.

C. The full irrigation system shall be from a single manufacturer.

2.2 MATERIALS

A. General

1. Provide only new materials, without flaws or defects and of the highest quality of their specified class and kind.
2. Comply with pipe sizes indicated. No substitution of smaller pipes will be permitted. Larger sizes may be used subject to acceptance of the Engineer.
3. Provide pipe continuously and permanently marked with manufacturer's name or trademark, size schedule and type of pipe, working pressure at 73 degrees F. and National Sanitation Foundation (NSF) approval.

B. Pipe, Fittings, And Connections

1. Polyvinyl chloride pipe: ASTM D2241, Type 1, Grade 1 rigid, unplasticized PVC, extruded from virgin parent material, conforming to CS256-63. Provide pipe homogeneous throughout and free from visible cracks, holes, foreign materials, blisters, wrinkles, and dents.
   a. All piping for sleeves under roadways, sidewalks, etc., shall be PVC, Schedule 80, unless otherwise stated on the plans.
   b. All main line piping shall be polyvinyl chloride pipe and shall be SDR 21, Class 200, integrated bell and spigot type rubber gasketed joint.
   c. All lateral pipe shall be polyvinyl chloride pipe and shall be SDR 21, Class 200, solvent weld bell end.
2. Fittings:
   a. Fittings for Ductile Iron main line piping shall be ductile iron gasketed fittings. The ductile iron fittings shall have deep bell pushon joints with gaskets meeting ASTM F-477. These fittings shall be for change of direction and or tapped service tees. These fittings shall be manufactured by Harco Manufacturing or approved equal.
   b. Fittings for PVC lateral piping shall be schedule 40 PVC fittings, suitable for solvent weld and threaded connections.

C. Sprinklers, Valves, And Associated Equipment:

1. Sprinklers
   a. Sports Turf Sprinklers
      The full or part-circle sprinklers shall be a gear driven stainless steel riser Hunter I25 rotary type. The sprinkler shall be of a pop-up design with an overall height of 9”, a body diameter of 3-1/2", a cap diameter of 2-1/2" and a pop-up stroke of 2-3/8". The sprinkler shall be mounted up to 1/2" below the final finished grade and shall have a 1" NPT female threaded inlet. The sprinkler shall be capable of covering depicted radius at 50 pounds per square inch pressure with a discharge rate of 35.0 gallons per minute per zone Water distribution shall be via two (2) nozzles mounted in a 1-1/2" diameter stainless steel nozzle turret. The dual nozzles shall elevate 2-3/8" when in operation. Radius reduction shall be adjustable up to 25%, by means of a stainless steel radius adjustment screw accessible from the top of the nozzle when the sprinkler is properly installed.

The body and cap of the sprinkler shall be injection molded from ABS, a non-corrosive, impact-resistant, UV-resistant, heavy-duty plastic material. The sprinkler shall have a plastic filter screen sized to prevent entry of foreign material into the nozzle. All components shall be removable from the top of the sprinkler case.

Retraction shall be achieved by a heavy-duty stainless steel retraction spring. The sprinkler shall have a riser seal and a wiper. Rotation shall be accomplished by a sealed, oil-packed gear-drive assembly isolated from the water supply. The drive assembly gear mechanism shall be constructed of brass and stainless steel gears.

The sprinkler shall have a standard rubber cover available in black or lavender for effluent water use applications.

Various arc patterns shall be achieved with any one of twelve fixed arc gear drive assemblies.

The sprinkler shall be developed and manufactured by an ISO 9001-certified facility.

2. Manual Gate Valves:
   a. Manual gate valve shall be installed where indicated on the plans. **Non-Rising Stem:** Valves shall be Class 125 and 200 psi CWP, non-rising stem, screw-in bonnet, solid wedge and USA manufactured in accordance with MSS-SP 80. Body, bonnet, external stuffing box and wedge are to be of bronze ASTM B-62. Stems shall be of dezincification-resistant silicon bronze ASTM B-371 or low-zinc alloy B-99, non-asbestos packing and malleable or ductile iron handwheel. For buried service - Bronze Cross or Bronze handwheel required. Valve ends shall be threaded-type. The bronze valve shall be model # T-113, manufactured by Nibco or approved equal.
   b. Cast Iron Gate Valve
      Resilient Wedge design: Valves shall be 200 psi CWP and USA manufactured, valves to basically meet AWWA C-509. Body and bonnet are to be of cast iron alloy ASTM A-126 Class B. Valve to be epoxy coated inside and outside. Two upper o-ring stem seals. Sealed counter sunk body bonnet bolts providing no exposure of bonnet bolts. Stems to be stainless steel. Resilient rubber encapsulated wedge. Cast iron 2” square operating nut. Valve ends shall be IPS PVC push-on joint.
3. Electric Valve
   a. The **PGV-201** – 2" plastic angle/globe valve with flow control remote control valve and have a maximum pressure rating of 220 PSI. The diaphragm shall be made of double-beaded, fabric-reinforced rubber to retain flexibility and provide maximum sealing throughout its area. The diaphragm assembly shall be fully serviceable, held together with stainless-steel components. All parts shall be serviceable from the top of the valve without removing the valve from the line. The valve may be installed at any angle without affecting valve operation. All other internal parts shall be made of brass and stainless steel to ensure corrosion resistance.

      The valve shall have an internal manual downstream bleed to prevent flooding of the valve box and be capable of operation by hand with a screwdriver or a socket wrench. The manual bleed also shall be capable of external bleed for system flushing. The valve shall have a removable, self-flushing, 120-mesh, stainless-steel filter screen. The screen will be positioned on the supply side of the stream. The valve shall have a manual flow control with a hand-operated, rising-type flow-control stem with a control wheel/handle. The flow control shall be adjustable down to zero flow.

      For 1" models, friction loss at 40 GPM shall not exceed 7.0 PSI on electric valves. For 1-1/4" models, friction loss at 100 GPM shall not exceed 16.0 PSI on electric valves. For 1-

1/2" models, friction loss at 120 GPM shall not exceed 15.0 PSI on electric valves. For 2" models, friction loss at 180 GPM shall not exceed 14.0 PSI on electric valves. For 2-1/2" models, friction loss at 250 GPM shall not exceed 7.0 PSI on electric valves. For 3" models, friction loss at 350 GPM shall not exceed 7.5 PSI on electric valves. The burst pressure safety rating shall be 750 PSI. The valve must open or close in less than one minute at 220 PSI, and less than 30 seconds at 20 PSI.

The valve shall have a plastic solenoid, which is fully encapsulated and have a captured hex plunger and spring. The solenoid will have a removable retainer for servicing of the spring and plunger. The plunger shall be on a stainless-steel solenoid seat for longer life. The 24V a.c. solenoid shall open with a 22.5V a.c. minimum at 220 PSI. At 24V a.c. average inrush, current shall not exceed 0.40 amps. Average holding current shall not exceed 0.20 amps.

Line Pressure - Voltage
220 PSI - 22.5
200 PSI - 21.1
175 PSI - 20.2
150 PSI - 19.1
125 PSI - 18.2
100 PSI - 17.1
75 PSI - 16.1
50 PSI - 16.0

The valve shall have a built-in, Schrader-type valve for attaching a pressure gauge to verify downstream pressure. The valve shall be able to field retrofit with an optional pressure-regulating module, EZReg(TM), which can be factory or field installed. The regulator shall be able to be field-installed or serviced under pressure. The valve shall have a forward-flow design to ensure more precise regulation when used with a pressure regulator.

Pressure Regulating Electric Models:

The pressure regulator, EZReg(TM), shall be of dial design to permit visual setting of pressure with or without the valve being operated or the use of a pressure gauge. The regulator shall be of a screw-in type and shall regulate precisely over a 5-100 PSI range with maximum inlet pressure of 220 PSI. The regulator shall maintain the set pressure within ± 3 PSI (with a 10 PSI differential between inlet and outlet).

The [1" / 1-1/4" / 1-1/2" / 2" / 2-1/2" / 3"] 220 Series valve shall be of [electric, electric pressure regulating] configuration with female-threaded inlet and outlet connections. The 1"-2" valves shall be an in-line configuration and the 2-1/2" / 3" valves shall be an angle configuration.

The valve shall be developed, manufactured, qualified and released in the USA. The valve shall come with a 5-year trade warranty.

The valve shall be manufactured, qualified and released in the USA. The valve, model number 220-26-08, shall be manufactured by The Toro Company, Irrigation Division, El Paso, Texas, USA or approved equal.

Pressure Reducing Valve shall be capable of reducing existing pump pressure and discharge rate to above note per zone flow rate and pressure. Pressure reducing valve

shall be mounted in a code compliant enclosure and be design to provide for easy removal during winterization. Include unions at both ends of valve.

4. Valve Access Boxes:
   a. Valve access boxes shall be tapered enclosures of rigid plastic material comprised of fibrous components, chemically inert and unaffected by moisture corrosion and temperature changes. Provide lid of same material, green in color.
   b. Valve access boxes for electric valve assemblies shall be 10” x 15” cover and 12” deep. The valve box shall be model # 1419-12, manufactured by Carson Industries or approved equal.
   c. Valve access boxes for the cast iron gate valves shall be manufactured specifically for cast iron gate valves which are in three pieces, base section, adjustable riser section and a cast iron lid. The valve box shall be model # 461, manufactured by Carson Industries or approved equal.
   d. All valve boxes shall be supplied by the same manufacturer.

D. Controls:

1. Provide a 48**-station** controller, in the existing metal cabinet and be capable of automatic, semi-automatic and manual operations. All programming shall be accomplished by use of a simple programming dial and selection buttons with a large LCD for ease of programming. It shall be housed in a metal weather-proof, locking enclosure suitable for indoor or outdoor use. It shall have a manufacturers limited warranty of 5 years.

   Salvage the existing controller if new controller is required.

   The controller shall have [12/15/18/24] stations for metal models with four independent programs that can run simultaneously and with each station's watering time independently variable from one minute to 10 hours in one-minute increments. The controller shall have 16 total start times assignable to any program(s). The controller shall stack (put on hold) start times to prevent overlap within a program. If two (or more) start times are programmed, causing watering times to overlap, the controller will stack the additional start time and run it when the first cycle finishes.

   The controller shall have a seven-day calendar, odd/even day or interval options of one to 30 days. The controller shall have a 365-day calendar for true unattended odd/even day programming with excluded day option when used with the odd/even day option and shall have automatic leap year compensation. Time-of-day, day-of-week, programming and operational status information shall be shown in a large LCD display. The Master Valve shall be programmable by program.

   The controller shall have a Season Adjust feature that allows the independent adjustment of each irrigation program from 10% to 200% in 10% increments without permanently altering the program. The controller shall have a programmable Off/Rain Delay setting to allow all programs to be disabled permanently or for a specified period of one to seven days. At the end of the specified rain delay period, the controller will automatically resume normal operation. The controller shall have a Rain Off position on the dial, which will immediately turn off station watering and prevent future automatic watering to occur while the dial is set in this mode. The controller shall have a program erase feature which erases all programmed station run times, start times, water days, resets season adjust to 100% and resets the Master Valve to On for a selected program.

   The controller shall have a manual-start feature that allows all or independently selected stations to be run on a program. The controller shall also have true manual single station On/Off

capability. When a program is running (automatic or manually started), the controller will display the currently running program, the currently running station, time remaining on the running station and status of the Master Valve. While operating in the manual mode, the user may adjust the run time of the current station, pause and resume the current station, advance directly to the next station or cancel the cycle. Run-time adjustments made while a program is operating in the manual mode shall not affect normal program memory.

The controller shall have a sensor port compatible with normally open, switch-type sensors. The controller will suspend automatic program operation when the sensor is active. The controller shall have an integrated bypass switch on the front panel to allow the operation of automatic programs while the sensor is active (open).

The controller shall have a self-diagnostic electronic circuit breaker with valve-short detection that identifies and overrides an electrical malfunction and shall continue to operate all other stations in the program in sequence. The controller shall display the problem station until the operator resets the controller. The controller shall have the SurgePro(TM) System, which consists of heavy-duty surge protection consisting of MOVs and inductors.

The controller shall use a standard 9-volt alkaline battery for real-time clock retention in the event of a power failure. The battery will be included with the clock. The controller shall maintain the real-time clock and date for 90 continuous days with a fully charged alkaline battery. The battery saving option places the controller in a shut-down mode while maintaining the real time clock. Program data shall be stored in non-volatile memory that will be retained faithfully for a minimum of 30 years without power. The controller shall have a snap-out program module for off-site programming when battery is installed.

The controller shall have a Valve Test Terminal (Hot Post). The controller shall have a power input of 120V a.c. (±10%) or 220V a.c. + 10% and be capable of operating up to two 24V a.c. solenoids per station at 0.50 amperes (12 VA). In addition, the controller shall be capable of running a 24V a.c. Pump/Master Valve output circuit at 0.5 amperes (12 VA). The controller shall be capable of running up to four 24V a.c. solenoids plus a Master Valve at 1.24 amperes. The controller shall allow the selective use of the Pump/Master Valve circuit by station. Total controller output load shall not exceed 1.25 amperes (30 VA) at 24V a.c.

The controller shall be developed by an ISO 9001-certified facility. The controller, model number CC-M-24, shall be manufactured by The Toro Company, Irrigation Division, Riverside, California, USA or approved equal.

2. Irrigation central controls shall incorporate a rain sensor to cancel the irrigation program if a preset amount of rain has fallen. Rain sensor shall use a water-absorptive material to measure rainfall, and have a U.V. stabilized thermoplastic switch housing and aluminum mounting bracket. Sensor shall be adjustable from 1/8"-1".
3. The controller shall be grounded to 10 OHMS or less to insure proper surge and lightning protection.
4. The controller shall utilize the pump start circuit to operate the booster pump,

E. Electrical Control Wire:

1. Electrical control and common wire from the controller to the electric valves shall be type UF, 600 volt, PE coated direct burial single strand solid copper wire, sized at 14 gauge for zone wire and 12 gauge for the common wire. The color for zone wire shall be red and the color for the common wire shall be white.

2. 2-12 gauge wires shall be installed from the controller to the existing booster pump. These wires shall be used to activate the booster pump every time the irrigation controller turns on an irrigation cycle. The wire specification shall follow section E.1. The wire colors shall be white and red.
3. All wire within the building shall be installed in electrical conduit. Conduit shall be of steel construction.

F. Cross Connection Control:

1. Provide a Watts Services 909M1 2” size Reduced Pressure Zones Assemblies. RPZ shall include cap and tether test cocks, internal plymer coatings, quarter turn ball valves, bronze strainers.
2. Provide a weather proof stain less steel exterior grade enclosure on a 8” thick concrete based to protect. Box shall be 12 inch longer than complete piped system and 18 wider to allow removal for winterization.
3. Provide quick removal unions at each end and 2” copper risers to distribution pipe.

2.3 ACCESSORIES

A. Drainage fill shall be 1/2" to 3/4" crushed stone.

B. Fill shall be clean soil free of stones larger than 2" diameter, foreign matter, organic material and debris.

1. Provide imported fill material as required to complete the work. Obtain rights and pay all costs for imported materials.
2. Suitable excavated materials removed to accommodate the irrigation system work may be used as fill material subject to the Engineer's review and acceptance.

C. Wire connectors for 24 volt control wiring shall be as manufactured by Scotch, Model No. DBY or DBR.

2.4 IRRIGATION AND WELL PUMP CONTROLLER CABINET

A. The irrigation and well pump controller cabinet shal be a NEMA TYPE 4 CABINETS 24” x 36” x 12” and weight between 100 and 120 pounds. Cabinet shall be suitable for housing electrical controls in areas that may be regularly hosed down or are otherwise very wet.

1. Manufactured from 14 ga. galvannealed steel with 12 ga. removable panels on 3/8” collar studs.
2. Door is held secured by a stainless steel continuous hinge along one side and stainless steel screw clamps on the other three sides.
3. External mounting legs are standard.
4. A keyed water tight locking latch.
5. Seams are continuously welded and ground smooth. A rolled edge is supplied around cabinet opening to add extra strength, improve appearance and form a smooth base to receive compression from the neoprene gasket.
6. Print pocket and removable panel in white baked powder coat finish.
7. Finish: Gray baked powder coat finish inside and out. Larger cabinets are supplied with stiffeners for extra strength.
8. Cabinets conform to our interpretation of NEMA TYPR 4 requirements.
9. The cabinet shall be house a 48 station irrigation controller, A 60 amp electric panel, a variable speed pump controller/drive, and a wet work area duplex GFI receptacle.

B. The panel shall be mounted on HHS 3 ½" x 2 ½" x 3/8" steel members using ½"stainless steel through bolts. The irrigation and well pump controller cabinet shal be a NEMA TYPE 4 CABINETS 24" x 36" x 12" and weight between 100 and 120 pounds. Cabinet shall houseshall be suitable for housing electrical controls in areas that may be regularly hosed down or are otherwise very wet.

C. The mounts and panel shall installed on a an 18" x 36" x 48" deep concrete footing. Al wiring and cabling shall be installed in rigid steel conduit above grade and within the concrete footing. A grounding rod shall be provided.

PART 3 - EXECUTION

3.1 INSPECTION

A. Examine final grades and installation conditions. Do not start irrigation system work until unsatisfactory conditions are corrected.

3.2 PREPARATION

A. Layout and stake the location of each pipe run and all sprinkler heads and sprinkler valves. Obtain Engineer's acceptance of layout prior to excavating.

B. All sleeves required for the installation of the irrigation system are to be installed by this contractor. Wires are to be installed in separate sleeves.

3.3 INSTALLATION

A. Excavation And Backfill:

1. Excavation shall include all materials encountered.
2. Excavate trenches of sufficient depth and width to permit proper handling and installation of pipe and fittings.
3. Excavate to depths required to provide 2" depth of earth fill or sand bedding for piping when rock or other unsuitable bearing material is encountered.
4. Fill to match adjacent grade elevations with approved earth fill material. Backfilling will be done by hand placing soil under, around and above pipe so that it is hand tamped to a point 6" above the pipe. Special care shall be taken to insure that this layer is completely free of stones and other deleterious material. The remainder of the trench may be machine filled with appropriate available soil. Machine placed backfill shall be compacted to a suitable density by machine tamping and approved rolling to prevent settlement in trench.
   a. If within two (2) years from the date of final acceptance, settlement due to improper compaction occurs and an adjustment in pipes, valves and sprinkler heads, turf or paving is necessary to bring the system, turf or paving to the proper level of the permanent grades, the Contractor, as part of the work under this contract, shall make said adjustments without extra cost to the Owner.
5. Except as indicated, install irrigation mains outside of the building with a minimum cover of 36" based on finish grades, unless otherwise noted.
6. Excavate trenches and install piping and fill during the same working day. Do not leave open trenches or partially filled trenches open overnight.
7. Where it is necessary to cross existing sidewalks, pipe shall be installed by boring under the walkways. Proper boring equipment shall be used so that undermining of the walkways does not occur.

8. Pipe shall be installed strictly in accordance with the printed recommendations of the manufacturer, including bedding of pipe in the bottom of trench and securely thrusting of any main line fittings at changes in direction of the pipe.
9. All main line piping shall be located outside the primary playing areas. All valve boxes shall be located no closer than 10 feet outside of the playing surfaces.
10. Where pipe is to be installed through walls, core drill wall of sufficient diameter to install pipe and conduit. Once pipe and conduit is installed, seal opening around pipe with non-shrinking grout. Openings shall be watertight.
11. Existing plant material and turf shall be protected during installation. If excavation is necessary in turf areas, remove and replace sod. Any existing planting material and turf damaged during the installation shall be repaired and or replaced at Contractor's expense.

B. Plastic Pipe:

1. Pipe lines shall be installed of the size shown on the drawings and/or specifications and of the materials and workmanship herein specified.
2. All main line piping outside of buildings to be installed in trenches as per the provisions of Section 3.3.A. Lateral piping may either be installed in trenches as above or by pipe pulling.
3. Pipe shall be installed strictly in accordance with the printed recommendations of the manufacturer, including bedding of pipe in the bottom of trench.

C. Sleeves:

1. All sleeves for installation of the irrigation system are to be installed by this contractor. All wire shall be installed in separate sleeves.

D. Testing:

1. The Contractor shall be responsible for all hydraulic pressure testing of main lines and lateral lines. The testing shall be on a continuous basis commencing when the first section of the installation is complete and available for testing and prior to the installation of the pipe insulation. Final testing of the whole system under full operating conditions to be done following complete installation of all main and lateral piping, valves and sprinklers.
2. Prior to testing of the main line pipe, pipe shall be backfilled. Testing for all main line pipe and interior lateral pipe shall consist of a continuous application of water at a pressure of 100 PSI to the piping for a one hour period without visual evidence of leaks. If a leak is discovered within this period, the Contractor shall immediately repair the break and the system then retested for the period described above in this section. Testing of lateral lines located outside of building shall be done on a zone by zone operating basis with any leaks or breaks repaired when evidenced.

E. Service:

1. The Contractor shall return to the site during the Fall seasons of the warranty period and winterize the system. Drain all water from the system and blow out the system with compressed air.
2. The Contractor shall return to the site during the Spring seasons of the warranty period, start-up the system and demonstrate to the Owner the proper procedures for the system start-up, operation, and maintenance.

3.4 SPARE PARTS

A. Above and beyond the installation requirement, the Contractor shall leave with the Owner, the following loose equipment:

1 None.

3.5 DISPOSAL OF WASTE MATERIAL

A. Transport unsuitable excavated material, including rock, to designated disposal areas. Stockpile or spread as directed. Remove from site and legally dispose of trash and debris.

3.6 ACCEPTANCE

A. Test and demonstrate to the Engineer and Owner, the satisfactory operation of the system free of leaks.

B. Instruct the Owner's designated personnel in the operation of the system, including adjustment of sprinklers, controllers and valves.

C. Upon acceptance, the Owner will assume operation of the system.

3.7 CLEANING

A. Perform cleaning during installation of the work and upon completion of the work. Remove from site all excess materials, soil, debris, and equipment. Repair damage resulting from irrigation system installation.

END OF SECTION 32 80 13

Section 32 90 15
LOWER FIELD PLANTING SOILS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. The General Documents, as listed on the Table of Contents, and applicable parts of Division 1, GENERAL REQUIREMENTS, shall be included in and made a part of this Section.

B. Examine all Contract Documents and all other Sections of the Specifications for requirements therein affecting the work of this trade.

1.2 SUMMARY

A. The work of this Section consists of providing all equipment and materials and do all work necessary in supply and place planting soils as indicated on the Contract Documents and as specified. Supplying and placement of planting soils shall include, but not be limited to:

1. Sampling and testing of modified loam borrow.
2. Sampling and testing of existing on-site topsoil.
3. Supplying, placing, spreading and grading of modified loam borrow.
4. Modifying, screening, placing, spreading and grading of existing, on-site topsoil.
5. Providing all other sampling, testing, supplying, placing, spreading and grading of planting soils as required by this Sect ion.

1.3 RELATED WORK UNDER OTHER SECTIONS

A. The following items of related work are specified and included in other Sections of the Specifications:

1. Section 32 10 00; SITE PREPARATION
2. Section 31 20 00; EARTHWORK
3. Section 31 00 00; EROSION AND SEDIMENT CONTROL
4. Section 32 90 20; NATURAL FIELD SPORT SURFACING

1.04 REFERENCES

A. The latest edition of the following standards, as referenced herein, shall be applicable.
1. Massachusetts Highway Department Standard Specifications most recent edition)
2. “Standard Specifications for Highway Materials and Methods of Sampling and Testing, American Association of State Highway and Transportation Officials (AASHTO).”
3. City of Worcester Engineering and Department of Public Works Standards and Specifications.
4. Massachusetts Storm Water Design and Installation Manual
5. Regulation for Massachusetts Pollutant Discharge Elimination System
6. ASTM D 75 Practice for Sampling Aggregates
7. ASTM D 422 Test Method for Particle-Size Analysis of Soils
8. ASTM D698-00 Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lb/ft^3)
9. ASTM Dl 557 Moisture-Density Relations of Soils and Soil-Aggregate Mixtures using 10-lb

Rammer and 18-in. Drop

10. A.O.A.C.: Association of Official Agricultural Chemists.

1.05 SCOPE

A. Provide all planting soils and required planting related work for non-athletic surface areas including all excavation filling, placement, etc.

1.06 SUBMITTALS

A. At least 30 days prior to ordering materials, the Contractor shall submit to the Owner's Representative samples, certifications, manufacturer's product data and. certified test results for materials as specified below. No materials shall be ordered or delivered until the required submittals have been reviewed and approved by the Owner's Representative. Delivered materials shall closely match the approved samples. Approval shall not constitute final acceptance. The Owners Representative reserves the right to reject, on or after delivery, any material that does not meet these Specifications.

1. Existing On-Site Topsoil: Sample and test existing on-site topsoil. The Contractor shall sample the existing loam soils of the construction site in the following manner:
   a. Sampling of existing topsoil in situ prior to stockpiling: Using a spade, the Contractor shall take thin vertical slices from the top 10 inches. to 12 inches (25 - 30cm) of the soil.
   b. Sampling Locations: Unless otherwise indicated, samples shall be taken at the following locations and frequency:
   c. Ten (10) locations per one acre (0.4 hectares) of the site as directed by the Owner's Representative.
2. Preparation of Samples: Contractor shall place these soil slices into a large, clean plastic container and mix thoroughly. Contractor shall take one cup of soil mixture and dry it at room temperature (do not dry samples in an oven or on a stove or radiator. Once soil is dry, place soil in sandwich size zip-type plastic bag and close it tightly. Label each sample on outside of bag, identifying sample by soil type and acre. Provide an approved site plan showing locations of stockpiles cross referenced to soil samples and test results.
   a. Testing will be at the Contractor's expense. Contractor shall deliver all samples to testing laboratories and shall have the testing report sent directly to the Owner's Representative. Perform all tests for gradation, organic content soil chemistry, cation exchange capacity, and pH by UNH Soil and Plant Tissue Laboratory, , or by a private testing laboratory specializing in the testing of soils for fertilization of woody plant material. Testing reports shall include the following tests and recommendations.
   b. Mechanical gradation (sieve analysis) shall be performed and compared to the USDA Soil Classification System. Sieve analysis shall be by combined hydrometer and wet sieving using sodium hexametaphosphate as a dispersant in compliance with ASTM D 422 after destruction of organic matter by H_2O_2. To facilitate review and approval of sieve analysis, provide a computer-generated gradation curve from UMASS Soil & Plant Tissue Laboratory.
   c. Percent of organic matter shall be determined by the loss on ignition of oven-dried samples Test Samples minus #10 material shall he oven-dried to a constant weight at a temperature of 450 degrees Fahrenheit (752 degrees Centigrade).
   d. Chemical analysis shall he undertaken for Nitrate Nitrogen, Ammonium, Nitrogen, Phosphorus, Potassium, Calcium, Manganese, extractable Aluminum, Lead, Zinc, Cadmium, Copper, Soluble Salts, and acidity (pH) and buffer (pH). A Conductivity Meter shall be used to measure Soluble Salts in 1:2 soil/water (v/v). Except where otherwise noted, nutrient tests shall be for available nutrients.

e. Soil analysis tests shall show recommendations for soil additives to correct soils deficiencies as necessary, and for additives necessary to accomplish lawn and planting work as specified.

3. If biosolid compost is used as an organic component of the proposed planting soil mixture, the amount of organic material used shall not exceed agronomic rates for nitrogen and phosphorus for trees and shrubs, turf or ornamental perennials. Provide certificates of agronomic rates from vendor for organic matter used in loam borrow manufacturing process. Biosolid compost shall be tested by an approved testing laboratory to determine that the compost is mature, stable and suitable for use in a growing medium.
4. Peat Moss: Submit a one cubic foot sample and supplier's certification of contents.
5. Limestone: Submit supplier's certification that the limestone being supplied conforms to these Specifications.
6. Acidulant: Submit supplier's certification that the acidulant being supplied conforms to these Specifications.
7. Fertilizer:
   a. Submit product data of seeding and planting fertilizer and certificates showing composition and analysis. Submit fertilization rates for fertilizer product based upon soil testing, analysis, and recommendations as specified herein.
   b. Submit the purchasing receipt showing the total quantity purchased for the project prior to installation.
8. Gypsum: Submit manufacturer's product data and 2 pound (1 kilogram) sample.
9. All additives needed to amend a specific soil in order to meet these specifications.

1.07 EXAMINATION OF CONDITIONS

A. All areas of the existing site where topsoil is to be sampled for testing shall be inspected by the Contractor before starting work and any issues that might inhibit or prevent the sampling operation shall be reported to the Owner's Representative prior to beginning this work.

B. The Contractor and any sub-Contractor responsible for the execution of the Work of this Section shall review and confirm in writing that the subsoil elevations have been brought to the proper subgrade elevations prior to proceeding with the spreading of existing on-site topsoil on loam borrow.

C. The Contractor and any sub-Contractor responsible for the execution of the Work of this Section shall review the subgrades and verify that the subgrades have been prepared in accordance with the requirements of this Section prior to proceeding with the spreading of existing on-site topsoil or loam borrow. Carefully review the requirements of this Section to understand the requirements of percolation testing, compaction, slope and absence of debris of the suhgrade prior to spreading of the loam borrow.

D. The Contractor shall he solely responsible for judging the full extent of work requirements involved, including but not limited to sampling and testing of on-site stockpiles of delivered off-site loam borrow prior to final plant installation.

1.08 DEFINITIONS

A. The following definitions shall apply to the work of this Section.

B. The following size distributions of mineral particles by diameter and sieve size shall apply to the following conventional names of soil types:

Conventional Name	Retained on U.S. Sieve No.	Diameter (mm)
Very coarse sand	#18	1-2
Coarse sand	#35	0.5- 1
Medium sand	#60	0.25-0.5
Fine sand	#140	0.10-0-25
Very fine sand	#270	0.05-0.10
Silt	by hydrometer	0.002- 005
Clay	by hydrometer	Less than 0002

C. Loamy sands shall conform to USDA Soil Taxonomy definitions and as follows: Soil material that contains at the upper limit 85 to 90 percent sand, and the percentage of silt plus 1.5 times the percentage of clay is not less than 15; at the lower limit the soil material contains not less than 80 to 85 percent sand, and the percentage of silt plus twice the percentage of clay does not exceed 20.
   1. Loamy coarse sand: 25 percent or more very coarse and coarse sand, and less than 50 percent any other one grade of sand.
   2. Loamy sand: 25 percent or more very coarse, coarse, and medium sand, and less than 50 percent fine or very fine sand.
   3. Loamy fine sand: 50 percent or more fine sand or less than 25 percent very coarse, coarse, and medium sand and less than 50 percent very fine sand.
   4. Loamy very fine sand: 50 percent or more very fine sand.

D. Sandy loam shall conform to USDA Soil Taxonomy definitions and as follows: Soil material that contains either 20 percent clay or less, and the percentage of silt plus twice the percentage of clay exceeds 30 percent, and 52 percent or more sand; or less than 7 percent clay, less than 50 percent silt, and between 43 percent and 52 percent sand.
   1. Coarse sandy loam: 25 percent or more very coarse and coarse sand and less than 50 percent any other grade of sand.
   2. Sandy loam: 30 percent or more very coarse, coarse and medium sand, but less than 25 percent very coarse sand, and less than 30 percent very fine or fine sand.
   3. Fine sandy loam: 30 percent or more fine sand and less than 30 percent very fine sand or between 15 and 30 percent very coarse, coarse, and medium sand.

PART 2 - PRODUCTS

2.01 LOAM - GENERAL

A. The Contractor shall provide sufficient loam borrow to complete all loaming operations required of the Contract Documents, as specified in this Section and as directed by the Owner's Representative. Loam borrow shall comply with the following specifications.

B. Loam borrow shall be obtained from one of the following sources:
   1. Naturally well-drained areas which have never been stripped before and have a history of satisfactory vegetative growth. Comply with all City and Town bylaws or regulations concerning the removal of topsoil from their boundaries.

2. On-site topsoil stripped, stockpiled on the site under the work of the Division 31 Section 312000, EARTHWORK.
3. A commercial processing facility specializing in the manufacturing of loam.
4. All sources shall be acceptable provided that, after testing and the addition of necessary soil additives specified in this Section, the loam borrow meets the following specifications.

2.02 LOAM

A. Loam borrow for turf areas as described in the Division 32 Section 329020; NATURAL FIELD SPORT SURFACING, of this Specification, shall be one of the following loamy sands and sandy loams; “loamy sand”, “loamy fine sand”, “loamy very fine sand”, or “coarse sandy loam”: determined by mechanical analysis (ASTM D 422) and based on the “USDA Classification System” and as defined in this Section. It shall he of uniform composition, without admixture of subsoil.

B. It shall be free of stones greater than 0.73 inches (19 mm) lumps, plants and their roots, debris and other extraneous matter as determined by the Owner’s Representative.

C. Planting soil for lawn areas shall have the following grain size distribution for material passing the #10 (2.0 mm) sieve:

Millimeter	**Percent Passing by Weight**	
	Maximum	Minimum
2	-	100
1	100	82
0.5	87	65
.025	72	49
0.10	45	30
0.05	32	22
0.002	5	2

1. Maximum size shall be 0.75 inches (19 mm) largest dimension. The maximum retained on the #10 sieve shall be 25% by weight of the total sample.
2. The ratio of the particle size for 80% passing (080) to the particle size for 30% passing (D30) shall be 6.0 or less. (D80/D30 < 6.0).
3. In addition to the foregoing, all loam borrowed to be used for loaming and seeding shall be mechanically screened processed loam borrow that passes a 3/4 inch by 6 inch screen size.

D. Organic content and pH for specific planting use shall be as follows:
1. Areas planted with turf grasses per the Division 32 Section 329020; NATURAL FIELD SPORT SURFACING, of this Specification:
   a. pH: 6.0 through 7.0
   b. Organic Content 4.0 - 6.0 percent as determined by the loss on ignition of oven-dried samples passing #10 sieve (Muffle furnace temperature: 450 +1- 10 degrees C for8 hours)

2. Top 18 inches (450 mm) of areas planted with tree as described in the Division 2 Section 02950, PLANTING, of this Specification:
   a. pH: 5.5 through 6.5 for non-acid loving plants
   b. pH: 4.5 through 5.5 for Ericaceae and other acid-loving plants
   c. Organic Content 4.0 - 6.0 percent as determined by the loss on ignition of oven-dried samples passing #10 sieve (Muffle furnace temperature: 450 +1- 10 degrees C for 8 hours)
3. Below 1 8 inches (450 mm) in tree pit when details call for depths of loam borrow to exceed 18 inches (450 mm):
   a. pH: 5.5 through 6.3 for non-acid loving plants
   b. pH: 4.5 through 5.5 for Ericaceae and other acid-loving plants
   c. Organic Content 1.0 - 3.0 percent as determined by the loss on ignition of oven-dried samples passing #10 sieve (Muffle furnace temperature: 450 I-I- 10 degrees C for 8 hours)
   4. Loam borrow shall be pH adjusted for particular planting applications and shall be adjusted prior to delivery to the Project sites as recommended by UMASS Soil & Plant Tissue Laboratory test results.
      a. When pH of loam borrow is equal to or greater than 7 use aluminum sulfate to adjust pH downward to required levels.
      b. When pH of loam borrow is less than 7 use either sulfur or ferrous sulfate to adjust pH downward to required levels.
      c. When pH of loam borrow must be raised to the required levels use limestone.
      d. Regardless of amendment Contractor chooses to use, Contractor, not the Owner, shall be responsible for obtaining specified pH by seeding and/or planting time.

E. Loam borrow shall be free of plants and their roots, debris and other extraneous matter. It shall be uncontaminated by salt water, foreign matter and substances harmful to plant growth. The electrical conductivity (EC2) of a 1:2 soil-water suspension shall be equal to or less than 1.0 milliohms/cm. (Test minus sieve #4 material.) Loam borrow shall not have levels of extractable aluminum greater than 200 parts per million except for Ericaceae and other acid-loving plants. Cation Exchange Capacity (CEC) shall be greater than or equal to 12, except when loam borrow is being used to establish Conservation seeding, in which case the CEC shall be between 2 and 5.

F. Loam borrow may be the manufactured product of a commercial processing facility specializing in the production of manufactured soils and loam borrow. Loam borrow shall he manufactured from sands, silts, clays, peat moss, and biosolids as specified in Division 2 Section 02901, PLANTING SOILS. Loam borrow may be manufactured outside the project area and delivered to the project for spreading or the component soils and organics may be delivered to project site and mixed in situ.
   1. Manufactured loam borrow shall be manufactured sufficiently in advance of spreading on the project so that ammonium, pH, soluble salts and the Carbon/Nitrogen ratio will have stabilized at the time of sampling and testing by the Contractor. On-site testing of loam borrow will be performed by the Contractor to verify that delivered material meets the requirements of this Section.

   2. Manufactured loam borrow shall contain equal amounts of biosolid compost and peat moss to establish the required organic levels.

G. On-site topsoil stripped and stockpiled tinder the work of the Division 31 Section 312000, EARTHWORK, may be re-used if, with or without amending or blending with other material, it meets the above requirements. On-site topsoil and amendments shall he tested in accordance

with requirements for loam borrow and submittals shall be made for review and acceptance as specified herein. The Contractor shall provide additional loam borrow as required to complete the required work.

H. All loam borrow proposed for use shall be tested for conformance to the specifications.

I. The Owner's Representative reserves the right to reject on or after delivery to the proiect site any material which does not, in his opinion, meet these specifications.

2.03 SOIL ADDITIVES

A. General: Soil additives shall be used to counteract soil deficiencies as recommended by the. soils analysis and as supplements for lawn construction as specified herein.

B. Acidulant for adjustment of loam borrow pH shall be commercial grade flours of sulfite, ferrous sulfate, or aluminum sulfate that are unadulterated. Acidulants shall be delivered in unopened containers with the name of the manufacturer, material, analysis and net weight appearing on each container.

C. Ground limestone for adjustment of loam borrow pH shall contain not less than eighty five percent (85%) of total carbonates and shall be ground to such fineness that forty percent (40%) will pass through 100 mesh sieve and ninety five percent (95%) will pass through a 20 mesh sieve. Contractor shall be aware of loam borrow pH and the amount of lime needed to adjust pH to specification in accordance with testing lab recommendations.

D. Organic component of the manufactured loam borrow shall he compost and peat moss used in equal proportions. Compost shall be a stable humus-like material produced from the aerobic decomposition of organic residues. The residues, if biosolids, shall consist of compost meeting MA-DEP Type 1 requirement or approved equal. The residues shall be dark brown or black in color, with no visible free water or dust and no unpleasant odor, meeting the following criteria certified by the producer.

1.	carbon-nitrogen ratio	minimum 10:1 maximum 25:1
2.	stability CO_2 evolution test or Dewar Self-heating test or Woods End Laboratory's Compost Test Kit	<10 mg CO_2 - C/g BVS/day <10 degrees C above room temp
3.	organic content	40 percent minimum dry weight (Loss on Ignition; minus #10 Sieve, 430 degrees C)
4.	particle size	90 percent passing one-half inch screen 100 percent passing one inch screen
5.	inorganic debris	1 percent maximum (dry weight)
6.	pH	minimum 5.5 - maximum 8.0
7.	Soluble Salts	>2 and <4.0 mmhos/cm (ds/m)
8.	density	850-1,050lb./cy

E. Peat moss shall he composed of the partly decomposed sterns and leaves of any of several species of sphagnum moss. It shall be free from wood, decomposed colloidal residue and other foreign matter. It shall have an acidity range cf 3.3 pH to 5.5 pH as determined in accordance with the methods of testing of A.O.A.C., latest edition. Its water absorbing ability shall be a minimum of 1,100% by weight on an oven-dry basis.

F. Sand, as required for mixing with topsoil to meet Specification requirements shall be uniformly graded coarse sand consisting of clean, inert, rounded grains of quartz or other durable rock and free from loam or clay, surface coatings, mica, other deleterious materials with the following gradation.

Millimeter	**Percent Passing by Weight**	
	Maximum	Minimum
5	-	100
2	100	80
1	86	58
0.5	50	18
.025	24	7
0.10	0	10
0.05	0	4.5
0.002	0	0.3

1. The ratio of the particle size for 70% passing (D70) particle size for 20% passing (D20) shall be 4.0 or less. (D70/D20 < 4.0)

G. Gypsum (CaSO4-2H2O) shall be agricultural grade, granular form. Gradation shall conform to the following:

Sieve Designation	**Percent Passing by Weight**
No. 8 (2.36 mm)	100
No. 16(1.18 mm)	97
No. 30(0.60mm)	82
No. 50(0.30 mm)	46
No. 100 (0.15 mm)	21

H. Commercial fertilizer shall be a product complying with the State and United States fertilizer laws. Deliver fertilizer to the site in the original unopened containers hearing the manufacturer's certificate of compliance covering analysis and which stall be furnished to the Owner's Representative. Fertilizer shall contain not less than the percentages of weight of ingredients as recommended by the soil analysis.
   1. Fertilizer for planting shall he formulated for top-dressing, soil surface application to plants. Fertilizer shall be designed and certified by the manufacturer to provide controlled release of fertilizer continuously for not less than 9 months. One hundred percent of the nitrogen content shall be derived from organic materials. Nitrogen source shall be coated to ensure

slow release. Fertilizer percentages of weight of ingredients shall be as recommended by the soil testing and analysis as specified herein.

PART 3 - EXECUTION

3.01 FILLING AND COMPACTION

A. Perform percolation tests on existing subsoils or placed fill prior to placing and spreading loam borrow.
   1. Perform percolation testing of subsoil or placed fills to determine whether or not the subgrade will drain properly. Perform percolation tests in accordance with the requirements for percolation testing for each lift of loam borrow described in this Section.
   2. In the event that percolation testing indicates that the subsoil, placed fills or ordinary borrow has been over compacted and will not drain, the contractor shall loosen up the top 36 inches of the subgrade to be planted or seeded by ripping or other mechanical means. Re-compact the borrow by driving a small, tracked dozer over the area at low speeds so that the tracks of the bulldozer pass over the affected area and the soil is compacted to a density that will percolate in accordance with this Section. Under no circumstances shall wheeled vehicles be driven over subsoil, placed fills or ordinary borrow that have been shown to percolate or subsoil, placed fills or ordinary borrow that has been loosened and shown to percolate. The work of loosening the top 36 inches of soil and recompacting the soil shall be as specified in Division 31 Section 312000, EARTHWORK, of this Specification.
   3. Perform sufficient percolation tests in areas of poorly draining or compacted subsoil or compacted placed fills as directed by the Owner's Representative to ensure that these underlying soils drain. Likewise, perform sufficient percolation tests after ripping and loosening to ensure that the soils are no longer too compact to drain.

B. Subsoil or ordinary borrow shall have been excavated and filled as required by the Contract Documents and specified under Division 32 Section 312000, EARTH WORK, of this Specification. Do not damage the work previously installed. Maintain all required angles of repose of materials adjacent to the loam as shown on the Contract Documents. Do not over excavate compacted subgrades of adjacent pavement or structures during loaming operations.

C. Confirm that the subgrade is at the proper elevation and that no further earthwork is required to bring the subgrade to proper elevations. Subgrade elevations shall slope parallel to the finished grade and or toward the subsurface drain lines as shown on the Contract Documents. Provide a written report to the Owner's Representative that the subgrade has been placed to the required elevations and that the suhgrade drains water in accordance with the required percolation tests. Perform no work of placing and spreading loam until elevations have been confirmed and written report has been accepted by the Owner's Representative.

D. Clear the subgrade of all construction debris, trash, rubble and any foreign material. In the event that fuels, oils, concrete washout or other material harmful to plants brave been spilled into the subgrade material, excavate the soil sufficiently to remove the harmful material. Such construction debris, trash, rubble, and foreign material shall be removed from the site and disposed of in a legal manner. Fill any over excavation with approved fill and compact to the required subgrade compaction levels.

E. Do not proceed with the installation of loam borrow until all utility work in the area has been installed.

F. Protect adjacent walls, walks and utilities from damage or staining by the loam borrow. Use one-half inch plywood and or plastic sheeting as directed to cover existing concrete, metal and

masonry work and other items as directed during the progress of the work. Clean up all trash and any soil or dirt spilled on any paved surface at the end of each working day.

3.02 FINE GRADING

A. Immediately prior to dumping and spreading the loam borrow, the subgrade shall be cleaned of all stones greater than 2 inches and all debris or rubbish. Such material shall be removed from the site, not raked to the edges and buried. Notify the Owner's Representative that the subsoil has been cleaned and request his/her attendance on site to review and approve subgrade conditions prior to spreading loam borrow.

B. Loam borrow delivered to the site shall be protected from erosion at all times. Materials shall be spread immediately. Otherwise, materials that set on site for more than 24 hours shall be covered with tarpaulin or other soil erosion system acceptable to the Owner's Representative and surrounded by silt fence installed in accordance with the Division 32 Section 321000, EROSION AND SEDIMENT CONTROL, of this Specification.

C. No loam borrow shall be handled, planted, or seeded in any way if it is in a wet or frozen condition. A moist loam borrow is desirable.

D. Soil additives shall be spread and thoroughly incorporated into the layer of loam borrow by harrowing, tilling, or other methods reviewed by the Owner's Representative. The following soil additives shall be incorporated:
   1. Ground limestone or acidulant as required by soil analysis to achieve the required pH as described in this Section. Spread limestone at the rate required by soil analysis up to a maximum limit of 200 pounds per 1,000 square feet (90 kilograms per 90 square meters). Should recommendations of soil analysis require greater rates of application than 200 pounds per 1,000 square feet (90 kilograms per 90 square meters), a surface application of limestone not in excess of 50 pounds per 1,000 square feet (23 kilograms per 90 square meters) shall be made to the established lawn the season after Final Acceptance in accordance with the requirements of Division 22 Section 329030, ATHLETIC FIELD SEEEDING.
   2. Fertilizer at the rate and of analysis recommended by the soil analysis. This shall be the first in a series of fertilizer applications made under this Contract and shall be applied and incorporated under this Section.
   3. Biosolid compost, peat moss, sand or other soil amendments as required by soil analysis.

E. Loam borrow shall be sampled and tested in accordance with the requirements of this Section to verify application and incorporation of limestone, fertilizer and other soil amendments.

F. After loam borrow and required additives have been spread, carefully prepare the loam borrow by scarifying, harrowing, or tilling the loam to integrate soil additives into the top six (6) inches of the loam. Remove all large stiff clods, lumps, brush, roots, stumps, litter and other foreign matter. Remove all stones over 3/4 inch in diameter from the top six (6) inches of the loam bed. Loam borrow shall also be free of smaller stones in excessive quantities as determined by the Owner's Representative.

G. Sufficient grade stakes shall be set for checking the finished grades. Stakes must be set in the bottom of swales and at the top of slopes. Deviation from indicated elevations that are greater than one-tenth of a foot shall not be permitted. Connect contours and spot elevations with an even slope. Finish grades shall be smooth and continuous with no abrupt changes at the top or bottom of slopes.

H. During the compaction process, all depressions caused by settlement or rolling shall he filled with

additional loam borrow and the surface shall be regraded and rolled until presenting a smooth and even finish corresponding to the required grades.

I. The Contractor shall install loam borrow in successive horizontal lifts no thicker than 6 inches in turf areas and 12 inches in plant bed areas to the desired compaction as described in this Section. The Contractor shall install the soil at a higher level to anticipate any reduction of loam borrow volume due to settling, erosion, decomposition, and other similar processes during the warranty period. The Owner's Representative will ensure that the full depths of loam borrow for lawn and plant beds are obtained by digging holes in the loam borrow at the same frequency as for compaction testing.
   1. Compact loam to the required density as specified herein.
   2. Maximum dry density for topsoils and loam shall he determined in accordance with ASTM D698. The following percentages of minimum to maximum dry densities shall be achieved for fill materials or prepared subgrades:

In Lawn and Tree Pits:	**Minimum**	**Maximum**
Fills within lawn and planting areas in top eighteen inches of finished grade	80%	82%

   3. The surface area of each lift hall shall be scarified by raking prior to placing the next lift.

J. In addition to the range cited above, compact each lift sufficiently to reduce settling but not enough to prevent the movement of water and feeder roots through the soil. The loam borrow in each lift should feel firm to the foot in all areas and make only slight heel prints. At completion of the loam borrow installation, the soil should offer a firm, even resistance when a soil sampling tube is inserted from lift to lift. After the placement of each lift, perform percolation tests to determine if the soil has been over compacted. Perform the following percolation test procedure:
   1. Dig a hole in the installed soil that is a minimum of 4 inches in diameter. Holes in 6-inch lift in turf areas shall be 4 inches deep. Holes in 12-inch lifts in plant beds shall be 8 inches deep. Do not penetrate through the lift being tested.
   2. Fill the hole with water and let it drain completely. Immediately refill the hole with water and measure the rate of fall in the water level.
   3. In the event that the water drains at a rate less than one inch per hour, till the soil to a depth of 8" minimum to break the over compaction.
   4. Perform a minimum of one soil percolation test per 10,000 square feet area of turf area and 2,500 square feet of tree and shrub planting area as directed by the Owner's Representative.

K. Select equipment and otherwise phase the installation of the loam borrow to ensure that wheeled equipment does not travel over subsoil, placed fills or ordinary borrow or already installed soil. Movement of tracked equipment over said soils will be reviewed and considered for approval by the Owner's Representative, if it is determined by the Owner's Representative that wheeled equipment must travel over already installed soil, provide a written description of sequencing of work that ensures that compacted soil is loosened and uncompacted as the work progresses or place one-inch thick steel plate ballast (or equivalent ballast approved by the Owner's Representative) over the length and width of any travel way to cover loam borrow to protect it from compaction.

L. Disturbed areas outside the limit of lawn work shall be graded smooth and spread with a minimum of 6 inches of loam borrow to the finished grade.

M. Contractor shall be responsible for maintaining all stockpiles of existing, on-site topsoil on the site until final placement of existing on-site topsoil and loam borrow has been approved by the Owner's Representative in writing. Contractor shall provide survey data plotted on a 20-scale plan of the site and prepared by a Registered Surveyor or Civil Engineer. Survey data and plans shall show the volume of stockpiles of existing, on-site topsoil for review and analysis by the Owner's Representative. Upon written approval by the Owner's Representative, Contractor shall remove all excess unused existing on-site topsoil from the site and dispose of it in a legal manner.

3.03 ACCEPTANCE

A. Confirm that the final grade of loam borrow is at the proper finish grade elevations. Adjust grade as required to meet the contours and spot elevations noted on the Plans. Request the presence of the Owner's Representative to inspect final grade. Do not proceed with the remaining work of this Contract until the Owner's Representative has given his/her written approval of the final grade.

END OF SECTION 32 90 15

Section 32 90 20
NATURAL FIELD SPORT SURFACING

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. The General provisions of the Contract, including General and Supplementary General Conditions, and Division 1 General Requirements and Division 01 General Requirements, apply to work specified in this section.

B. Carefully examine all of the Contract Documents for requirements which affect the work of this Section. The exact scope of work of this section cannot be determined without a thorough review of all Specification Sections and other Contract Documents.

C. Refer to Drawings for further definition of location, extent, and details of work described in this Section.

D. Cooperate and coordinate with other trades in executing work as described in this Section.

E. Where referred to, Standard Specifications, Recommendations of Technical Societies, and/or Manufacturer's Associations, plus Codes of Federal, State, and Local Agencies shall include all amendments current as of date of issue of these Specifications.

F. In all cases when conflict exists between information contained in this Section and in other parts of the Contract Documents, the Contractor shall assume that the most expensive solution is required.

G. In all cases, when a question exists to the level of quality required for a product and/or installation, the highest quality is required.

1.2 SCOPE

A. Provide all labor, materials, tools, and equipment, including, excavation, base and subgrade preparation, , underdrainage, drainage blanket, root zone placement, and grading for the living grass sports field. Provide all components necessary to form a complete and operating whole. The worked shall be coordinated with the installation of the irrigation system.

B. The Contractor is responsible for the purchase and installation of all fixed items, and providing all non-fixed items.

C. The Contractor is responsible for all associated testing both preliminary and construction monitoring testing required to complete the sand/sol blending operations and placement.

1.3 DEFINITIONS

A. Most terms used within the documents are industry standard. Certain words or phrases shall be understood to have specific meanings as follows:

1. Provide: Furnish and install completely connected up and in operable condition.
2. Furnish: Purchase and deliver to a specific location within the building or site.
3. Install: With respect to equipment furnished by others, install means to receive, unpack, move into position, mount and connect, test, and removal of all packaging materials.

1.4 RELATED WORK SPECIFIED IN OTHER SECTIONS:

A. The following related work is to be performed under designated sections.
1. 033000 – Cast-in-Place Concrete
2. 329030 – Athletic Field Seeding
3. 329080 - Athletic Field Renovation

1.5 CODES AND STANDARDS

A. Comply with the latest edition of the following standards:
1. *The latest edition of the* Massachusetts Department of Transportation's Standard Specification for Road and Bridge Construction
2. “Standard Specifications for Highway Materials and Methods of Sampling and Testing, American Association of State Highway and Transportation Officials (AASHTO).”
3. ASTM F2396 Standard Guide for Construction of High Performance Sand-Based Root zones for Sports Fields1

1.6 SUBMITTALS

A. Provide all necessary data and information to determine compliance with requirements of this section. In cases where product or system substitutions are proposed, submit a letter which outlines a comparison of specified products to the proposed substitute(s).

B. Product Data: drawings including standard printed specifications and diagrams.

C. Shop drawings including drawings depicting installation directions and dimensions for all sports equipment.

1. Provide signed statement by contractor indicating that they have read and fully understand the instructions and requirements.

D. Material safety data sheets on all products, as necessary.

E. Statement of the presents of toxic and or hazardous materials. Any toxic and or hazardous material exceeding 100 ppm shall be included in this list.

1.7 QUALITY ASSURANCE

A. The Contractor shall only accept bids from those Vendors that have been pre-approved, identified as approved equal, or that indicate their products meet the specifications.

B. All soil testing associated with this Work shall be completed by an Agronomist experienced in the testing of growing soils and mediums.

1.8 GUARANTEE

A. Keep work in good repair and condition without expense to Owner in regards to defects in workmanship or materials for a period of not less than one (1) year from date of Substantial Completion.

B. Products to be warranted for a period of not less than two (2) years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 SUBSOIL SAND

A. Subsoil sand shall consist of clean, inert, hard durable grains of quartz and be free from loam, clay, silt and organic materials. Sand shall meet the following sieve requirements.

Size Fraction	Particle Diameter Range	Specified Range (%)
Fine gravel	2.0 – 3.4 mm	<5%
Very Coarse sand	1.0 – 2.0 mm	<5%
Coarse sand	0.5 – 1.0 mm	<5%
Medium sand	0.25 – 0.5 mm	>25%
Fine sand	0.15 – 0.25 mm	<20%
Very fine sand	0.05 – 0.15 mm	<5%
Silt	0.002 – 0.05 mm	<6%
Clay	<0.002 mm	<3%

Additionally;

- No more than 30% in the combined very coarse sand, fine gravel and gravel fractions.
- At least 60% of the total sand should be in the combined medium sand and coarse sand fractions.
- No more than 40% in the combined fraction less than 0.25 mm (fine sand, very fine sand, silt and clay fractions).
- A Coefficient of Uniformity ($CU=D_{60}/D_{10}$) value of 2.5 - 4.5.

2.2 TOPSOIL

A. Topsoil: Fertile, friable, natural loam free of subsoil, clay lumps, brush, stones, or other deleterious materials larger than two (2) inches in greatest dimension, conforming to the requirements of MADOT and meeting the following gradation requirements:

Sieve	Percent Passing
1	100
½”	90 100
¼”	70 95
No. 40	35- 75
No. 100	20-55
Combined Silt and Clay	<30%

1. pH range: 5.5 - 7.6
2. Organic Content: 3% - 10%

B. Natural topsoil may be amended with approved materials, by approved methods, to meet the above specifications. All topsoil material both import and on-site material shall be screened using a 1” mesh screen.

PART 3 - EXECUTION

3.1 SUBGRADE

A. Subgrade soil shall be re-graded subsoil brought to within 10" of finish grade. Contractor shall verify that subgrade has been prepared according to the specifications with regard to compaction, grade tolerances and debris-free prior to beginning work.

B. Finish grades of the subgrade shall be verified using laser operation survey instruments with a tolerance of +/- 1/2 inch. A survey of the finished spot grades is to be developed by a licensed surveyor over the entire surface in the form of a grid at 25 foot spacing in two directions. The surface shall also be checked using a 10 foot straight edge to identify high a low spots that must be corrected. The tolerance for high and low spots shall be +/- 1/2 inch.

C. The subgrade shall be compacted to 83 to 87% of Standard Proctor. Subgrade exceeding this range shall be scarified to a depth of 6", regraded, rolled and retested for compliance.

D. In all cases where and or when areas to receive planning soil have been used as haul roads, travel paths, stockpiling and or storage, the complete subgrade shall be scarified to a depth of 6", regraded, rolled and retested for compliance.

3.2 TRANSITION LAYER

A. A minimum of 6 inches of sand subsoil shall be placed and graded and rolled. This layer shall graded and lightly rolled. All depths are compacted measure.

3.3 GRADING TOPSOIL

A. The topsoil material shall be graded with a small dozer less than 5.0 psi per square foot of track area. Under no circumstances will loaded rubber-tired vehicles in excess of 1 ton be allowed on the gravel base prior to or during the spreading of the root zone mix.

B. The material shall be uniformly graded onto the field. Once the topsoil material has been spread uniformly over the field and rough graded, operate the irrigation system as necessary to settle and compact the mix to a final uniform 9 inch depth plus the transition layer thickness. Compaction shall be 82 to 85 percent or a bulk density between 1.45 and 1.65 grams per cm^3.

C. Finish grades shall be verified using laser operation survey instruments with a tolerance of +/- 1/4 inch. A survey of the finished spot grades is to be developed by a licensed surveyor over the entire surface in the form of a grid at 25 foot spacing in two directions. The surface shall also be checked using a 10 foot straight edge to identify high a low spots that must be corrected. The tolerance for high and low spots shall be +/- 1/4 inch.

D. Install turf grass per section Seeding or Athletic Field Sod depending requirements

E. Settlement topdressing. The contractor shall fill or top dress any areas of observed settlement that occur within the first year of the installation. The Contractor shall be responsible for providing settlement topsoil topdressing.

END OF SECTION 32 90 20

PART 1 GENERAL

1.01 GENERAL PROVISIONS

A. The General provisions of the Contract, including General and Supplementary General Conditions, and Division 1 General Requirements and Division 01 General Requirements, apply to work specified in this section.

B. Carefully examine all of the Contract Documents for requirements which affect the work of this Section. The exact scope of work of this section cannot be determined without a thorough review of all Specification Sections and other Contract Documents.

C. Refer to Drawings for further definition of location, extent, and details of work described in this Section.

D. Cooperate and coordinate with other trades in executing work as described in this Section.

E. Where referred to, Standard Specifications, Recommendations of Technical Societies, and/or Manufacturer's Associations, plus Codes of Federal, State, and Local Agencies shall include all amendments current as of date of issue of these Specifications.

F. In all cases when conflicts exist between information contained in this Section and in other parts of the Contract Documents, the Contractor shall assume that the most expensive solution is required.

G. In all cases, when a question exists to the level of quality required for a product and/or installation, the highest quality is required.

1.02 SUMMARY

A. The Contractor shall provide all labor, materials, equipment and services necessary for, and incidental to, preparation of ground surfaces, fertilizing, seeding, mulching, and maintenance of seeded areas as shown on the Drawings or as specified herein

B. Seed shall be sown from April 1st to June 15th or from September 1 1st to October 15th, unless otherwise approved by the Engineer.

1.03 SUBMITTALS

A. Quality Control Submittals:

1. Certification:
   a Submit manufacturers or vendor's certified analysis for soil amendments and fertilizer materials.
   b Submit vendor's certified analysis for each grass seed mixture required, stating botanical and common name, percentages by weight, percentages by purity, germination, and weed seed.
2. Maintenance Instructions: Submit instructions recommending procedures to be established for maintenance of landscaped work for one (1) full year. Submit prior to expiration of Contractor's

maintenance period.

3. Submit description of planned mulching techniques and corresponding manufacturer's installation recommendation for approval by the Engineer.

1.04 QUALITY ASSURANCE

A. All landscaping work shall be performed by one (1) Contractor, with proven experience in athletic field turf establishment.

B. Package the standard products with the manufacturer's certified analysis. For other materials, provide analysis by recognized laboratory made in accordance with methods established by the Association of Official Agriculture Chemists, wherever applicable.

C. The Contractor shall provide and pay for all costs in connection with an approved independent testing facility to determine conformance of materials with the specifications.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Deliver packaged materials in containers showing weight, analysis and name of manufacturer. Protect materials from deterioration during delivery, and while stored at site.

PART 1 PRODUCTS

2.01 MATERIALS

A. Fertilizer:
1. Commercial fertilizer (5-10-5) inorganic, or organic, containing not less than five (5) percent nitrogen, ten (10) percent available phosphoric acid, and five (5) percent water soluble potash.
2. If, as an alternative, the Contractor wishes to substitute for commercial fertilizer 5-10-5, another commercial fertilizer with a 1- 2-1 ratio, such as 10-20-10 or 6-12-6, he may do so with the approval of the Engineer and the rate of fertilizer to be used shall be whatever amount is required to furnish the same amount of nitrogen as would be supplied by the 5-10-5.

B. Seed:
1. Seed shall be fresh, clean, new-crop seed mixed in the proportions specified for species and variety, conforming to Federal and State Standards.
2. Use the following standard mixture blue seal classic, unless a special mixture is otherwise indicated or approved by the Engineer:

PART 2 -

Species	% By Weight	% By Purity	% Germination
Kentucky Bluegrass 3 Cultivars	75	85	80

Perennial Ryegrass 3 Cultavars	25	85	80
TransFix" Intermediate Ryegrass (SRO Seeds)	10	95	85

PART 3 -

Each of the Seed Mixture components shall consist of a blend of 3 separate turf grass cultivars (in equal proportions) of that species.

1. Kentucky Blue Grass Cultivars must be three separate cultivars and shall be selected from the following: Barii, Blackstone, BlueStar, Challenger, Coventry, Fairfax, Glade, Livingston, Marquis, Midnight, Moonlight, Nuglade, Preakness, Quantum Leap, Unique
2. Weed seed content shall not exceed 0.25%.

B. Water: Clean, potable.

C. Mulch:

1. Provide and install mulch adequate to protect the seeding during its growing period. It shall be the responsibility of the Contractor to determine the appropriate mulching techniques for the particular site conditions and acquire approval of the same from the Engineer.
2. Clean straw for gentle slopes, consisting of stalks of oats, wheat, rye, or other approved crops which are free of noxious weed seeds. Weight shall be based on fifteen (15) percent moisture content.
3. Mulching blanket for steep slopes and drainage swales: "Curlex Blanket" by Amxco, "Ero-Mat" by Armco, or equal.

2.02 ACCESSORIES

A. Soil Amendments for the topsoil football practice field:

1. Soil amendments are not to be made without review and authorization by the Engineer.
2. Lime: Natural limestone containing not less than 85% of total carbonates, ground so that not less than 90% passes a 10-mesh sieve and not less than 50% passes a 100-mesh sieve.
3. Aluminum Sulfate: Commercial grade.
4. Peat Humus: FS Q-P-166 and with texture and pH range suitable for intended use.
5. Bonemeal: Commercial, raw, finely ground; 4% nitrogen and 20% phosphoric acid.
6. Superphosphate: Soluble mixture of treated minerals; 20% available phosphoric acid.
7. Sand: Clean, washed sand, free of toxic materials.
8. Perlite: Conforming to National Bureau of Standards PS 23.
9. Vermiculite: Horticultural grade, free of toxic substances.
10. Sawdust: Rotted sawdust, free of chips, stones, sticks, and soil or toxic substances and with 7.5 lbs. nitrogen uniformly mixed into each cubic yard of sawdust.
11. Manure: Well-rotted, unleached stable or cattle manure containing not more than 25% by volume of straw, sawdust or other bedding materials and containing no chemicals or ingredients harmful to plants.
12. Commercial Fertilizer: Complete fertilizer of neutral character, with some elements derived from organic sources and containing available plant nutrients.

B. Soil Amendments for the Sand blended soccer field:
   1. Soil amendments are to follow the requirements the project Agronomist

PART 3 EXECUTION

3.01 PREPARATION OF SPORTS FIELD SOIL

A. Assure that the field surface is clean and free of roots, plants, stones, clay lumps and other extraneous materials harmful or toxic to plant growth. Obtain approval of installed rootzone prior to proceeding with seeding operations.

B. Mix fertilizer into top 2 inches of topsoil at a rate of 10 lbs. per 1000 square feet.

C. Mix approved soil amendments into top 2 inches of topsoil at necessary rates.

D. Water dry topsoil to depth of 4 inches at least 48 hours prior to seeding to obtain a loose friable seed bed.

E. Complete any and all mixture/incorporation of amendments/fertilizers PRIOR to final grading

3.02 PREPARATION OF UNCHANGED GRADES

1. Where lawns are to be planted in areas not altered or disturbed by excavating, grading, or stripping, prepare soil for seeding as follows:
   a Till to a depth of not less than 6 inches.
   b Apply soil amendments and initial fertilizers as specified.
   c Remove high areas and fill in depressions.
   d Till soil to a homogeneous mixture of fine texture, free of lumps, clods, stones, roots, and other extraneous matter.
   e Prior to preparation of unchanged areas, remove existing grass, vegetation and turf. Dispose of such materials off the campus; do not turn over into soil being prepared for lawns.
   f (Brillion Seeder or approved equal)Apply specified commercial fertilizer at rates specified and thoroughly mixed into upper 2 inches of topsoil. Delay application of fertilizer, if lawn planting will not follow within one week.

3.03 SEEDING

A. Seeding of athletic fields shall be accomplished by Brillion seeding only.

B. Apply seed at not greater than 4 lbs. per 1000 square feet and not less than 3.75 lbs per 1,000 square feet.

C. Roll seeded area with roller weighing no more than 150 lbs. per foot of roller width.

D. Water seeded areas to a depth of four (4) inches within the soil column.

3.04 MULCHING

A. Spread straw uniformly over seeded area with 75% ground coverage and at least 1-1/2 inches loose

depth.

B. If, in the opinion of the Engineer, wind will disrupt the mulching, apply asphalt emulsion at a rate of 10 gallons per 1000 square feet.

C. Place mulching blanket in accordance with submitted manufacturer's recommendations.

3.05 PROTECTION

A. Immediately after seeding and erect barricades and warnings to protect seeded areas from traffic until grass is established.

B. Repair or replace damaged landscape work as directed by Engineer.

3.06 MAINTENANCE

A. Begin maintenance immediately after seed placement.
   1. Watering:
      a. Keep soil moist during seed germination period with applied irrigation water a decrease in watering rate once turf is established.
      b. Supplement rainfall to produce a total soil depth penetration of 2 inches each day after germination.
      c. Prevent erosion and displacing seed.
   2. Mowing:
      a. When grass reaches 4 inches in height, mow to 2-1/2 inches in height.
      b. Maintain grass between 1-1/2 inches and 2-1/2 inches in height.
      c. Do not cut off more than 30% of grass leaf in a single mowing.
      d. Remove grass clippings.
   3. Reseed and mulch spots larger than 16 square inches not having coverage. Reseed and mulch spots greater than 1 square foot that exhibit non-uniform coverage.
   4. Maintain lawns by watering, fertilizing, weeding, mowing, trimming, and other operations such as rolling, regardening and replanting as required to establish a smooth, acceptable lawn, free of eroded or bare areas.
   5. Maintain and protect all seeded areas until final acceptance of the Contract. Final acceptance of "Seeding: will not be made until an acceptable uniform stand of grass is obtained in all new lawn areas, except that the Engineer at his discretion may accept a portion or portions of the "Seeding" at various times. Upon acceptance by the Engineer of a seeded area, the Owner will immediately assume responsibility for maintenance and protection of that portion of the Contract Seeding.

END OF SECTION 32 92 23

PART 1 - GENERAL

1.01 GENERAL PROVISIONS

A. The General provisions of the Contract, including General and Supplementary General Conditions, and Division 1 General Requirements and Division 01 General Requirements, apply to work specified in this section.

B. Carefully examine all of the Contract Documents for requirements which affect the work of this Section. The exact scope of work of this section cannot be determined without a thorough review of all Specification Sections and other Contract Documents.

C. Refer to Drawings for further definition of location, extent, and details of work described in this Section.

D. Cooperate and coordinate with other trades in executing work as described in this Section.

E. Where referred to, Standard Specifications, Recommendations of Technical Societies, and/or Manufacturer's Associations, plus Codes of Federal, State, and Local Agencies shall include all amendments current as of date of issue of these Specifications.

F. In all cases when conflicts exist between information contained in this Section and in other parts of the Contract Documents, the Contractor shall assume that the most expensive solution is required.

G. In all cases, when a question exists to the level of quality required for a product and/or installation, the highest quality is required.

H. The Contactor shall have experience in field renovaton using sand-slit surface drainage improvements consisting of 1" wide by 8" deep sand-filled cut-in slits and associated subdrainage. Equipment for installations of the sand-filled slits shall be a one pass aerator similar to a Redimex Sandmaster with hoper for placement of the sand.
   1. Sand slits shall intercept drainage pipe trenches as shown on the drawings. The 6" wide by 18" drainage pipe trenches shall be installed with equipment similar to a Ride-on-Trencher one side discharge control. Spoil from drainage trench excavation shall be removed and disposed of off-site and shall not be allowed to contaminate the surface soil nor the drainage trench backfill.

1.02 SCOPE

A. The Contractor shall provide all labor, materials, equipment and services necessary for, and incidental to, athletic field renovation, growing medium and layered drainage improvements as outlined below. The surface of the turfgrass area shall be irrigated through the process at a rate of that is appropriate for this process. This effort includes multiple steps in the Work:
   1. Initial surface treatment:
      a. Apply herbicide application, fungicide application, fertilizing.
      b. Deep-tine shatter aeration of the surface to a depth of 16" using solid tines of >1" diameter. Procedure shall be completed in two directions with the second pass being 45 degrees from the alignment of the initial pass.

c. Install cut-in 2” perforated HDPE subdrainage hose into 6” wide by 18” deep trenches using a rideon-trencher. Complete remove all drainage trench spoils and dispose of off-site. Do not allow drainage trench spoils to mix or contaminate the topsoil nor the drainage trench.Bed and backfill using sand. Provide compactions.
d. Install 1” wide by 8” deep cut-in sand-filled silt drains at a spacing of 10” inches on center.
e. Sand top dress field area with a 3/8” deep pass, broom drag sand to distribute sand over depressions.
f. Installation of cut-in 6” wide by 18” deep sand–slots with 2” perforated drain hose.
g. Also included is re-establishment of turfgrass cover, mowing, and maintenance of seeded areas as specified herein.

2. On-going surface treatment:
a. Apply herbicide application, pest management treatment, fungicide application, fertilizing.
b. Deep-tine shatter aeration of the surface to a depth of 16” using solid tines. Procedure shall be completed in two directions with the second pass being 45 degrees from the alignment of the initial pass.
c. Apply a 1/2” depth sand topdress layer (~100 tons/acre) across the entire and follow that by broom drag operation to distribute sand into aeration holes and microundulation depressions.
d. Also included is re-establishment of turfgrass cover, mowing, and maintenance of seeded areas as specified herein.

B. Timning:
1. After the initial surface treatment, aeration and topdressing shall be completed twice a year during the two years after completion of the intial surface treatment as part of the project maintenance requirements..
2. After the initial surface treatment apply fungicide and fertilizer on a seasonal basis. Interseeding shall be performed during spring and fall seasons. This shall be performed for during the two years after completion of the intial surface treatment as part of the project maintenance requirements.

C. Seed shall be sown from April 1st to June 15th or from August 21st to October 15th, unless otherwise approved by the Engineer. Seed shall be sown three to four weeks from date of post emergent weed treatment.

1.03 SUBMITTALS

A. Quality Control Submittals:
1. Certification:
a Submit manufacturers or vendor’s certified analysis for soil amendments and fertilizer materials.
b Submit vendor’s certified analysis for each grass seed mixture required, stating botanical and common name, percentages by weight, percentages by purity, germination, and weed seed.
2. Maintenance Instructions: Submit instructions recommending procedures to be established for maintenance of athletic field work for one (1) full year. Submit prior to expiration of Contractor’s maintenance period.
3. Submit description of planned mulching techniques and corresponding manufacturer’s installation recommendation for approval by the Engineer.

4. Submit all required State and Local licenses required to perform outlined work.

1.04 QUALITY ASSURANCE

A. All landscaping work shall be performed by one (1) Contractor, with proven experience in athletic field turf establishment.

B. Package the standard products with the manufacturer's certified analysis. For other materials, provide analysis by recognized laboratory made in accordance with methods established by the Association of Official Agriculture Chemists, wherever applicable.

C. The Contractor shall provide and pay for all costs in connection with an approved independent testing facility to determine conformance of materials with the specifications.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Deliver packaged materials in containers showing weight, analysis and name of manufacturer. Protect materials from deterioration during delivery, and while stored at site.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Herbicide:
1. Broad spectrum broadleaf/annual grass herbicide such as Q4-Plus or equal.
2. Pre-emergent crabgrass herbicide shall be Lebanon's Tupersan Crabgrass Control or equal.

B. Fungicide:
1. Broad spectrum systemic strobilurin-fungicide such as Strobe 50WG or equal.

C. Fertilizer:
1. Fertility program shall be based upon recommendations made from actual soil test values. In general, the program shall consist of a pre-plant fertilizer with elevated P in a 1-2-1 ratio such as a commercial fertilizer (5-10-5) inorganic, or organic, containing not less than five (5) percent nitrogen, ten (10) percent available phosphoric acid, and five (5) percent water soluble potash; or similar.
2. Grow-in fertility yet to be determined but in general should consist of about 0.25 lbs actual N per week following seed germination until about mid-October upon which time N fertility should be reduced and provided by a slow release form and increased K fertilization.

D. Seed:
1. Seed shall be fresh, clean, new-crop seed mixed in the proportions specified for species and variety, conforming to Federal and State Standards.
2. Seeding rate shall be 4 lbs per 1000 $ft^{2.}$
3. Use the following standard mixture blue seal classic, unless a special mixture is otherwise indicated or approved by the Engineer:
   a The seed blend shall be comprised of a blend of 75% Kentucky Bluegrass, 15% Perrennial Ryegrass, and 10% Intermediate Ryegrass.
   b The seed blend shall be comprised of the following cultivars. No substittutions will be allowed unless specifically approved by Project Engineer.

Species	% By Weight	% By Purity	% Germination
Kentucky Bluegrass 3 Cultivars	75	85	80
Perennial Ryegrass 3 Cultavars	25	85	80
TransFix" Intermediate Ryegrass (SRO Seeds)	10	95	85

E. Water: Clean, potable.

2.02 ACCESSORIES

F. Soil Amendments for the topsoil:
1. Soil amendments are not to be made without review and authorization by the Engineer.
2. Lime: Natural limestone containing not less than 85% of total carbonates, ground so that not less than 90% passes a 10-mesh sieve and not less than 50% passes a 100-mesh sieve.
3. Aluminum Sulfate: Commercial grade.
4. Peat Humus: FS Q-P-166 and with texture and pH range suitable for intended use.
5. Bonemeal: Commercial, raw, finely ground; 4% nitrogen and 20% phosphoric acid.
6. Superphosphate: Soluble mixture of treated minerals; 20% available phosphoric acid.
7. Sand: Clean, washed sand, free of toxic materials meeting the following requirements.
8. Perlite: Conforming to National Bureau of Standards PS 23.
9. Vermiculite: Horticultural grade, free of toxic substances.
10. Sawdust: Rotted sawdust, free of chips, stones, sticks, and soil or toxic substances and with 7.5 lbs. nitrogen uniformly mixed into each cubic yard of sawdust.
11. Manure: Well-rotted, unleached stable or cattle manure containing not more than 25% by volume of straw, sawdust or other bedding materials and containing no chemicals or ingredients harmful to plants.
12. Commercial Fertilizer: Complete fertilizer of neutral character, with some elements derived from organic sources and containing available plant nutrients.

2.03 MATERIALS FOR DRAINAGE TRENCH AND SLIT INSTALLATION

A. Sand backfill. The amending sand backfill material shall be the same for both the drainage trench and sand slits (and topdressing sand). The sand need not be kiln-dried for slit backfill but must be dry enough to allow free flow within the sand slit installation equipment.

B. BACKFILL SAND SPECIFICATIONS:
The sand shall be a washed sand product meeting the following criteria conforming to ASTM F2396 as modified:

Size Fraction	Particle Diameter Range	Specified Range (%)
Gravel	> 4.75 mm	0%
Gravel	3.4 – 4.75 mm	<5%
Fine gravel	2.0 – 3.4 mm	<20%
Very Coarse sand	1.0 – 2.0 mm	<34%)
Coarse sand	0.5 – 1.0 mm	25% - 50%
Medium sand	0.25 – 0.5 mm	>20%
Fine sand	0.15 – 0.25 mm	<10%
Very fine sand	0.05 – 0.15 mm	<5%
Silt	0.002 – 0.05 mm	<5%
Clay	<0.002 mm	<3%

Additionally;

- No more than 30% in the combined very coarse sand, fine gravel and gravel fractions.
- At least 60% of the total sand should be in the combined medium sand and coarse sand fractions.
- No more than 15% in the combined fraction less than 0.25 mm (fine sand, very fine sand, silt and clay fractions).
- A Coefficient of Uniformity ($CU=D_{60}/D_{10}$) value of 2.5 - 4.5.

2.04 DRAINAGE PIPE

A. Pipe:
1. Pipe shall be ADS N-12 high-density polyethylene pipe (HDPE) as manufactured by Advanced Drainage Systems (ADS), or approved equal, and shall conform to the requirements of AASHTO M-294. Solid wall pipe shall be corrugated smooth wall pipe (corrugated dual walled pipe sections) only.
2. HDPE pipe will be perforated where indicated. Perforated pipe shall be corrugated smooth wall pipe (corrugated dual walled pipe sections) only.
3. HDPE 2” perforated drainage hose shal be spiral corrugated interior and exterior corrugations. Minimum inside diameter and average outer diameter shall be 1.91-inches and 2.3-inches respectively. Average pipe stiffness at 5% deflection shall be 50 pii when tested in accordance with ASTM D2412. Average weight shall be 0.13 pounds per foot. The material formulation shall include recycled polyethylene.
3. Pipe and fittings shall be made of polyethylene compounds which conform to the physical requirements of Type III, Category 3, 4 or 5, P23, P33, or P34, Class C per ASTM D-1248 with the applicable requirements defined in ASTM D-1248. Clean reworked material may be used.
4. Pipe shall be of the diameters shown on the Drawings.
5. No flexible hose type shall be allowed for use on this project.

B. Couplings:
1. Filed joints shall be made with HDPE band couplers.
2. Couplers and pipe shall be from the same manufacturer.

3. Couplers shall be corrugated to match the pipe corrugations and the width shall not be less than one-half the nominal diameter of the pipe. Split couplers shall be manufactured to engage an equal number of corrugations on each side of the pipe joint.
4. One half inch diameter galvanized steel bolts and nuts or nylon ties as supplied by manufacturer shall be used on coupling bands.

PART 3 - EXECUTION

3.01 PREPARATION OF ATHLETIC FIELD TURFGRASS FOR RENOVATION

A. Spray-apply broadleaf post emergence herbicide over the full natural turfgrass area. Products should be suitable for weed species present at the site.
   1. Apply herbicide at high range of labelled rate.

B. Spray-apply systemic fungicide over the full natural turfgrass area. Products should be suitable for preventative protection for expected turfgrass fungus which are typical for the region.
   1. Apply systemic fungicide as per maximum allowed labelled rate. The purpose of this application is to lower the potential for disease occurrence to the existing turfgrass during the stressful renovation period.
   2. Apply fungicide treatment 1-1.5 weeks prior to the Power Raking (scalp/verticut) procedure.

3.02 POWER RAKING

A. Scalp/verticut (power rake) turf over the full natural turfgrass area.
   1. A field assessment shall be made to determine the most practical depth to remove turfgrass without complete removing of the existing turf crown tissue. Typical removals are ¾” +/- ¼”. Some areas anticipate higher/lower due to surface undulations/irregularities.
   2. The intent of this procedure is to remove thatch growth and open the turfgrass up to all proper application of topdressing sand/soil and seed.
   3. Remove generated power raking blade clippings by turf sweeper-vac. .

3.03 DEEP TINE SHATTER AERATION

A. Solid-tine shatter aerate the turf over the full natural turfgrass area.
   1. Process shall include three complete passes. The second pass shall be perpendicular to the first and the third pass shall be at 45 degrees to the first two passes.
   2. It is recommended that the one of the following solid-tine shatter aerators be used for this procedure:
      a Agri-vator with 6 inch tines. Effective quake goes beyond depth.
      b Verti-drain or similar with 8 inch tine
   3. Tines shall be 3/4" to 1" diameter with a tine spacing of 5" wide by 2.5" between rows (set for maximum kick) over the full natural turfgrass area.

B. Repeat deep tine shatter aeration after undulation rolling.

3.04 INSTALLATION OF DRAINAGE TRENCHES AND DRAINAGE SYSTEM

A. The drainage trenches shall be excavated in conformance with the depth, dimensions, and locations (spacing) as contained within the specifications herein and drawings; in preparation for

installation of drain lines. All excavated soil from the drainage trenches shall be removed and disposed of off site. Prior to installation of drainlines, the drainage trenches shall be backfilled to a minimum depth of 2 inches for a bedding layer of the drain lines. The bedding material shall be an approved fine-gravel aggregate (such as an ASTM C33 designated '#89' stone). The immediate backfill around the drainlines (the filter stone) shall be the same as the bedding layer and shall be installed such that there is a minimum of 2 inches of this stone below, above, and adjacent to each side of the drainline. After the backfill around the drainline, the remaining trench depth shall be backfilled with the approved amending sand (no soil or organic component) to the surface of the existing turf surface.

3.05 INSTALLING SAND SLITS

A. During the drainage system installation process, the existing turf shall be maintained at a mow height of 1 inch.
B. Once the drainage system has been installed, backfilled, compacted, and approved by project architect, the sand-filled slits shall be installed. The sand slits shall be installed at an on-center spacing of 10" and shall be 1" wide and 8" deep.
C. The orientation of the sand sits shall be diagonal to the subsurface drainage trenches and transverse (intercept) the sand-filled drainage trenches..

3.06 SAND TOPDRESSING

A. The field shall be prepared for installation of drainage system and for the sand-filled trenches by the process of low-mowing (1 inch mow height) with clippings removed. Following mow height reduction, roll the surface with a lightweight turf roller.
B. During the drainage system installation process, the existing turf shall be maintained at a mow height of 1 inch.
C. Once the drainage system has been installed, backfilled, compacted, and approved by project architect, the sand-filled slits shall be installed. The sand slits shall be installed at an on-center spacing of 10" and shall be 1" wide and 8" deep.
D. The orientation of the sand sits shall be diagonal to the subsurface drainage trenches and transverse (intercept) the sand-filled drainage trenches..

E. The specifications for the turf slitting equipment is:

Operational width	62" (1.56 m)
Operating depth	8" (0-200 mm)
Tractor speed measured at 540 rpm at PTO	0.3 - 0.9 mph (0.5 - 1.5 Km/h)
PTO rpm: (max.)	540
Weight Including Verti-Quake	4376.2 lbs / 1985 Kg
Number of Filling coulters	6
Distance between the Filling coulters	10" (260 mm)
Thickness of the Filling coulters	1" (25 mm)
Recommended tractor Min.	65-90 hp with four-wheel drive
Maximum operating capacity	25,833 ft2/h (2400 m2/h)
Dimensions (with Verti-Quake 2516)	167.7"x89"x74.8" 4.26x2.26x1.90m
Hopper loading height	75" (1.9m)
Hopper capacity	53cu. ft. (1.5m3)
Hydraulic connection value -	1 single operating valve

Flow min. 15 l/min (4 Gallon/min)

3.07 SAND TOPDRESSING

C. Topdress with sand over the full natural turfgrass area.
1. Topdress at a rate of 100 tons per acre. This is equivalent to an average ½" per acre.
2. Drag sand into aeration holes via drag mat. Dragging shall be performed in multiple directions.
3. Topdressing sand shall meet the same gradation limits as in Part 2.03.

D. Perform an additional drag mat pass after first overseeding pass..

3.08 OVERSEEDING (INTERSEEDING)

A. Overseed over the full natural turfgrass area.
1. Immediately prior to overseeding/interseeding practice, make a final mowing at 1" to the existing turf.
2. Overseed with turfgrass seed blend at a rate of 4 lbs per 1000 ft^2.
3. Apply as blend or if unavailable as a blend, apply each seed source in separate passes/application.
4. Seed shall be seeded as a broadcast application (followed by light dragging as indicated). Dedicated drop seeders are acceptable as long as they do not produce a seed "row" effect. "Row" planting seeders are not acceptable.

B. Perform an additional drag mat pass to improve soil-seed contact Immediately prior to overseeding/interseeding practice, make a final mowing at 1" to the existing turf.
1. Drag mat pass to be light so as to not bury seed more than ¼" deep.

C. As Contractor is responsible for seed establishment, it may be advisable to utilize fungicide-treated (coated) seed. If coated seed is utilized, increase seeding rate to 6 lbs per 1000 ft^2.

D. Seed shall be seeded as a broadcast application (followed by light dragging as indicated). Dedicated drop seeders are acceptable as long as they do not produce a seed "row" effect. "Row" planting seeders are not acceptable..

3.09 TURFGRASS ESTABLISHMENT

A. Establish turfgrass.
1. Test soil to determine fertilization needs. Develop program to promote aggressive seed germination and establishment.
2. Apply fertilizer at a high rate of range provided in product literature based on pounds per acre.
3. Set irrigation rate and schedule to promote seed germination. Set irrigation rate to apply 2.0 inches of water per week with timing appropriate for late summer turf establishment. Taper off irrigation amount and timing as seed establishes so a to avoide soil saturated conditions.
4. Apply systemic fungicide at preventiative rates at 2 weeks following seed germination.

3.10 PROTECTION

A. Immediately after seeding and erect barricades and warnings to protect seeded areas from traffic until grass is established.

B. Repair or replace damaged landscape work and/or irrigation as directed by Engineer.

3.11 MAINTENANCE

A. Begin maintenance immediately after seed placement.

B. Watering:
1. Keep soil moist during seed germination period with applied irrigation water and practice a decrease in watering rate once turf is established to reflect turf development and seasonal changes.
2. Supplement rainfall to produce a total soil depth penetration of 2 inches each day after germination.
3. Do not mow existing turf for 3 weeks after overseeding/interseeding.
4. Prevent erosion and displacing seed.
5. Test soil to determine end of season fertilizer and nutrient treatments.

C. Mowing:
1. Do not mow existing turf for 3 weeks following overseeding/interseeding.
2. The mow height during turf establishment shall be two inches.
3. When grass reaches 2.5 inches in height, mow to 2 inches in height.
4. Maintain grass between 2 inches and 2-1/2 inches in height.
5. Do not cut off more than 30% of grass leaf in a single mowing.
6. Remove grass clippings by bagging only (no turf sweeper/vacs).

D. Reseed and mulch spots larger than 16 square inches not having coverage. Reseed and mulch spots greater than 1 square foot that exhibit non-uniform coverage.

E. Maintain lawns by watering, fertilizing, weeding, mowing, trimming, and other operations such as rolling, regardening and replanting as required to establish a smooth, acceptable lawn, free of eroded or bare areas.

F. Maintain and protect all seeded areas until final acceptance of the Contract. Final acceptance of "Seeding: will not be made until an acceptable uniform stand of grass is obtained in all new lawn areas, except that the Engineer at his discretion may accept a portion or portions of the “Seeding” at various times. Upon acceptance by the Engineer of a seeded area, the Owner will immediately assume responsibility for maintenance and protection of that portion of the Contract Seeding.

3.12 SPRING MAINTENANCE

A. Test soil to determine fertilization needs. Develop program to promote aggressive seed germination and establishment.

B. Interseeding with Kentucky Bluegrass (Turf Blue HGT) at a rate of 1 to 2 pounds per 1,000 sf.

C. Apply pre-emergent herbicide four weeks after germination of overseeding.

D. Mowing to be performed for a period of one month during spring season.
   1. When grass reaches 2.5 inches in height, mow to 2 inches in height.
   2. Maintain grass between 2 inches and 2-1/2 inches in height.
   3. Do not cut off more than 30% of grass leaf in a single mowing.
   4. Remove grass clippings.

3.13 YEAR ONE MAINTENANCE

A. Begin maintenance immediately after spring maintenance seed placement. Maintenance to be authorized based on a yearly service.

B. Apply pre-emergent herbicide four to six weeks after initial spring application.

C. Watering:

   1. Keep soil moist during seed (interseeding) germination period with applied irrigation water and practice a decrease in watering rate once turf is established to reflect turf development and seasonal changes.
   2. Supplement rainfall to produce a total soil depth penetration of 2 inches each day after germination.
   3. Prevent erosion and displacing seed.
   4. Test soil to determine seasonal fertilizer and nutrient treatments.

D. Mowing to be performed by Owner based on Contractors recommendations:

   1. When grass reaches 2.5 inches in height, mow to 2 inches in height.
   2. Maintain grass between 2 inches and 2-1/2 inches in height.
   3. Do not cut off more than 30% of grass leaf in a single mowing.
   4. Remove grass clippings.

E. Reseed and mulch spots larger than 16 square inches not having coverage. Reseed and mulch spots greater than 1 square foot that exhibit non-uniform coverage.

F. Maintain lawns by watering, fertilizing, weeding, mowing, trimming, and other operations such as rolling, regrading and replanting as required to establish a smooth, acceptable lawn, free of eroded or bare areas.

G. Maintain and protect all seeded areas until final acceptance of the Contract. Final acceptance of "Seeding: will not be made until an acceptable uniform stand of grass is obtained in all new lawn areas, except that the Engineer at his discretion may accept a portion or portions of the “Seeding” at various times. Upon acceptance by the Engineer of a seeded area, the Owner will immediately assume responsibility for maintenance and protection of that portion of the Contract Seeding.

H. Post Aceptance Maintance required by the Contractor is outlined in Section 3.14 Below.

3.14 POST ACCEPTANCE ON-GOING MAINTENANCE SERVICE

A. The Contractor shall provide extended maintenance in order to complete the renovations required by the Contract. Extended maintenance shall be prequired for a two year period and include the

following:

1. After the initial surface treatment and after acceptance of the surface by the engineer, aeration and topdressing shall be completed twice a year during the two years after completion of the intial surface treatment as part of the project maintenance requirements.This work shal be completed in the at the end of the fall playing season and at the end of spring playing season.
2. After the initial surface treatment and after acceptance of the surface by the engineer, test soil for nutrient requirements, apply fungicide and fertilizer on a seasonal basis. Interseeding shall be performed during spring and fall seasons as wear indicates. This shall be performed for during the two years after completion of the intial surface treatment as part of the project maintenance requirements. Use the same seed blend during this period as specified for the renovation.

B. During the period of extended maintenance by the Contractor, The Owner shall assume all general maintenance activities.

1. The recommended turfgrass maintenance rquirements for the Owner shall include; mowing, irrigation, monthly fertilization, reseeding and turfgrass establishment of thin and bare spots, raking and or hose washing the migratied infield mix out of the turfgrass edge (to avoid forming alip).
2. The recommended infield area maintenance requires for the Owner shall include: infill edging, rebuilding the mound each season, grooming the infield area, rebuilding base areas, rebuilding homeplate and batters boxes. Once a year the infield area should be decompacted, regradedrolled and groomed as part of preseason preparation
3. It is recommended that the mound and plate areas of the field are covered (tarped) and weighted at all times when not in play. The purpose of the tarps are not simply to protect these high-clay soil areas from rain but just as importently to maintain the soil moisture and keep these areas from drying out. Once dried, these soils are hard to rewet. Hard/dry clay soils tend to remain hard/dry and resist rewettin. In that case the applied water for rewetting tends to first make a slick/mud layer on the surface while the hard/dry clay soil underneath only slowly rewets.
4. In addition to the above it is recommended that after completion of the Contractor's POST ACCEPTANCE that the Owner engages an ON-GOING MAINTENANCE SERVICE.

END OF SECTION 329223

Section 32 91 13.16
MULCH

PART 1 GENERAL

1.0 RELATED DOCUMENTS

Division 00 – PROCUREMENT AND CONTRACTING REQUIREMENTS
Division 01 - GENERAL REQUIREMENTS, as listed in the Table of Contents, including but not limited to the following sections, shall be included in and made a part of this Section:

01 30 00 – SUBMITTALS
01 43 39 – MOCK-UPS
01 81 13 – SUSTAINABLE DESIGN REQUIREMENTS

1.1 DESCRIPTION OF WORK

A. Provide all equipment and materials, and do all work necessary to construct the stone mulch surfacing in planting areas as shown and as drip strip around the building, as indicated on the Drawings and as specified.

1.2 RELATED WORK

A. Examine Contract Documents for requirements that affect work of this Section. Other Specification Sections that directly relate to work of this Section include, but are not limited to:

1. Section 31 20 00, EARTH MOVING Excavation, backfill, compaction and establishment of subgrade elevations.
2. Section 32 80 00, IRRIGATION SYSTEM
3. Section 32 93 00, TREES, PLANTS AND GROUND COVERS

1.3 REFERENCES

A. Comply with applicable requirements of the following standards. Where these standards conflict with other specified requirements, the most restrictive requirements shall govern.

1. American Society for Testing and Materials (ASTM):

D 1557	Moisture-Density Relations of Soils and Soil Aggregate Mixtures Using 10-lb. (4.54-kg) Rammer and 18-in. (475-mm) Drop

2. Massachusetts Department of Transportation (MASSDOT)

Specifications	Standard Specifications for Highways and Bridges

1.4 SUBMITTALS

A. Samples: The following samples shall be submitted:

Material	Sample Size or Quantity
Steel edge	12 in. long section with one stake

B. Manufacturer's Product Data: Manufacturer's product data shall be submitted for the following materials:

Steel edge

C. A 2 lb. sample of stone aggregate shall be submitted for the Architect's approval of material gradation and color, to be native/tan color range.

1.5 TESTING AND INSPECTION

A. The Owner reserves the right to test and inspect materials and construction of stone dust surfacing in accordance with the requirements of Section 014500, QUALITY CONTROL.

PART 2 PRODUCTS

2.1 CRUSHED NATIVE STONE SURFACING MULCH

A. Areas labelled SM on Drawings: Crushed native stone for surfacing shall be in the tan range, 3/8" - ½" crushed, washed, stone.

B. Areas labelled SMB on Drawings shall be Crushed bluestone in the blue/gray range, 3/8"-½" crushed, washed stone.

C. All other areas to receive bark mulch.

D. All stone mulch shall meet the following gradation:

Sieve Size	% Passing by Weight
1/4 in.	100
3/8 in.	80 - 100
No.4	15 - 85
No. 8	0 - 5
No. 200	< 1

2.2 BARK MULCH

A. Mulch shall be a 100% fine-shredded pine bark, of uniform size and free from rot, leaves, twigs, debris, stones, or any material harmful to plant growth. Bark shall have been shredded and stockpiled no less than six months and no more than two years before use. No chunks 3 in. or more in size, and thicker than 1/4 in. shall be left on site.

2.3 EDGING

A. Heavy Duty Edging shall be: Cleanline XL Edging: by Permaloc Corporation, Holland MI 49424, telephone (800) 356-9660, (616) 399-9600, Heavy Duty Duraedge by JD Russell Company, PO Box 183471, Shelby Township, MI 48318 p: 586.254.8500; www.jdrussell.com; Border Guard by Border Concepts, 7621 Little Ave, Suite 426, Charlotte, NC 28226, p: 800.845.3343, www.borderconcepts.com.

1. Thickness: min 3/16 inch
2. Length: Min 10' sections.
3. Depth: min 6"
4. Connection Method: Section ends shall splice together with a horizontal 0.060 inch (1.52 mm) thick x 1 inch (25 mm) wide x 4 inches (102 mm) long aluminum sliding connector.
5. Sections shall have loops on side of section to receive stakes.
6. Stake: min. 12" (305mm) Stakes to interlock into section loops.
7. Finish color: Black. Contractor to submit samples for approval. Paint finish shall comply with AAMA 2603 for electrostatically baked on paint.

PART 3 EXECUTION

3.1 GRADING

A. Areas to receive crushed native stone surfacing will be compacted and brought to subgrade elevation under Section 31 20 00, EARTH MOVING before work of this section is performed. Final fine grading, furnishing and installing crushed native stone surfacing and compaction of these materials as required to form a uniform, accurate, aggregate at required elevations and to required lines, shall be done under this Section.

B. Existing subgrade material which will not readily compact as required shall be removed and replaced with satisfactory materials. Additional materials needed to bring subgrade to required line and grade and to replace unsuitable material removed shall be material conforming to this Section.

C. Subgrade of areas to receive crushed native stone surfacing shall be recompacted as required to bring top 4 in. of material immediately below to a compaction of at least 90% of maximum density, as determined by ASTM D 1557. Subgrade compaction shall extend for a distance of 4" beyond proposed edge of crushed native stone surfacing.

D. Excavation required in subgrade shall be completed before fine grading and final compaction of subgrade are performed. Where excavation must be performed in completed subgrade, subsequent backfill and compaction shall be performed as specified

in Section 31 20 00, EARTH MOVING and Section 329300 Trees, Plants and Groundcovers. Completed subgrade after filling such areas shall be uniformly and properly graded.

E. Areas being graded or compacted shall be kept shaped and drained during construction. Ruts greater than or equal to 1 in. deep in subgrade, shall be graded out, reshaped as required, and recompacted before placing crushed native stone surfacing.

F. Materials shall not be stored or stockpiled on subgrade.

G. Disposal of debris and other material excavated and/or stripped under this section, and material unsuitable for or in excess of requirements for completing work of this section shall be disposed of off-site.

3.2 EDGING

A. Edging shall be installed at locations indicated on the Drawings. Where required, edging shall be cut square and accurately to required length.

1. Steel edging shall be securely staked in required position. Stakes shall be driven every 30 in. o.c. along length of edging.
2. Adjacent lengths of edging shall overlap or be spliced together with manufacturer's standard splicer unit.
3. Edging shall be set plumb and vertical at required line and grade. Straights sections shall not be wavy; curved sections shall be smooth and shall have no kinks or sharp bends.

3.3 STONE MULCH SURFACING AND BARK MULCH

A. Mulch shall be installed only after excavation, construction and planting or any other work which might damage or displace it has been completed. Damage caused during construction shall be repaired before acceptance.

B. Crushed native stone mulch shall be installed in all rain garden areas, at drip strips around the building and in planting areas as shown on the construction drawings to a depth as indicated in the details, all other planting areas are to receive bark mulch.

C. Water shall be added to crushed native stone mulch as required to remove any fines that may have settled during installation.

END OF SECTION

Section 32 92 00
LAWNS AND GRASSES

PART 1 GENERAL

1.0 RELATED DOCUMENTS

Division 00 – PROCUREMENT AND CONTRACTING REQUIREMENTS
Division 01 - GENERAL REQUIREMENTS, as listed in the Table of Contents, including but not limited to the following sections, shall be included in and made a part of this Section:

01 30 00 – SUBMITTALS
01 43 39 – MOCK-UPS
01 81 13 – SUSTAINABLE DESIGN REQUIREMENTS

1.1 DESCRIPTION OF WORK

A. Provide all materials and equipment, and do all work required to complete the seeding and sodding of lawns, as indicated on the Drawings and as specified.

1.2 RELATED WORK

A. Examine Contract Documents for requirements that affect work of this Section. Other Specification Sections that directly relate to work of this Section include, but are not limited to:

1. Section 31 20 00, EARTH MOVING
2. Section 32 80 00, IRRIGATION SYSTEM
3. Section 32 91 19, LANDSCAPE GRADING
4. Section 32 93 00, TREES, PLANTS AND GROUND COVERS.

1.3 REFERENCES

A. Comply with applicable requirements of the following standards. Where these standards conflict with other specified requirements, the most restrictive requirements shall govern.

1. American Society for Testing and Materials (ASTM):

C 136	Sieve Analysis of Fine and Coarse Aggregates
D 422	Particle-Size Analysis of Soils
E 11	Wire-Cloth Sieves for Testing Purposes

1.4 SUBMITTALS

A. Samples: The following samples shall be submitted:

Material	Quantity (lb.)
Seed, each mix	1

B. Manufacturer's Product Data: Manufacturer's product data shall be submitted for the following materials:

Cellulose fiber mulch

C. Certificates: Labels from the manufacturer's container certifying that the product meets the specified requirements shall be submitted for the following materials:

Grass seed

1.5 DELIVERY, STORAGE, AND HANDLING

A. Digging Sod:

1. Sod shall not be dug at the nursery or approved source until ready to transport sod to the site of the work or acceptable storage location.
2. Before stripping, sod shall be mowed at a uniform height of 2 in.
3. Cut sod to specified thickness and to standard width and length

B. Transportation of Sod:

1. Sod transported to the Project in open vehicles shall be covered with tarpaulins or other suitable covers securely fastened to the body of the vehicle to prevent injury. Closed vehicles shall be adequately ventilated to prevent overheating of the sod.
2. Evidence of inadequate protection following the digging, carelessness while in transit, or improper handling shall be cause for rejection.
3. Sod shall be kept moist, fresh, and protected at all times. Such protection shall encompass the entire period during which the sod is in transit, being handled, or are in temporary storage.
4. Upon arrival at the temporary storage location or the site of the work, sod material shall be inspected for proper shipping procedures. Should the sod be dried out, the Architect will reject the sod. When sod has been rejected, the Contractor shall at once remove it from the area of the work and replace it with acceptable material.
5. Unless otherwise authorized by the Architect, the Contractor shall notify the Architect at least two working days in advance of the anticipated delivery date of sod material.

C. Handling and Storage of Sod:

1. Sod material shall be handled with extreme care to avoid breaking or tearing strips.
2. Sod shall not be stored for longer than 30 hours prior to installation. Sod shall be stored in a compact group and shall be kept moist. Sod shall be prevented from freezing.
3. Sod that has been damaged by poor handling or improper storage will be rejected by the Architect.

D. Deliver seed in original sealed containers, labeled with analysis of seed mixture, percentage of pure seed, year of production, net weight, date of packaging, location of packaging, and name of seed grower. Damaged packages will not be accepted.

E. Seed shall be stored under cool and dry conditions so that the endophytic seed in the mixture is capable of maintaining a high level of endophytes

F. Deliver fertilizer in sealed waterproof bags, printed with manufacturer's name, weight, and guaranteed analysis.

1.6 PLANTING SEASON

A. Planting season shall be as follows:

Material	Planting Season	
	Spring	Fall
Seeding and sodding	3/15 to 5/15	8/15 to 10/15

B. Planting shall only be performed when weather and soil conditions are suitable for planting the material specified in accordance with locally accepted practice.

C. Planting season may only be extended with the written permission of the Architect.

1.7 ACCEPTANCE

A. Acceptance:

1. The Architect will inspect all work for Substantial Completion upon written request of the Contractor. The request shall be received at least ten calendar days before the anticipated date of inspection.
2. Acceptance of material by the Architect will be for general conformance to specified requirements, and shall not relieve the Contractor of responsibility for full conformance to the Contract Documents.
3. Upon completion and reinspection of all repairs or renewals necessary in the judgement of the Architect, the Architect will recommend to the Owner that the work of this Section be accepted.

B. Sod and seed areas will be accepted when in compliance with all the following conditions:

1. Roots are thoroughly knit to the soil;
2. Absence of visible joints (sodded areas);
3. All areas show a uniform stand of specified grass in healthy condition;
4. At least 60 days have elapsed since the completion of work under this Section.

PART 2 PRODUCTS

2.1 GENERAL

A. Materials shall be extracted or recovered and manufactured from within 500 miles of project site.

2.2 SEED

A. Seed mixture: To be a Certified No-Mow Fine Fescue with Annual Rye seed mix. Standard grade seed of the most recent season's crop. Seed shall be dry and free of mold. Seed shall be inoculated with endophytes. Seed mixture shall be as follows:

SEED MIX

Name of Seed	% by Weight in Mixture
Festuca longifolia Hard Fescue	25
Festuca rubra var. commutate Chewing Fescue	20
Festuca rubra var. rubra Creeping Red Fescue	20
Festuca ovina Sheep Fescue	25
Perennial Ryegrass	10

2.3 SOD LAWN

A. Certified Turfgrass Sod: Superior sod grown from certified, high quality seed of known origin or from plantings of certified grass seedlings or stolons. It shall be inspected by the certification agency of the state in which it is grown to assure satisfactory genetic identity and purity, overall high quality and freedom from noxious weeds as well as excessive quantities of other crop and weedy plants at time of harvest. All seed or original plant material in mixture must be certified. Turfgrass sod shall meet the published state standards for certification.

1. Sod shall be a mixture of four or five current and improved bluegrass varieties found in the top 25% of the NTEP (National Turfgrass Evaluation Proceedings), with last two tests spanning over 8 years. Mixture shall contain approximately equal proportions of each hybrid component.

B. Sod shall be nursery grown on cultivated mineral agricultural soils. Sod shall have been mowed regularly and carefully, and otherwise maintained from planting to harvest.

C. Thickness of Cut: Sod shall be machine cut at a uniform soil thickness of 5/8 in., plus or

minus 1/4 in., at the time of cutting. Measurement for thickness shall exclude top growth and thatch.

D. Strip Size: Individual pieces of sod shall be cut to the supplier's standard width and length. Maximum allowable deviation from standard widths and lengths shall be plus or minus 1/2 in. on width, and plus or minus 5% on length. Broken strips and torn and uneven ends will not be acceptable.

E. Strength of Sod Strips: Standard size sections of sod shall be strong enough to support their own weight and retain their size and shape if suspended vertically when grasped in the upper 10% of the section.

F. Moisture Content: Sod shall not be harvested or transplanted when moisture content (excessively dry or wet) may adversely affect its survival.

G. Time Limitations: Sod shall be harvested, delivered, and transplanted within a 36 hour period unless a suitable preservation method is approved prior to delivery. Sod not transplanted within this period shall be inspected and approved by the Architect prior to its installation.

H. Thatch: Sod shall be relatively free of thatch. A maximum of 1/2 in. (uncompressed) thatch will be permitted.

I. Diseases, Nematodes, and Insects: Sod shall be free of diseases, nematodes, and soil-borne insects. State Nursery and Plant Materials Laws require that all sod be inspected and approved for sale. The inspection and approval must be made by the State Agricultural Department, Office of the State Entomologist.

J. Weeds: Sod shall be free of objectionable grass and broad leaf weeds. Turfgrass sod shall be considered free of such weeds if less than five such plants are found per 100 sq. ft. of area.

1. Turfgrass sod shall not be acceptable if it contains any of the following weeds: common bermudagrass (wiregrass), quackgrass, johnsongrass, poison ivy, nutsedge, nimblewill, Canada thistle, bindweed, bentgrass, wild garlic, ground ivy, perennial sorrel and bromegrass.

2.4 FESCUE SOD

A. Fescue sod to be Certified No Mow Fine Fescue Sod: Superior sod grown from certified, high quality seed of known origin or from plantings of certified grass seedlings or stolons. It shall be inspected by the certification agency of the state in which it is grown to assure satisfactory genetic identity and purity, overall high quality and freedom from noxious weeds as well as excessive quantities of other crop and weedy plants at time of harvest. All seed or original plant material in mixture must be certified. No Mow Fescue sod shall meet the published state standards for certification.

1. Sod shall be a mixture of three fescues: creeping red, chewing and hard fescues adapted to both mown and unmown conditions. Shall be grown in a controlled environment free of weeds, disease and insect infestations.

B. Sod shall be nursery grown on cultivated mineral agricultural soils. Prior to harvesting No Mow fescue sod shall be mown to a height of 2” for shipment.

C. Thickness of Cut: Sod shall be machine cut at a uniform soil thickness of 3/4 in., plus or minus 1/4 in., plus top growth at the time of cutting.

D. Strip Size: Individual pieces of sod shall be cut to the supplier's standard width and length typically 24” wide x 48” long. Maximum allowable deviation from standard widths and lengths shall be plus or minus 1/2 in. on width, and plus or minus 5% on length. Broken strips and torn and uneven ends will not be acceptable.

E. Strength of Sod Strips: Standard size sections of sod shall be strong enough to support their own weight and retain their size and shape if suspended vertically when grasped in the upper 10% of the section.

F. Moisture Content: Sod shall not be harvested or transplanted when moisture content (excessively dry or wet) may adversely affect its survival.

G. Time Limitations: Sod shall be harvested, delivered, and transplanted within a 36 hour period unless a suitable preservation method is approved prior to delivery. Sod not transplanted within this period shall be inspected and approved by the Architect prior to its installation.

H. Thatch: Sod shall be relatively free of thatch. A maximum of 1/2 in. (uncompressed) thatch will be permitted.

I. Diseases, Nematodes, and Insects: Sod shall be free of diseases, nematodes, and soil-borne insects. State Nursery and Plant Materials Laws require that all sod be inspected and approved for sale. The inspection and approval must be made by the State Agricultural Department, Office of the State Entomologist.

J. Weeds: Sod shall be free of objectionable grassy and broad leaf weeds. No Mow Fescue sod shall be considered free of such weeds if less than five such plants are found per 100 sq. ft. of area.

1. No Mow Fescue sod shall not be acceptable if it contains any of the following weeds: common bermudagrass (wiregrass), quackgrass, johnsongrass, poison ivy, nutsedge, nimblewill, Canada thistle, bindweed, bentgrass, wild garlic, ground ivy, perennial sorrel and bromegrass.

.

2.5 SOD FARM GROWING MEDIUM

A. Sod farm growing medium shall be as specified in Section 329300, TREES, PLANTS AND GROUND COVERS.

2.6 PLANTING SOIL

A. Planting soil shall be as specified in Section 329300, TREES, PLANTS, AND GROUND COVERS.

2.7 WATER

A. Water shall be suitable for irrigation and free from ingredients harmful to seeded or sodded areas.

2.8 SOIL AMENDMENTS

A. Soil amendments shall be as specified in Section 329300, TREES, PLANTS AND GROUND COVERS.

2.9 CELLULOSE FIBER MULCH

A. Cellulose fiber mulch shall be composed of virgin wood, contain a green color additive, be weed free, and non-polluting, containing no germination or growth - inhibiting factors, similar to Hydro Mulch, manufactured by Conwed Corporation, St. Paul, Minnesota 55113.

2.10 WEED CONTROL

A. Weed control for stockpiled topsoil shall be a non-selective weed killer for control of grassy and broadleaf weeds; weed control shall have short residual, allowing seeding and sodding operations to occur within 7 days of application.

PART 3 EXECUTION

3.1 PREPARATION OF SUBGRADE

A. Subgrade shall be examined and prepared in accordance with Section 329300, TREES, PLANTS AND GROUNDCOVERS.

3.2 PLACING AND SPREADING PLANTING SOIL

A. Planting soil shall not be spread until it is possible to follow immediately or within 24 hours with seeding and sodding operations. If planting soil is spread prior to this time it shall be cultivated to loosen soil prior to seeding and sodding.

B. Placing and spreading planting soil shall be performed as specified in Section 329300, TREES, PLANTS AND GROUNDCOVERS.

3.3 APPLICATION OF SOIL AMENDMENTS

A. Fertilizer and conditioners shall be applied as specified in Section 329300, TREES, PLANTS AND GROUNDCOVERS.

3.4 FINISH GRADING

A. Contractor shall set grade lines for Landscape Architect's review and approval. All work per Section 329119 LANDSCAPE GRADING.

1. Final surface of topsoil immediately before seeding and sodding shall be within $\pm$ 1/2 in. of required elevation, with no ruts, mounds, ridges, or other faults, and no pockets or low spots in which water can collect. Stones, roots, and other debris greater than 1 in. in any dimension, which are visible at the surface, shall be removed and the resulting holes filled with topsoil, leaving a uniform planar surface.

B. Finish grade surface with a drag or rake. Round out all breaks in grade, smooth down all lumps and ridges, fill in all holes and crevices. Rolling with a light roller is acceptable, if the surface is scarified afterward.

1. Lawn: Compaction of topsoil for finish grade shall be 85% to 88%.

C. In the event of settlement, the Contractor shall readjust the work to required finished grade.

3.5 SEED APPLICATION

A. Seed shall be applied in two applications; first shall be by mechanical spreader; second shall be by hydroseeding method as specified below.

B. First Application: Seed shall be broadcast by means of an approved mechanical spreader, to give a uniform application at rates recommended by seed supplier.

1. Seed shall be applied in two equal applications for uniform coverage; direction of travel of spreader for second pass shall be perpendicular to that of the first pass. Seeding shall not be done when it is raining or snowing, or when wind velocity exceeds 5 mph.
2. Following seeding the area shall be lightly raked to mingle seed with top 1/8 to 1/4 in. of soil. Area shall then be fine graded. Stones and other debris greater than 1 in. in any dimension which are visible on surface shall be removed.

C. Following seeding and raking, entire area shall be rolled with a hand roller having a weight of 60 to 90 lb./ft. of width, and a minimum diameter of 2 ft. Entire area shall then be watered by use of lawn sprinklers, or other approved means. Initial watering shall continue until the equivalent of a 2 in. depth of water has been applied to entire seeded surface, at a rate which will not dislodge the seed. Watering shall be repeated thereafter as frequently as required to prevent drying of the surface, until the grass attains an average height of 1/4 in. Watering methods and apparatus which may cause erosion of the surface shall not be permitted.

D. At Contractor's Option: In lieu of mechanical spreader, seed may be spread by the hydroseeding method, utilizing power equipment commonly used for that purpose.

1. Seed, lime, fertilizer, and mulch shall be mixed and applied to achieve application quantities specified herein for the conventional seeding method, with mulch applied at the rate of 1,200 lb./acre. Other provisions specified above for conventional seeding shall apply also to hydroseeding.
2. Mulch shall be applied in two stages with 5% to 10% of the quantity applied with seed and the balance applied separately.
3 Seed shall not be placed in water until immediately before application.
4. Centrifugal pumps shall not be used to apply seed mix without fiber mulch. Hand broadcast or use gear pump.
5. Gelscape shall be incorporated at the rate of 15 lb. per acre.

E. Rope off entire seeded area to prevent vehicles and pedestrians from entering area.

3.6 SODDING

A. Edges of the sodded areas shall be smooth, and all sodded areas shall conform to the design cross sections and grade. At edges adjacent to curbs, paved areas, etc., top surface of earth in sod shall be 1/2 in. below adjacent hard surface.

B. Sod shall be placed and all sodding operations completed within 72 hours following stripping from sod source bed.

C. On slopes steeper than 2 to 1, sod shall be fastened in place with suitable wood pins or other approved methods, spaced at not less than 1 pin per square foot.

D. Surface of completed sodded area shall be smooth. Sod shall be laid edge-to-edge, with tight-butted, staggered joints. Sod shall be carefully placed to insure that it is neither stretched or overlapped. Immediately after laying sod shall be pressed firmly into contact with sod bed by tamping or rolling, to eliminate air pockets. Following compaction, topsoil shall be used to fill all cracks, and excess soil shall be worked into grass with rakes or other suitable equipment. Sod shall not be smothered with excess fill soil.

E. Immediately after sodding operations have been completed, entire surface shall be compacted with a cultipacker roller or other approved equipment weighing 100 to 160 lb./ft. of roller.

F. Completed sod shall immediately be watered sufficiently to uniformly wet the soil to at least 1 in. below the bottom of sod bed.

3.7 MAINTENANCE

A. Except as otherwise specified below, maintenance shall include all operations required to produce an established lawn, including but not limited to:
   Fertilizing
   Mowing
   Replanting
   Watering
   Weeding

B. Maintenance of seeded areas shall begin upon completion of seeding and shall continue through completion of two mowings as specified below is completed.

   1. Watering
      a. Week No. 1: Provide all watering necessary to keep seed bed moist at all times. Perform watering daily or as necessary to maintain moist soil to a depth of 4 in.
      b. Week No. 2 and until acceptance of the building, or until mowing as specified below is completed. Water as necessary to maintain adequate moisture in the upper 4 in. of soil to promote seed germination.

   2. Mowing
      a. Not more than 40% of the grass leaf shall be removed during the first or subsequent mowings.
      b. Bluegrass and other cool season grasses shall be maintained between 1-1/2 in. and 2-1/2 in.
      c. All clippings shall be removed.

C. Maintenance of sodded areas shall begin upon completion of sodding and shall continue a minimum of 45 days thereafter including two mowings, unless sodding is not completed until after September 15, in which case maintenance shall continue through June 15 the following year.

   1. Watering
      a. Week No. 1: Provide all watering necessary for rooting of sod. Soil on sod pads shall be kept moist at all times. Perform watering daily or as necessary to maintain moist soil to a depth of 4 in. Watering shall be done during the heat of the day to prevent wilting.

b. Week No. 2 and Subsequent Weeks: Water as necessary to maintain adequate moisture in the upper 4 in. of soil to promote deep root growth.

2. Mowing
   a. Mowing shall not be attempted until the sod is firmly rooted and securely in place. Not more than 40% of the grass leaf shall be removed during the first or subsequent mowings.
   b. Bluegrass and other cool season grasses shall be maintained between 1-1/2 in. and 2-1/2 in.
   c. All clippings shall be removed.
   d. After 2 mowings, the Contractor shall top dress the sod with an application of fertilizer at the rate of 1 pound of actual nitrogen per 1000 square feet.

D. After grass has sprouted, seeded areas which fail to show a uniform stand of grass shall be replanted as often as necessary to establish an acceptable stand of grass with no visible bare spots > 4".

E. Weeds and growth other than varieties of grass named in grass seed formula shall be removed. Removal may be accomplished by use of suitable herbicides or by physical removal, in which case top growth and roots shall both be removed, and bare spots exceeding specified limits shall be reseeded. Owner approval required prior to any application of fertilizer or herbicide.

F. If lawn or grass is established in the fall and maintenance is required to continue into spring months, lawn and grass shall receive an application of lime and fertilizer in the spring. Lime and fertilizer shall be spread in a uniform layer over the entire lawn surface, at the following rates.

Material	Application Rate
Lime	100 lb./1000 sq. ft.
Fertilizer	20 lb./1000 sq. ft.

G. Remove rope barricades only after second cutting of lawns.

END OF SECTION

Section 32 93 00
TREES, PLANTS AND GROUND COVERS

PART 1 GENERAL

1.10 RELATED DOCUMENTS

Division 00 – PROCUREMENT AND CONTRACTING REQUIREMENTS
Division 01 - GENERAL REQUIREMENTS, as listed in the Table of Contents, including but not limited to the following sections, shall be included in and made a part of this Section:

01 30 00 – SUBMITTALS
01 43 39 – MOCK-UPS
01 81 13 – SUSTAINABLE DESIGN REQUIREMENTS

1.1 DESCRIPTION OF WOR

A. Provide all materials and equipment, and do all work required to complete the planting, including furnishing and placing planting soil, as indicated on the Drawings and as specified.

1.2 RELATED WORK

A. Examine Contract Documents for requirements that affect work of this Section. Other Specification Sections that directly relate to work of this Section include, but are not limited to:

1. Section 312000, EARTH MOVING
2. Section 329119, LANDSCAPE GRADING
3. Section 329200, LAWNS AND GRASSES

1.3 REFERENCES

A. Comply with applicable requirements of the following standards. Where these standards conflict with other specified requirements, the most restrictive requirements shall govern. All standards shall include the latest additions and amendments as of the date of advertisement for bids.

1. American National Standards Institute, Inc. (ANSI):

Z60.1	American Standard for Nursery Stock (Sponsor: American Nursery and Landscape Association)
A 300	American National Standards for Tree Care Operations

2. American Society for Testing and Materials (ASTM):

C 136	Sieve Analysis of Fine and Coarse Aggregates
D 422	Particle-Size Analysis of Soils
E 11	Wire-Cloth Sieves for Testing Purposes
F 405	Corrugated Polyethylene (Pe) Tubing and Fittings

3. "Hortus Third", A Concise Dictionary of Plants Cultivated in the United States and Canada, Cornell University, L.H. Bailey Hortorium, MacMillian Publishing Co., New York, NY.

1.5 SUBMITTALS

A. Samples: The following samples shall be submitted:

Material	Sample Size or Quantity
Mulch	1 bag each bark and stone mulch
Soil separator	1 ft.^{2}
Planting soil	1 lb. each mix
Tree stake	24 in. length
Organic Compost	1 lb.
Imported Base Loam	1 lb.
Stripped site base loam	1 lb.
Coarse Sand	1 lb.
Blended Planting soils (ea.)	1 lb.

B. Sources for Soil Components and Soil Mixes: Submit information identifying sources for all soil components and the firm responsible for mixing of soil mixes.

1. Landscape Architect shall have the right to reject any soil source provider. Soil components and blends must be approved in writing prior to delivery to site.

C. Certificates: Labels and reports from the manufacturer/supplier certifying that the product meets the specified requirements shall be submitted for the following materials:

Commercial fertilizer
Limestone
Organic Compost
Coarse Sand
Imported Base Loam
Stockpiled Site Loam (Contractor to have tested and submit report to Landscape Architect if intending to use as base loam)

D. Test Reports: Test reports from an approved testing agency indicating compliance with the specifications shall be submitted for all components listed above (1.5C) and any other materials designated by the Architect.

1.6 OWNER'S INSPECTION AND TESTING

A. Work will be subject to inspection at all times by the Architect. The Owner reserves the right to engage an independent testing laboratory in accordance with requirements of Section 014000, QUALITY REQUIREMENTS to analyze and test materials used in the construction of the work. Where directed by the Architect, the testing laboratory will make material analyses and will report to the Architect whether materials conform to the requirements of this specification.

1. Cost of tests and material analyses made by the testing laboratory will be borne by the Contractor.
2. Testing equipment will be provided by and tests performed by the testing laboratory.

1.7 CONTRACTOR'S INSPECTION AND TESTING

A. The Contractor shall engage an independent testing agency, experienced in the testing of agricultural/manufactured soils and acceptable to the Architect, to perform the topsoil/planting soil tests and analyses specified herein. All costs associated with testing shall be the Contractor's responsibility.

1. Particle size analysis shall include the following gradient of mineral

content:

USDA Designation	Size in mm
Gravel	+ 2 mm Very
coarse sand	1-2 mm
Coarse sand	0.5-1 mm
Medium sand	0.25-0.5 mm
Fine sand	0.1-0.25 mm
Very fine sand	0.05-0.1 mm
Silt	0.002-0.05 mm
Clay	< 0.002 mm

2. Chemical analysis shall include the following:
   a. pH and buffer pH
   b. percentage of organic content by oven-dried weight
   c. Nutrient levels by parts per million, including phosphorus, potassium, magnesium, manganese, iron, zinc, and calcium. Nutrient test shall include testing laboratory recommendations for supplemental additions to the soil, if necessary, based on the requirements for ornamental horticultural plants. Recommendations shall include rates at which additives are to be applied.
   d. Soluble salt by electrical conductivity of a 1:2 soil/water sample.

1.8 SOURCE QUALITY CONTROL

A. Identification of plant materials shall be as named in "Hortus Third".

B. Selection of Plant Materials: Contractor shall submit to Architect a complete list of all proposed nurseries including location, contact #, plant list for each nursery, all proposed substitutions, credits and/or additional charges. No tagging will occur until this list is complete and submitted. Contractor shall be responsible for delays if list is not submitted complete and in advance of proposed tagging dates.

1. Inspect all nursery materials to determine that the materials meet the requirements of this section. Proposed materials shall be flagged by the nurseries for review by the Contractor and the Architect.
2. Schedule with the Architect a time for viewing plant material at the nursery. Trips to nurseries shall be efficiently arranged to allow Architect to maximize viewing time. A minimum of six weeks shall be allowed for this viewing prior to time that plants are to be dug.
3. Architect may choose to attach seal to each plant, or representative samples.
4. Viewing and/or sealing of plant materials by the Architect at the nursery does not preclude the Architect's right to reject material at the site of planting.
5. Architect will provide a maximum of two (2) tagging trips within 2.5 hour drive from Boston, MA.

C. Plant Photographs: For any plants not tagged by Landscape Architect contractor is to provide color photographs in digital format of each required species and size of plant material as it will be furnished for the Project. Take photographs from an angle depicting true size and condition of the plant to be provided. Include a scale rod or other measuring device in each photograph. Include a minimum of three photographs showing best plant quality and worst plant quality for each species to be furnished. Clearly identify photographs with botanical name, size and source nursery.

1.9 QUALITY ASSURANCE

A. Installer Qualifications: A qualified landscape Installer whose work has resulted successful establishment of plants. Installer shall provide evidence of the following credentials:

1. Professional Membership: Installer shall be a member in good standing of either the Professional Landcare Network or the American Nursery and Landscape Association.
2. Experience: Five years' experience in landscape installation in addition to requirements in Division 01 General Requirements."
3. Installer's Field Supervision: Require Installer to maintain an experienced full-time supervisor on Project site when work is in progress.
4. 3 projects similar scale (within 10% of proposed project SF of landscape area and/or construction value) within last 5 years
5. 3 references with phone numbers
6. 3 photos each for each reference project
7. Positive responses from all references
8. Reference project review by Architect and Owner within New England area
9. Proof of no current or past litigation over project work.

B. Pesticide Applicator: State licensed, commercial.

C. Soil-Testing: Testing Agencies: The following firms are acceptable testing. Agencies for the various components.
1. Leaf Yard Waste Compost Stability Test and Pathogens/ Metals/ Vector Attraction: Woods End Research Laboratory, P.O. Box 297, Mt. Vernon, ME, 04352, tel: 201.293.2457, fax: 201.293.2488.
2. Leaf Yard Waste Compost/ All other tests except those listed above: University of Massachusetts, West Experiment Station, Amherst, MA 01003, tel: 413.545.2311, fax: 413.545.1931.
3. Mechanical Gradation and Chemical Analysis, All Components and Soil Mixes: University of Massachusetts, West Experiment Station, Amherst, MA 01003, tel: 413.545.2311, fax: 413.545.1931. or Approved Equal.

D. Certificate/Certified Reports: Within 2 weeks of placement, contractor shall submit certification that all soil blend components and all soil blends meet all environmental standards of the State of MA.

E. Submit certified reports for the following data for all proposed blended planting soils:
1. Mechanical gradation (sieve analysis) shall be performed and compared to the USDA Soil Classification System. Percent clay (0.002 mm) shall be reported separately in addition to silt (ASTM D-422-63, hydrometer method).
2. The silt and clay content shall be determined by a Hydrometer Test of soil passing the #270 sieve.
3. Chemical analysis shall be undertaken for Phosphorus, Potassium, Calcium Magnesium, Aluminum, Iron, Manganese, Lead, Cation Exchange Capacity, Soluble Salts, acidity (pH) and buffer pH. Recommendations for pH adjustments and fertilizer soil amendments shall be included with all test reports.
4. Certified reports on analyses from producers of composted organic materials are required, particularly when sources are changed. Analyses will include all tests for criteria specified in 2.2C.
5. Density Tests: In-place density testing is required in all areas. Placed planting soils must be inspected for compaction level by a soil scientist or by the following: ASTM D1556 Density of Soil and Rock In Place Using Sand Cone Method, ASTM D6938-10 Nuclear Methods or ASTM D2167-08 Rubber Balloon method after conducting ASTM D698 Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort. In-place density tests shall be carried out at a rate of one test per 1,000 square feet for each type of material placed.
6. Allow sufficient time to obtain all blended soil test approval and obtain the maximum dry density and optimum moisture content by ASTM 698 Standard Proctor Test.

F. In-place percolation tests shall be performed using Turf-Tec IN2-W Infitrometer utilizing manufacturer's operating instructions. Turf-Tech IN2-W Infiltrometer as manufactured by Turf Tec International, 1471 Capital Circle NW, Suite #13, Tallahassee, FL 32303. Order Line 800-258-7477, Phone 850-580-4026, Fax 850-580-4027.
1. In-place infiltration tests shall be carried out at a rate of one test per each 1,000 square feet in lawn areas and planting beds.

1.10 PLANT MATERIAL QUANTITIES

A. In the event of a discrepancy in plant material quantities between the Drawings and the Plant List(s), the larger quantity shall be required.

1.11 UNAVAILABILITY OF PLANT MATERIALS

A. Before changes or substitutions can be made due to unavailability of plant material, submit satisfactory evidence that the Contractor has advertised for a one month period in a trade journal such as the "American Nurseryman", (Tel. 312-427-7339 and Fax: 312-427-7346), with no response, or has undertaken other methods of locating plant material acceptable to the Architect. No planting substitutions are allowed without written approval of Landscape Architect.

1.12 DELIVERY, STORAGE, AND HANDLING

A. Transportation of Plant Material: Plants transported to the project in open vehicles shall be covered with tarpaulins or other suitable covers securely fastened to the body of the vehicle to prevent injury to the plants. Closed vehicles shall be adequately ventilated to prevent overheating of the plants. Trees shall not be transported when daytime air temperatures are below 20°.

1. Plants shall be kept moist, fresh, and protected at all times. Such protection shall encompass the entire period during which the plants are in transit, being handled, or are in temporary storage.

2. Unless otherwise authorized by the Architect, notify the Architect at least five working days in advance of the anticipated delivery date of any plant material. A legible copy of the bill of lading, showing the quantities, kinds, and sizes of materials included for each shipment shall be furnished to the Architect, if requested.

B. Storage: Unless specific authorization is obtained from the Architect, unprotected plants shall not remain on the site of work longer than three days prior to being planted.

1. Plants that are not planted immediately shall be protected as follows:
   a. Earth balls shall be kept moist, not be allowed to freeze, and their solidity carefully preserved.
2. Both the duration and method of storage of plant materials shall be subject to the approval of the Architect.

C. Handling of Plant Materials: Exercise care in handling plant materials to avoid damage or stress.

1.13 REJECTION OF MATERIALS

A. Evidence of inadequate protection following digging, carelessness while in transit, or improper handling or storage, shall be cause for rejection.

B. Upon arrival at the temporary storage location or the site of the work, plants shall be inspected for proper shipping procedures. Plants with roots dried out, large branches broken, balls of earth broken or loosened, or areas of bark torn shall be subject to rejection by the Architect.

C. Rejected plants shall be removed from the area of work and replaced with same species of the required size and quality.

D. Architect may reject plants on site if they do not meet quality requirements and/or form represented in photo submittals.

1.14 DIGGING/PLANTING SEASONS

A. Spring Digging: Spring digging of plant materials may commence as soon as the ground has thawed and weather conditions make it practicable to dig at the nursery.

1. Deciduous plants shall not be dug after they have leafed out.
2. Broadleaf evergreens and conifers shall not be dug after new growth or candle push is visible.

B. Fall Digging: Fall digging of plant materials may commence after dormancy has begun and shall continue until such time as the ground has frozen or weather conditions make it impractical to work.

1. Fall digging hazards shall conform to American National Standards Institute, Inc. (ANSI) species and guidelines.

C. Planting Seasons: Planting shall only be performed when weather and soil conditions are suitable for planting the material specified, in accordance with locally accepted practice, approval of the Architect, and to maintain the Contractor's guarantee.

1.15 ACCEPTANCE FOR SUBSTANTIAL COMPLETION

A. The Architect shall inspect all work of this Section for Acceptance for Substantial Completion upon receipt of written notice of completion by the Contractor. The request shall be received at least ten calendar days before the anticipated date of inspection.

B. Acceptance of plant material by the Architect shall be for general conformance to specified size, character, and quality, and shall not diminish responsibility for full conformance to the Contract Documents.

C. Upon completion and reinspection of all repairs or renewals necessary in the judgement of the Architect, the Architect shall recommend that Acceptance for Substantial Completion of the work of this Section be given by the Owner.

D. Acceptance in Part

1. The work may be Accepted in parts when it is deemed to be in the Owner's best interest to do so, and when permission is given to the Contractor in writing to complete the work in parts.

2. Acceptance and use of such areas by the Owner shall not waive any other provisions of this Contract.

1.16 MAINTENANCE

A. The Contractor shall maintain plant material until the completion of the guarantee period and Final Acceptance of work, as described in paragraph 3.20 of this Section.

1.17 GUARANTEE

A. Plants shall be guaranteed for a period of one year after the date of Acceptance by the Owner.

1. When the work is Accepted in parts, the guarantee periods shall extend from each of the partial Acceptances to the terminal date of the last guarantee period. Thus, all guarantee periods terminate at one time.

B. Plants shall be healthy, free of pests and disease, and in flourishing condition at the end of the guarantee period. Plants shall be free of dead and dying branches and branch tips, and shall bear foliage of normal density, size, and color.

C. Replace dead plants and all plants not in a vigorous, thriving condition, as determined by the Architect during and at the end of the guarantee period, without cost to the Owner, as soon as weather conditions permit and within the specified planting period.

1. Replacements shall closely match adjacent specimens of the same species. Replacements shall be subject to all requirements stated in this Specification.

2. Make all necessary repairs due to plant replacements. Such repairs shall be done at no extra cost to the Owner.

3. The guarantee of all replacement plants shall extend for an additional one year period from the date of their Acceptance after replacement. In the event that a replacement plant is not acceptable during or at the end of the said extended guarantee period, the Owner may elect one more replacement or credit for each item.

D. At the end of the guarantee period, and no less than five days prior to final inspection, staking and guying materials, and tree wrap and ties shall be removed from the site.

1.18 FINAL INSPECTION AND FINAL ACCEPTANCE

A. At the end of the guarantee period, the Architect shall, upon receipt of written notice of end of guarantee period, inspect the work for Final Acceptance. Request shall be received at least ten calendar days before the anticipated date for Final Inspection.

B. Upon completion and reinspection of full repairs or replacements necessary in the judgment of the Architect at that time, the Architect shall recommend to the Owner that Final Acceptance of the work of this Section be given.

PART 2 PRODUCTS

2.1 PLANTS

A. Except as otherwise specified, size and grade of plant materials and their root balls shall conform to ANSI Z60.1.

B. Plants shall have outstanding form; symmetrical, heavily branched with an even branch distribution, densely foliated and/or budded, and a strong, straight, distinct leader where this is characteristic of species. Plants shall possess a normal balance for the species between height and spread. The Architect will be the final arbiter of acceptability of plant form.

1. Shade Trees: Single-stem trees with straight trunk, well-balanced crown, and intact leader, of height and caliper indicated, complying with ANSI Z60.1 for type of trees required.
2. Small Trees: Branched or pruned naturally according to species and type, with relationship of caliper, height, and branching according to ANSI Z60.1.
3. Multi-stem Trees: Branched or pruned naturally according to species and type, with relationship of caliper, height, and branching according to ANSI Z60.1.
4. Deciduous Shrubs: Form and Size: Deciduous shrubs with not less than the minimum number of canes required by and measured according to ANSI Z60.1 for type, shape, and height of shrub.
5. Coniferous Evergreens: Form and Size: Normal-quality, well-balanced, coniferous evergreens, of type, height, spread, and shape required, complying with ANSI Z60.1.
6. Coniferous Evergreens: Form and Size: Specimen-quality, exceptionally heavy, tightly knit, symmetrically shaped coniferous evergreens.
7. Broadleaf Evergreens: Form and Size: Normal-quality, well-balanced, broadleaf evergreens, of type, height, spread, and shape required, complying with ANSI Z60.1.

C. Plants shall be healthy and vigorous, free of disease, insect pests and their eggs, and larvae.

D. Plants shall have a well-developed fibrous root system.

E. Plants shall be free of physical damage such as scrapes, broken or split branches, scars, bark abrasions, sunscalds, fresh limb cuts, disfiguring knots, or other defects.

F. Plants shall meet the sizes indicated on the Plant List. Plants larger or smaller than specified may be used only if accepted in writing by the Architect.

G. Where a size or caliper range is stated, at least 50% of the material shall be closer in size to the top of the range stated.

H. Plants shall not be pruned before delivery.

I. All trees and shrubs shall be labeled. Labels shall be durable and legible, stating the correct plant name and size in weather-resistant ink or embossed process. Labels shall be securely attached to all plants prior to delivery to the site, being careful not to restrict growth.

J. Plants indicated as "B&B" shall be balled and burlapped.

1. Unless otherwise permitted by the Architect, plants shall be nursery grown.
2 Plants shall be grown for at least two years under climatic conditions similar to those in the locality of the Project.
3. Nursery grown plants shall be dug in the current planting season. No heeled in plants or plants from cold storage that were dug in the previous season shall be accepted.

K. Container grown plants shall be well rooted and established in the container in which they were grown. They shall have grown in the container for a sufficient length of time for the root system to hold the planting medium when taken from the container, but not long enough to become root bound. Container grown plants exceeding the sizes indicated in ANSI Z60.1 shall have containers which are not less than 75% of the ball sizes for comparable B&B plant material. Each container plant shall be inspected and circling roots loosened or pruned as needed.

L. Canes or Trunk(s) and Branches:

1. Very well formed and sturdy with distinct leader and no crotches that may interfere with growth of leader. Trees with included bark in crotches shall be avoided.
2. Branching, well- spaced and uniformly distributed both vertically and around the circumference to form a well-balanced plant.
3. Scars shall be free of rot and not exceed ¼ the diameter of the wood beneath in greatest dimension unless completely healed (except pruning scars).
4. Pruning scars clean cut leaving little or no protrusion from the trunk or branch.
5. Graft union completely healed.
6. No mechanical or pest damage.
7. No extreme succulence.
8. Evidence of adequate twig growth in the past 2-4 years, and well-formed buds.
9. Root flare must be exposed to adequate depth and be visible.

M. Foliage:

1. Densely supplied with healthy, vigorous leaves of normal size, shape, color and texture
(except shrubs moved bare-root or deciduous shrubs when dormant).
2. One half of the foliage should be growing on the lower 2/3 of the trunk.
3. No chlorosis.
4. No more than 5% of total foliage affected by pest or mechanical damage.

N. Root System:

1. Sturdily established and evenly distributed.
2. Container grown plants shall be well developed and hold the soil ball together when removed from the container.
3. Container grown plants shall not be excessively rootbound.

2.2 PLANTING SOIL

A. Base Loam

1. Existing topsoil from on-site source(s) may be used for planting base loam, to the extent available, if it meets the requirements of this Section for planting soil, or if approved by the Architect.
2. If the existing topsoil does not meet requirements imported base loam should be sourced and tested to meet requirements of the project.
   a. Base Loam, as required for blending with sand and compost, shall be a naturally occurring soil formed from geologic soil forming processes without admixtures of sand or organic matter sources (composts). Base Loam, which has been contaminated by incorporation of subsoil, shall not be acceptable for use. Base Loam as required for the work shall be free of subsoil, large stones, earth clods, sticks, stumps, clay lumps, roots or other objectionable, extraneous matter or debris. Base Loam shall also be free of quack-grass rhizomes, Agropyron Repens, and the nut-like tubers of nutgrass, Cyperus Esculentus, and all other primary noxious weeds. Base Loam shall not be delivered or manufactured into soil blends while in a frozen or muddy condition. Base Loam for mixing shall conform to the following grain size distribution for material passing the #10 sieve:

	Percent Passing	
U.S. Sieve Size Number	Minimum	Maximum
10	---	100
18	85	100
35	70	95
60	50	85
140	36	53
270	32	42
0.002mm	3	6

   b. The ratio of the particle size for 80% passing (D_{80}) to the particle size for 30% passing (D_{30}) shall be 8 or less ($D_{80}/D_{30} < 8$).
   c. Maximum size shall be one-inch largest dimension. The maximum retained on the #10 sieve shall be 20% by weight of the total sample. Tests shall be by combined hydrometer and wet sieving in compliance with ASTM D422 after destruction of organic matter by ignition.
   d. The organic content shall be between 4.0 and 8.0 percent by weight.
   e. pH shall be between 5.8 and 7.0.
   f. Chemical analysis shall be undertaken for Phosphorus, Potassium, Calcium Magnesium, Aluminum, Iron, Manganese, Lead, Cation Exchange Capacity, Soluble Salts, acidity (pH) and buffer pH.

B. Coarse Sand

1. Sand for Soil Blends, protection of filter fabric and for drainage as required, shall be uniformly graded medium to coarse sand consisting of clean, inert, rounded to sub-angular grains of quartz or other durable rock free from loam or clay, mica, surface coatings and deleterious materials with the following grain size distribution for material passing the #10 sieve:

Percent Passing U.S. Sieve Size Number	Minimum	Maximum
10	100	--
18	60	80
35	25	45
60	8	20
140	0	8
270	0	3
0.002mm	0	0.5

2. Maximum size shall be one-inch largest dimension. The maximum retained on the #10 sieve shall be 20% by weight of the total sample.
3. The ratio of the particle size for 70% passing (D_{70}) to the particle size for 20% passing (D_{20}) shall be 3.0 or less (D_{70}/D_{20} <3.0). Tests shall be by combined hydrometer and wet sieving in compliance with ASTM D422.
4. pH shall be less than 7.5.

C. Organic Amendment (Compost)

1. Organic Matter for amending planting soils shall be a stable, humus-like material produced from the aerobic decomposition and curing of Leaf Yard Waste Compost, composted for a minimum of one year (12 months). The leaf yard waste compost shall be free of debris such as plastics, metal, concrete or other debris. The leaf yard waste compost shall be free of stones larger than 1/2", larger branches and roots. Wood chips over 1" in length or diameter shall be removed by screening. The compost shall be a dark brown to black color and be capable of supporting plant growth with appropriate management practices in conjunction with addition of fertilizer and other amendments as applicable, with no visible free water or dust, with no unpleasant odor, and meeting the following criteria as reported by laboratory tests. Compost shall contain no biosolids.

   a. The ratio of carbon to nitrogen shall be in the range of 12:1 to 25:1.
   b. Stability shall be assessed by the Solvita procedure. Protocols are specified by the Solvita manual (version 4.0). The compost must achieve a maturity index of 6 or more as measured by the Solvita scale. Stability tests shall be conducted by Woods End Research Laboratory, Mt. Vernon, Maine.
   c. Pathogens/Metals/Vector Attraction reduction shall meet 40 CFR Part 503 rule, Table 3, page 9392, Vol. 58 No. 32, and NH equivalent to Commonwealth of Massachusetts 310 CMR 32.00 (for applications to soils with human activity).
   d. Organic Content shall be at least 25 percent (dry weight). One hundred percent of the material shall pass a 1/2-inch (or smaller) screen. Debris such as metal, glass, plastic, wood (other than residual chips), asphalt or masonry shall not be visible and shall not exceed one percent dry weight. Organic content shall be determined by weight loss on ignition for particles passing a number 10 sieve according to procedures performed by the West Experiment Station at the University of Massachusetts, Amherst or equal.
   e. pH: The pH shall be between 6.5 to 7.4 as determined from a 1:1 soil-distilled water suspension using a glass electrode pH meter American Society of Agronomy Methods of Soil Analysis, Part 2, 1986.
   f. Salinity: Electrical conductivity of a one to five soil to water ratio extract shall not exceed 2.5 mmhos/cm (dS/m).

g. The compost shall be screened to 1/2-inch maximum particle size and shall contain not more that 3 percent material finer that 0.002mm as determined by hydrometer test on ashed material.

h. Nutrient content shall be determined by the University of Massachusetts Soil Testing Laboratory or equivalent laboratory and utilized to evaluate soil- required amendments for the mixed soils. Chemical analysis shall be undertaken for Nitrate Nitrogen, Ammonium Nitrogen, Phosphorus, Potassium, Calcium, Aluminum, Magnesium, Iron, Manganese, Lead, Soluble Salts, Cation Exchange Capacity, soil reaction (pH), and buffer pH.

2.3 PLANTING SOIL MIXES

A. All existing vegetation shall be removed from stockpiles prior to blending. Uniformly mix ingredients by windrowing/tilling on an approved hard surface area or by alternately processing materials through a screening plant. All soil components and Organic Amendment shall be maintained moist, not wet, during mixing. Amendments shall not be added unless approved to extent and quantity by the owner and additional tests have been conducted to verify type and quantity of amendment is acceptable. Percentages of components are approximate, and will be verified upon completion of individual test results for components of the various mixes. Due to variability of soil materials, mix ratios may require adjustment and re-submittal at the expense of the Contractor.

B. After component percentages are determined by the Landscape Architect, each planting soil mix shall be tested for physical and chemical analysis. Component percentages may be modified at any time by the Landscape Architect dependent upon the results of testing of the various components or final blends.

C. PERENNIAL, SHRUB AND TREE MIX SOILS

1. This Planting Bed Soil shall consist of a combination of approximately by volume one and a half parts Stripped Existing or Imported Base Loam, two parts Coarse Sand and one part Organic Amendment/Compost **(1.5L:2S:1C).** The following gradation for material passing a Number 10 Sieve shall be achieved in the final mix.

	Percent Passing	
U.S. Sieve Size No.	Minimum	Maximum
10	100	
18	85	95
35	60	85
60	42	65
140	21	44
270	18	24
0.002 mm	2	4

2. Maximum size shall be one half-inch largest dimension. The maximum retained on the #10 sieve shall be 10% by weight of the total sample.
3. The ratio of the particle size for 80% passing (D_{80}) to the particle size for 30% passing (D_{30}) shall be 6 or less (D_{80}/D_{30} <6).
4. The final mix shall have an organic content between 5 and 7 percent by weight.

5. The final mix shall have a hydraulic conductivity of not less than 1.5 inches per hour according to test procedure ASTM D5856-95 (2000) hour when compacted to a minimum of 86 percent Standard Proctor ASTM D 698. Tests shall be by combined hydrometer and wet sieving in compliance with ASTM D422 after destruction of organic matter by ignition.
6. Chemical analysis shall be undertaken for Phosphorus, Potassium, Calcium Magnesium, Aluminum, Iron, Manganese, Lead, Cation Exchange Capacity, Soluble Salts, acidity (pH) and buffer pH.

D. LAWN/SOD SOILS

1. Stripped Existing or Imported Base Loam, Sand and Compost, each as specified above, shall be combined in an approximate mix ratio of two and a half parts by volume Sand to one part by volume Base Loam to one and one half parts by volume Compost **(2.5S:1L:1C)** to create a uniform blend which meets the following requirements.
2. Gradation for Material Passing the Number 10 Sieve:

	Percent Passing	
U.S. Sieve Size No.	Minimum	Maximum
10	100	100
18	70	90
35	45	72
60	28	43
140	18	22
270	14	18
0.002mm	2	4

3. Maximum size shall be one-inch largest dimension. The maximum retained on the #10 sieve shall be 20% by weight of the total sample.
4. Ratio of the particle size for 70% passing (D70) to the particle size for 20% passing (D20) shall be 5.5 or less (D70/D20 <5.5).
5. Saturated hydraulic conductivity of the mix shall not be less than 3.0 inches per hour according to ASTM D5856-95 (2000) when compacted to a minimum of 88% Standard Proctor, ASTM 698.
6. Organic content shall be between 4.5 and 6.0 percent by weight.
7. pH shall be between 6.2 and 6.8
8. Chemical analysis shall be undertaken for Phosphorus, Potassium, Calcium Magnesium, Aluminum, Iron, Manganese, Lead, Cation Exchange Capacity, Soluble Salts, acidity (pH) and buffer pH.

E. BIORETENTION SOILS

The following specifications set forth the required characteristics for materials used in bioretention facilities.

1. Bioretention Planting Soil shall be a uniform mix and consist of loose, friable soil, free of ice, snow, and rubbish with no foreign matter, or material harmful to plant growth. Soil shall be reasonably free of stones, stumps, lumps, roots, and weeds or similar objects larger than 1-inch in diameter. No other materials or substances shall be mixed or dumped within the bioretention area that may be harmful to plant growth or prove a hindrance to the planting or maintenance operations.

2. Bioretention Planting Soil shall be a mixture of sand, compost, and base loam to the following approximate proportions by volume: 40% Sand, 20-30% topsoil, and 30-40% compost.

Compost, sand, and base loam materials shall be as specified herein.

3. The Bioretention Planting Soil mixture shall be tested and meet the following criteria:

Textural Class	**Percent of Total Weight**
Gravel (greater than 2 mm)	< 15%
Sand (0.05-2.0mm diameter)	> 85%
Silt (0.002-0.05 mm diameter)	< 10%
Clay (less than 0.002 mm diameter)	< 2%

4. The final Bioretention Planting Soil mixture shall be tested and meet the following parameters:

Parameters	**Range**
pH	5.5 – 7.5
Moisture Content	25% – 55%
Organic Matter Content	4 – 7% (dry weight basis)
Stone and Debris	< 5% (by weight)
Soluble Salts	2.5 mmhos (dS)
Magnesium	Minimum 32 ppm
Phosphorus (Phosphate-P_2O_5)	Not to exceed 69 ppm
Potassium (K_2O)	Minimum 78 ppm

Parameters	Range
Foreign Matter	<.05% (by weight)

5. The Bioretention Planting Soil mixture shall be free of Knotweed, Phragmites, Purple Loosestrife, Bermuda grass, Quackgrass, Johnson grass, Mugwort, Nutsedge, Poison Ivy, Canadian Thistle, Teathumb, or other noxious weeds.

2.4 LIMESTONE

A. Limestone shall be an approved agricultural limestone containing no less than 50% of total carbonates, and 25% total magnesium with a neutralizing value of at least 100%. The material shall be ground to such a fineness that 40% will pass through a No. 100 U.S. Standard Sieve, and 98% will pass through a No. 20 U.S. Standard Sieve. The lime shall be uniform in composition, dry and free flowing, and shall be delivered to the site in the original unopened containers, each bearing the manufacturer's guaranteed analysis. Any lime which becomes caked or otherwise damaged making it unsuitable for use, will be rejected.

2.5 ALUMINUM SULFATE

A. Aluminum sulfate shall be unadulterated and shall be delivered in containers with the name of the material and manufacturer and net weight of contents.

2.6 WATER

A. Water shall be suitable for irrigation and shall be free from ingredients harmful to plant life.

2.7 FERTILIZER

A. Commercial Fertilizer: Commercial-grade complete fertilizer of neutral character, consisting of fast- and slow-release nitrogen, 50 percent derived from natural organic sources of urea formaldehyde, phosphorous, and potassium in the following composition:

1. Composition: Nitrogen, phosphorous, and potassium in amounts recommended in soil reports from a qualified soil-testing agency. Manufacturer’s literature shall be submitted for approval.

B. Slow-Release Fertilizer: Granular or pelleted fertilizer consisting of 50 percent water- insoluble nitrogen, phosphorus, and potassium in the following composition:

1. Composition: Nitrogen, phosphorous, and potassium in amounts recommended in soil reports from a qualified soil-testing agency.

2.8 SUPERPHOSPHATE

A. Superphosphate shall be composed of finely ground phosphate rock as commonly used for agricultural purposes, and containing not less than 20% available phosphoric acid. The superphosphate shall be delivered to the site in the original unopened containers, each bearing the manufacturer's guaranteed analysis. Any superphosphate which becomes caked or otherwise damaged making it unsuitable for use, will be rejected.

2.9 MULCH

A. See Section 329113.16 Mulch

2.10 GUYING AND STAKING MATERIALS

A. Wood Stakes: Straight, sound, rough sawn lumber 2 in. x 2 in., if square, or 2-1/2 in. diameter, if round. Stakes shall be stained dark green. Wire for staking shall be 12 gauge steel.

B. Wire for Guying: Galvanized steel 1 x 19 preformed 3/16 in. diameter. Thimbles and nicopress clips shall be used for connections and splices.

C. Turnbuckles: ¼" x 73/4" Galvanized steel with a 21/2" in. lengthwise opening fitted with eyebolts, as manufactured by Crown Bolt Inc., or approved equal.

D. Hose: High quality braided rubber hose, 3/4 in. diameter and suitable length, black in color.

E. Strapping: Arbortie, manufactured by DeepRoot Green Infrastructure, LLC, 530 Washington Street, San Francisco, CA 94111Tel: 800 458 7668 or 415 781 9700; Fax: 800; 277 7668 or 415 781 0191, or approved equal.

2.11 ANTIDESICCANT

A. Antidessicant shall be an emulsion specifically manufactured for plant protection which provides a protective film over plant surfaces which is permeable enough to permit transpiration. Antidessicant shall be delivered in manufacturer's sealed containers and shall contain manufacturer's printed instructions for use.

B. Antidessicant shall be equal to the following:

Product	Manufacturer
Wilt-Pruf	Wilt-Pruf Products, Inc. P.O. Box 469 Essex, CT 06426
Winter Shield	Rockland Corporation

2.12 FUNGICIDE

A. Fungicide shall be "Bordeaux Mix", manufactured by Hi-Yield, or approved equal.

2.13 INSECTICIDE

A. Insecticide shall be LESCO Horticultural Oil spray, #001150, for control of insects and mites, manufactured by LESCO, Rocky River, OH 44116, or approved equal.

2.14 POST-EMERGENT HERBICIDE

A. Herbicide shall be QuikPRO™ herbicide, formulated as a water-soluble granule and packaged in easy-measure bottles, complete weed control, manufactured by Monsanto, or approved equal.

2.15 PRE-EMERGENT HERBICIDE

A. Herbicide shall be LESCO Ornamental Herbicide 5G, pre-emergent grassy and selected broadleaf weed control for ornamental plants, nursery stock and ground covers, #019515, manufactured by LESCO, Rocky River, OH 44116, or approved equal.

2.16 TREE WATERING STAKE

A. Tree watering stake shall be Deep Drip Tree Watering Stake, manufactured by Green King, LLC – World Headquarters,162 W. Boxelder Place – Suite #2, Chandler, AZ 85225;Tel: (480) 422-0251; Fax: (480) 503-2329**;** Email: info@deepdrip.com, or approved equal.

1. Stakes shall be 14 in., 24 in., or 36 in. as recommended appropriate by manufacturer for size of tree or shrub.

PART 3 EXECUTION

3.1 PREPARATION OF PLANT MATERIALS

A. Immediately before digging and following consultation with the Architect, spray all evergreen or deciduous trees in full leaf with Transplant Biostimulant, applying an adequate film over trunks, branches, twigs, and foliage and apply Transplant Biostimulant to the root ball area

B. Dig and ball and burlap (B&B) plants with firm, natural balls of earth, of depth and diameter not less than that recommended by the American Standard for Nursery stock. Plants moved with a ball will not be accepted if the ball is cracked or broken before or during planting operation. Remove all grass, weeds and accumulated soil resulting from nursery cultivation from the top of the root ball prior to digging so that the original trunk flare shows on top of the root ball.

C. Use only natural burlap and jute twine. Do not use synthetic fibers or wire to ball and burlap root balls. Wire baskets will be acceptable if removed in accordance with these specifications.

D. All plant material in transit or temporary stored shall be covered with burlap or similar covering to keep plants from drying out.

E. Ship and store bare root material in refrigerated trucks and storage areas. Keep roots moist and cool until time of planting.

F. If the construction schedule requires trees over 3 ½" in caliper to be planted in the fall, that are of a species considered to be difficult to transplant in the fall, these trees shall be root pruned the previous spring in the nursery.

1. The Architect will determine tree species to be root pruned.
2. A trench shall be dug around the tree at the limit of the proposed root ball to a minimum depth of 24" and back-filled.
3. A 3" high saucer shall be built around the tree outside the edge of the trench.
4. The tree shall be guyed or braced.
5. The tree shall be watered as necessary through the summer.
6. When the tree is dug in the fall, the digging shall be done using methods that preserve the new root growth growing in the soft soil of the trench.
7. Root pruning, when required, shall be done at no additional cost to the Owner, except for owner pre-purchased trees.

3.2 EXAMINATION OF SUBGRADE

A. Examine subgrade and rough grading before planting. Alert Architect to unacceptable rough grading or subgrade conditions.

3.3 DECOMPACTION OF PLANTING AREAS

A. After subgrade levels have been reached and immediately prior to placing planting soils, the entire subgrade area shall be loosened to a minimum depth of 12 inches utilizing the bucket of a backhoe or equivalent equipment.

B. Any subgrade areas which have become heavily compacted (defined as exceeding 86% -88% compaction ASTM C698 Standard Proctor) including, but not limited to, temporary parking areas, material stockpile areas, temporary roadways, construction areas, areas shown on the plans, or areas identified by Architect shall be deep-scarified. Immediately prior to placing soils, heavily compacted areas shall be loosened to a minimum depth of 36 inches using the teeth of a backhoe or other suitable equipment. Frequency of compaction tests shall be one per 200 square feet.

C. Using a wide-track bulldozer size D-5 or smaller, compact the scarified subgrade to 86% - 88% compaction ASTM D698 Standard Proctor. Contractor shall provide shovel dug test pits to the full depth of the mitigation, where located per the direction of the Architect, in order for the Architect to review whether the work has been done as required. Backfill the pits after the review(s).

D. Confirm that the subgrade is at the proper elevation and that no further earthwork is required to bring the subgrade to proper elevations. Provide a written report to Architect indicating that subgrade has been placed to the required elevations, has been decompacted according to the Contract Documents and is ready for inspection at least 3 days prior to placing planting soil. Perform no work of placing and spreading planting mixes until elevations have been confirmed and written report has been accepted by the Architect.

E. After the soils have been loosened and inspected, topsoil may be spread by using a wide track bulldozer size D-5 or smaller or may be dumped and spread with bucket of a backhoe from the edge of the loosened area. No rubber-tired equipment or heavy equipment except for small bulldozer shall pass over the subsoils (subgrade) after they have been loosened. If Contractor plans to utilize such areas for any use of heavy equipment, this should be carried out prior to beginning the process of loosening soils or filling in that area, or it shall be rescarified to meet this specification requirement.

3.4 SOIL DRAINAGE/DETRIMENTAL SOILS

A. Test drainage of five planting pits in locations as directed by the Architect. Pits shall be filled with water twice in succession. The time at which water is put into the pit for a second filling shall be noted. Architect shall then be notified of the time it takes for pit to drain completely. Planting operations shall not proceed until Architect has reviewed test drainage results.

1. To test drainage, dig a whole about 1 foot deep. Fill with water and allow it to drain completely. Immediately refill the pit and measure the depth of the water with a ruler.
   15 minutes later, measure the drop in water in inches, and multiply by 4 to calculate how much water drains in an hour.
2. Less than 1 inch per hour is poor drainage, indicating the site may stay wet for periods during the year. 1 to 6 inches of drainage per hour is desirable. Any subgrades with perc rates less than 1 in. per hour shall be decompacted and/or replaced as required to meet the specifications.
3. Infiltration rates for Bioretention Planting soils within the bioretention areas after installation shall be between 4in/hr and 10 in/hr.

B. The Contractor shall notify the Architect in writing of all soil or drainage conditions that are considered detrimental to growth of plant material. Submit proposal and cost estimate for correction of the conditions for Architect's approval before starting work.

3.5 LAYOUT OF PLANTING AREAS

A. Individual trees shall be located in the field as indicated on the Drawings for Architect’s approval prior to planting. Contractor shall provide one foreman, one loader with operator and two laborers to work with Architect in the field to determine the final location and orientation of each tree prior to planting. It is anticipated that this process may take several days to complete. Contractor shall plan to have this layout crew available to work with Architect at a slow and deliberate pace in order to achieve the desired results.

B. Individual shrubs and perennials to be planted shall be laid out in plant beds by The Contractor in ample time to allow inspection by the Architect.

3.6 PREPARATION OF SUBGRADE

A. Subgrade shall be brought to true and uniform grade and shall be cleared of stones greater than 2 in., sticks, and other extraneous material.

3.7 PLANT PIT EXCAVATION

A. Planting pits for trees and shrubs shall be excavated to the depth and dimensions indicated on the Drawings.

B. Excavation shall not begin until locations are approved by the Architect.

3.8 SPREADING OF PLANTING SOIL

A. Planting soil shall be spread in lifts not greater than 6 inches and compacted to a density between 82% and 86% Standard Proctor Maximum Dry Density in accordance with ASTM D698. The surface area of each lift, including the subgrade after it has been compressed by a backhoe, shall be scarified by raking prior to placing the next lift.

B. Place and spread planting medium to a depth greater than required such that after settlement, finished grade shall conform to the lines, grades and elevations shown on the Drawings. Ensure proper drainage in an uninterrupted pattern free of hollows and pockets.

C. Remove stiff clods, lumps, brush, roots, stumps, litter and other foreign material and stones over 1 inch diameter and legally dispose of off-site.

D. Surfaces shall be graded and smoothed, eliminating all sharp breaks by rounding, scraping off bumps and ridges, and filling in holes and cuts.

E. See Section 329400, 3.3 for soil placement and construction in bioretention basins.

3.9 PLANTING

A. Tree, shrub, and groundcover beds shall be excavated to the depth and widths indicated on the Drawings. If the planting pit for any tree is dug too deep, soil shall be added to bring it to correct level, and the soil shall be thoroughly tamped. Walls of plant pits shall be dug so that they are sloped as shown on the Drawings, and scarified. Do not excavate compacted subgrades of adjacent pavement or structures.

B. Plants shall be set as indicated on Drawings. Plants shall be set so that the root flare is at, or slightly above, finished grade. Plants located in poorly drained soils shall be set 2 to 4 inches above finished grade, gradually sloping between the top of the root ball and the surrounding finished grade.

C. Plants shall be turned to the desired orientation when required by Architect.

D. Containerized plants shall be removed from container taking care not to damage roots. The side of the root ball shall be scarified to prevent root-bound condition before positioning in planting pit.

E. Plants shall be positioned in center of planting pits, set plumb, and rigidly braced in position until all planting soil has been tamped solidly around the balls.

F. Pits shall be backfilled with planting soil. Soil shall be worked carefully into voids and pockets, tamping lightly every 6 in.

1. When pit is two-thirds full, plants shall be watered thoroughly, and water left to soak in before proceeding.
2. At this time, ropes or strings on top of balls shall be cut and shall be pulled back. Burlap or cloth wrapping shall be left intact around ball except that portions of wrap that are exposed at top of ball shall be turned under and buried. Non-biodegradable ball wrapping and support wire shall be totally removed from ball and planting pit.
3. Wire baskets shall be completely cut away from sides of root ball, and removed from pit. Bottom of basket may remain.
4. Remove nursery plant identification tags.

G. Backfilling and tamping shall then be finished and a saucer formed around plant pits as indicated on the Drawings.

H. Saucer shall be filled with water and water left to soak in. Saucer shall then be filled with water again.

3.10 TREE WATERING STAKE

A. Trees shall have 2-3 units on opposing sides or surrounding the tree base. After tree has been placed in the hole, insert 2-3 Deep Drip units vertically in the hole surrounding the tree before back-filling with soil. Stake size shall be as recommended by manufacturer. The top of Deep Drip can either be above ground level or below ground.

B. When positioned in the ground, remove cap and insert end of irrigation drip line and emitter into the shaft, aligning the drip line with the slot in the cap. Re-install cap to secure drip line and stop excess debris from entering shaft.

3.11 FERTILIZER APPLICATION

A. Fertilizer, if required, shall be applied at the rates recommended by soil testing results.

3.12 FUNGICIDE

A. Immediately after planting, all trunks of deciduous trees shall be sprayed with fungicide, applied as directed by chemical manufacturer.

3.13 PRE-EMERGENT-HERBICIDE

A. Immediately after planting, pre-emergent herbicide shall be applied to ornamental shrub beds and and around base of trees, in strict accordance with chemical manufacturer's printed instructions.

3.14 POST EMERGENT-HERBICIDE

A. Upon the appearance of weeds within planted areas, pre-emergent herbicide shall be applied to ornamental shrub beds and and around base of trees, in strict accordance with chemical manufacturer's printed instructions.

3.15 INSECTICIDE

A. Upon the appearance of insect problems, all trunks of deciduous trees shall be sprayed with insecticide, applied as directed by chemical manufacturer.

3.16 STAKING AND GUYING

A. Each tree shall be staked or guyed immediately following planting. All evergreen trees and deciduous trees over 4" caliper shall be guyed. Plants shall stand vertical and plumb after staking or guying. Set vertical stakes and space to avoid penetrating root balls or root masses. Allow enough slack to avoid rigid restraint of tree. Stakes and guys shall be installed as indicated on the Drawings.

3.17 MULCHING

A. Mulch shall be applied as follows (entire area listed shall be mulched):

Plant Type	Mulch Area	Mulch Depth, in.
Tree	Saucer	2
Shrub	Saucer or Bed	2

Mulch shall not be allowed to cover the base of trunks. Mulch bed diameters at trees 4'.

3.18 PRUNING

A. Each tree and shrub shall be pruned to preserve the natural character of the plant. Pruning shall be done after delivery of plants and after plants have been inspected and approved by the Architect. Pruning procedures shall be reviewed with Architect before proceeding.

B. Pruning shall be done with clean, sharp tools. Cuts shall be made flush, leaving no stubs. No tree paint shall be used.

C. Dead wood, suckers, and broken, weak, interfering and badly bruised branches shall be removed.

3.19 MAINTENANCE OF PLANTING

A. Maintenance shall begin immediately after each plant is planted and shall continue until Final Acceptance.

B. Maintenance shall consist of pruning, watering, cultivating, weeding, mulching, fertilizing, removal of dead material, repairing and replacing of tree stakes, tightening and repairing of guys, adjusting and replacing of damaged tree wrap material, resetting plants to proper grades and upright position, and furnishing and applying such sprays as are necessary to keep plantings free of insects and disease, and in a healthy growing condition.

C. Daily watering of 1 gal./caliper inch should be delivered to the root ball of each tree during the first summer after planting. Continue through fall, reducing frequency. For trees larger than 3 inch caliper, fill saucer with 6 – 8 gallons twice per week during hot, dry weather, and once per week during cooler, wetter periods.

D. Planting areas shall be kept free of weeds, grass, and other undesired vegetative growth.

END OF SECTION

Section 32 94 00

BIORETENTION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 DESCRIPTION OF WORK

A. Work Includes: Provide labor, materials, tools, and equipment required to complete the work as indicated on the Drawings and as specified within this section. The work shall include the installation of the bioretention areas as shown on the Drawings. Work shall include all excavation, soil media, aggregate media, grading, backfill, compaction, loaming, seeding, erosion control protection, outlet structures, and the stabilization of the bioretention area. Work shall be completed and coordinated with connecting storm drainage improvements as required in other specification sections.

1.3 RELATED WORK

A. Work Included: Provide labor, materials, and equipment necessary to complete the work of this Section, including but not limited to the following:

1. Install all materials specified for the bioretention areas.

B. Related Work: The following items are noted and included in this Section and will be performed under the designated sections:

1. Section 31 10 00 – SITE CLEARING
2. Section 31 20 00 – EARTH MOVING
3. Section 31 25 00 – EROSION AND SEDIMENTATION CONTROLS
4. Section 32 92 00 – LAWNS AND GRASSES
5. Section 32 93 00 – TREES PLANTS AND GROUND COVERS
6. Section 33 40 00 – STORM DRAINAGE UTILITIES

1.4 SUBMITTALS

A. General: Submit the following in accordance with Conditions of Contract and Division 1 Specification Sections.

1. Qualification Data: For qualified landscape Installer.
2. Shop Drawings: Shop drawings showing dimensions, joint and other details of all materials proposed for the work. Shop drawings shall be submitted to the Designer for approval prior to ordering material.
3. Product Samples: For sand, pea gravel, and crushed stone. Samples shall be provided in a sealable bag, minimum 6-inches x 6-inches in size.
4. Material Test Reports: For borrows, and aggregates. Sieve, pH, salt content, others as described below.
5. Bioretention Planting Soil and Sand Layer infiltration test results.
6. Bioretention Area Installation, Seeding and Planting Schedule: Indicating anticipated installation, seeding and planting dates for each type of planting to Landscape Architect.

7. Maintenance Instructions: Recommended procedures to be established by Landscape Contractor for maintenance of turf and plantings during a calendar year. Submit before expiration of required maintenance periods

1.5 DEFINITIONS

A. Finish Grade: Elevation of finished surface of bioretention planting soil.

B. Bioretention Planting Soil: Soil mixed offsite by blending mineral soils with sand and stabilized organic soil amendments resulting in a homogeneous planting soil for bioretention areas.

C. Subgrade: Surface or elevation of subsoil remaining after excavation is complete or top surface of a fill or backfill before bioretention materials are placed.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: A qualified landscape installer whose work has resulted in successful stormwater management installation. Require Installer to maintain an experienced full-time supervisor on Project site when construction, seeding, and planting is in progress.

B. Pre-Construction Conference: Conduct conference at Project site to comply with requirements of these specifications.

C. Mandatory construction inspections as specified in the Drawings.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Soil, borrow, and aggregate materials: Deliver soil, borrows, aggregates, and other bioretention materials to a pre-approved location in separate piles. Stockpiled left for an extended period (over a week) shall be surrounded by containment straw bales and completely covered with an approved blanket material to prevent invasive seed contamination from mixing with the stockpiled materials.

B. Seed: Deliver seed in original sealed, labeled, and undamaged containers.

C. Plants shall be delivered only after preparations for planting has been completed. They shall be planted immediately upon arrival at the site. If planting is delayed more than 6 hours after delivery, the plants must be properly maintained and watered by the Contractor.

1.8 PROJECT CONDITIONS

A. Bioretention Installation: Bioretention installation shall occur during one of the following periods. Coordinate bioretention installation periods with planting periods and initial maintenance periods to provide required maintenance from date of Substantial Completion.

B. Weather Limitations: Proceed with bioretention installation only when existing and forecasted weather conditions permit.

1.9 MAINTENANCE SERVICE

A. Initial Maintenance Service: Provide full maintenance by skilled employees of the Landscape Contractor until Substantial Completion.

PART 2 - PRODUCTS

2.1 BIORETENTION PLANTING SOIL

A. Refer to Specification Section 329300, Trees, Plants, and Ground Covers for bioretention planting soil requirements.

B. The infiltration rate of the Bioretention Planting Soil Layer within the bioretention areas after installation shall be between 4 in/hr. and 10 in/hr.

2.2 COARSE SAND

A. The infiltration rate of the Sand Filter layer within the bioretention areas after installation shall be 8 in/hr. or greater.

The sand filter layer shall consist of clean inert, hard, durable grains of quartz or other hard durable rock, free from clay, organics, surface coatings or other deleterious material. Sand shall meet ASTM C-33 (Fine Aggregate), with a Fines Modulus Index of 2.75 or greater and shall conform to the following gradation:

Sieve Size	**Percent Passing by Weight**
3/8-inch	100
No. 4	95-100
No. 8	80-100
No. 16	50-85
No. 30	25-60
No. 50	10-30
No. 100	2-10

2.3 PEA GRAVEL

A. Pea gravel shall be placed over the underdrain crushed stone. Pea gravel shall consist of durable crushed rock or durable crushed gravel stone free from ice and snow, sand, clay, loam, or other deleterious or organic material. The peas gravel shall be double washed and shall be ¼ to 3/8 inch in size or equivalent to #9 double washed crushed stone.

2.4 CRUSHED STONE

A. The crushed stone to be placed around the underdrain piping shall be clean double-washed crushed aggregate, free of rock dust, fines or soil particles. Crushed stone shall consist of durable crushed rock or durable crushed gravel stone, free from ice and snow, sand, clay, loam, or other deleterious or organic material. The crushed stone shall be uniformly blended and shall conform to the following requirements:

Sieve Size	Percent Passing by Weight
1-inch	100
¾-inch	90-100
½-inch	10-50
3/8-inch	0-20
No. 4	0-5

2.5 UNDERDRAIN PIPING

A. Underdrain piping shall be used in the drainage stone layer of the bioretention facilities as indicated on the plans.

B. Clean out pipes must be provided where indicated on the plans. Cleanouts shall consist of non-perforated Schedule 40 PVC pipe, PVC elbow, cap, and all associated fittings. Extend cleanout pipes to surface with securable cap. The top of the cap shall be 3 inches above the bioretention basin surface.

C. Underdrain piping shall conform to the following specifications:

PIPE	STANDARD	PERFORATIONS
4" Corrugated Polyethylene Pipe	ASTM F405 (Pipe Requirements) ASTM F405 (Joints and Fittings) ASTM D3350 (Material Properties) ASTM D2321 (Installation)	0.875" X 0.120" slots located in the outside valleys of the corrugations
4" PVC Drain Pipe	ASTM D2729 (Pipe Requirements) ASTM D2321 and ASTM F1668 (Installation)	1/2" holes @ 5" on center, located at the 4- and 8- o'clock position of the installed pipe

2.6 DRAINAGE FABRIC GEOTEXTILE FOR TEMPORARY SOIL PROTECTION

A. Filter fabric shall be used to temporarily cover the installed bioretention material layers to prevent siltation from other construction until the next material layer is placed. The fabric is to be removed prior to the placement of the next material.

B. Drainage filter fabric shall meet the following Minimum Average Roll Value (MARV) specifications across the weave:

PROPERTY	TEST METHOD	REQUIREMENT	PROPERTY	TEST METHOD	REQUIREMENT

Grab Tensile Strength	ASTM D4632	120 lb. min.	Apparent Opening Size	ASTM D4751	70 US Sieve
Grab Tensile Elongation	ASTM D4632	50% max.	UV Resistance	ASTM D4335	70% at 500 hrs. min.
Trapezoidal Tear Strength	ASTM D4533	50 lb. min.	Permittivity	ASTM D4491	1.8 sec^{-1}
CBR Puncture Strength	ASTM D6241	300 lb. min.	Flow Rate	ASTM D4491	135 gal/min/ft.2 min.

PART 3 - EXECUTION

3.1 COORDINATION

A. Pre-Installation Examination Required: The Contractor shall examine previous work, related work, and conditions under which this work is to be performed and shall notify the Owner in writing of all deficiencies and conditions detrimental to the proper completion of this work. Beginning work means the Contractor accepts substrates, previous work, and conditions. The Contractor shall not place any bioretention materials including the bioretention planting soil until all work in adjacent areas is complete and approved by the Owner.

B. The Designer shall review the subgrade for conditions that warrant the installation of an impervious membrane.

C. Coordinate activities with other project contractors so that there is no soil disturbance from traffic or other construction activities subsequent to placement.

D. Excavate and install underdrainage system after downstream storm drainage system has been installed to facilitate ease of subsurface connections. Protect gravel and underdrainage perforated piping from construction sediment by temporarily covering gravel/piping with filter fabric.

E. Schedule and coordinate bioretention basin soil installation with placement of Planting Soils in adjacent areas.

F. Restrict all additional traffic other than installation from retention areas prior, during, and after installation.

3.2 EXCAVATION AND COMPACTION

A. Compaction of the bioretention areas shall be avoided prior to construction. Place barricades to restrict access to the areas.

B. Do not work the soil when it is too moist or frozen. If the soil smears when worked, it is too moist.

C. The subgrade shall be nearly level with a gradient less than ½ (0.5) percent.

D. Subsoil compaction at the base of the bioretention facility shall be alleviated using primary tilling equipment such as a chisel plow, ripper, or subsoiler. Tilling operations shall be used to refracture the sub-grade to a depth of 12 inches.

E. Do not use heavy equipment within the bioretention basin. Heavy equipment can be used around the perimeter of the basin to supply materials. Grade bioretention materials with light equipment such as a compact loader or a loader with marsh tracks.

F. It is very important to minimize compaction of both the base of the bioretention area and the required backfill materials. When possible, use excavation hoes to remove original soil. If bioretention area is excavated using a loader, the contractor should use wide track or marsh track equipment or light equipment with turf type tires. Use of equipment with narrow tracks or narrow tires, rubber tires with large lugs, or high-pressure tires will cause excessive compaction resulting in reduced infiltration rates and storage volumes and is not acceptable. Compaction will significantly contribute to failure of the basin after installation.

3.3 BIORETENTION CONSTRUCTION

A. The following is the construction sequence required for proper installation of the bioretention basin. These steps may be modified with the approval of the Designer prior to the start of construction.

1. The Contractor shall conduct a pre-construction meeting with the Designer to review the installation requirements for the proposed bioretention area.
2. Clear and grub the proposed bioretention area.
3. Rough grade the bioretention area and excavate the bioretention facilities to within 1 foot of underdrain bottom.
4. Excavators or backhoes shall work from the sides to excavate the bioretention area to its appropriate design depth and dimensions. Excavating equipment shall have arms with adequate reach so they do not work in the footprint of the bioretention area. If applicable and per the Designer's direction the contractors shall utilize a cell construction approach in larger bioretention basins, whereby the basin is split into 500 to 1000 square foot temporary cells with a 10 to 15-foot earth bridge in between so that cells can be excavated from the side.
5. Any pretreatment cells and/or sediment forebays shall be excavated first and sealed to trap sediments.
6. All finish grading and stabilization for the contributing drainage area must be completed prior to beginning the final construction phase of the bioretention basin.
7. Install any temporary erosion and sediment controls to divert stormwater away from the bioretention area during final construction and until it is completed. Special protection measures such as erosion control fabrics may be needed to protect vulnerable side slopes from erosion during the construction process.
8. Excavate the bioretention facility to the bottom elevation of the crushed stone layer.
9. If infiltration is promoted, then the Contractor shall rip the bottom soils to a depth of six inches to promote greater infiltration.
10. After excavation of the basin bed is complete and preparation of the subgrade meets specifications, install the specified crushed stone in the bottom of the basin prior to underdrain pipe placement.
11. Install underdrain, including 4-inch perforated pipe and crushed stone as indicated on the Drawings.
12. Install pea gravel layer and sand layer as indicated on the Drawings.
13. Deliver approved Bioretention Planting Soil and store on adjacent impervious area or plastic sheeting.
14. Backfill with approved Bioretention Planting Soil to the design grade (un-compacted) as specified on the Drawings. Apply in 6-inch lifts until desired top elevation of bioretention is achieved. Wait 3 days to check for settlement, and add additional media as needed.
15. Stabilize all remaining disturbed areas and side slopes with seeding, hydroseeding, and/or erosion control blankets.

16. Seed bioretention basin as specified on the Drawings and water the seed during weeks of no rain for the first two months.
17. No seeding shall occur before the remaining disturbed areas surrounding the facility are stabilized.
18. The Contractor will be required to remove any sediment that washes into the bioretention basin during the construction and planting phases. If suitable vegetative cover has not been established along the bioretention basin slopes prior to seeding, a silt fence perimeter shall be installed at the toe of the bioretention basin slopes and remain in place until an approved vegetative cover has been established.
19. Conduct final construction inspection with Designer.
20. Remove remaining erosion and sediment controls only after surrounding disturbed areas have been properly stabilized.

B. Perforated Pipe Installation:

1. The main collector pipe for underdrain systems shall be constructed with a slope between 0.25 to 1.0%. All piping shall be of uniform gradient and provide unrestricted flow to the outlet.
2. Perforated pipe shall be placed with the perforations down at 4 and 8 o'clock positions (PVC pipe).
3. The ends of underdrain pipes without a cleanout shall be capped.
4. Place the remaining specified crushed stone to a depth of 12 inches.
5. Temporarily cover the crushed stone surface with fabric to prevent sedimentation of the gravel layer prior to the placement of the pea gravel layer. The fabric is to be removed prior to pea gravel layer placement.

C. Pea Gravel Installation: Place the pea gravel to a depth of 4 inches.

D. Sand and Bioretention Planting Soil Installation: Never work bioretention planting soil when wet or frozen.

1. The Bioretention Planting Soil media shall be homogenous. Soils that have visible lumps of material or coarse fragments (rocks) greater than 2.5 cm (1-inch) is cause for rejection.
2. The sand and bioretention planting soil shall be placed in 6-inch lifts. Installation traffic is allowed to spread and "seat" the soil, but additional soil compaction is strictly forbidden. Do not use heavy equipment within the bioretention facility.
3. Scarify the surface of each lift to prevent compaction interfaces that will reduce the functionality of the retention basin.
4. Test infiltration rates of completed Sand Filter layer and submit results to the Designer. Determine permeability of the layer using a single ring infiltrometer method after it has been scarified. Gain approval of Sand Filter layer installation infiltration prior to placement of the Bioretention Planting Soil layer. At the completion of the Bioretention Planting Soil layer prior to plant and seed placement, test the infiltration rate and submit to the Designer.
5. Heavy equipment can deliver bioretention materials to the basin from outside of the bioretention area.
6. Grade bioretention materials with light equipment such as a tracked skid-steer or a dozer/loader with marsh tracks.
7. Back blading of the soil with buckets or doze blades is strictly forbidden.
8. Volume of bioretention planting soil media shall be at least 110% of plan volume to account for settling and compactions.
9. The bioretention planting soil media shall be saturated with water to settle the media before the final lift so that it can be adjusted in the field to correspond to the plan

elevations. The water to saturate the placed bioretention planting soil shall either be provided by the Contractor or from a rain event capable of saturating the soil.

10. No other materials or substances shall be mixed or dumped within the bioretention area that may be harmful to plant growth or prove a hindrance to the planting or maintenance operations.

3.4 PROTECTION AND REPAIRS

A. During bioretention area construction, protect partially finished soil installation with weighted plastic tarps during heavy precipitation events until protective vegetation has been placed and established.

B. Bioretention areas shall be fully protected by silt fence or construction fencing or as shown in the Drawings during the entire construction period and until the site drainage area to the bioretention area is properly stabilized. Erosion control measures shall include at a minimum silt fence, straw bales, and erosion netting on the surfaces of bare soil surrounding the bioretention basins until vegetation is established. When possible, the bioretention area shall remain outside the limit of disturbance during construction to prevent soil compaction by heavy equipment.

C. If blowing of material is a concern, a biodegradable netting can be spread over the surface until the facility has gone through several wetting cycles.

D. Bioretention Area Protections shall be maintained until the surrounding surface areas have been fully stabilized throughout the entire vegetation establishment period and as approved by the Designer.

E. Vegetate the surrounding catchment areas as quickly as possible.

F. Protect newly graded areas from traffic, freezing, and erosion. Keep free of trash, debris or construction materials.

G. Repair, reshape and re-establish finished grades where areas settle, erode, are disturbed or damaged.

H. Refer to Section 32 90 00-Planting and Section 32 92 00 – Turf and Grasses for coordination of protection measures between retention construction and planting soil installation.

3.5 INSPECTION AND MAINTENANCE

A. After construction, monthly inspection of the bioretention facilities shall be conducted until the plants are established and the vegetative cover is 90% or greater.

B. The Contractor shall provide water to establish the seeding and/or plantings within the bioretention area.

C. Remove all visible accumulations of sediment on top of the vegetated surface with a flat shovel. Stabilize eroded areas with appropriate geotextile and replant as required to establish growth.

D. Check for sediment at inflow points including curb cuts, gravel filter strips, and/or pavement edges. Remove sediment as necessary.

E. Inspect side slopes and adjacent grass areas for erosion gullies and repair as necessary.

3.6 CLEAN UP

A. At the completion of the work, the Contractor shall remove all debris, materials, rubbish, excess dirt, etc., from the site and legally dispose of them in a manner satisfactory to the Designer. Contractor shall leave the premises in a clean, safe, and satisfactory condition. The contractor shall be responsible for any costs incurred in this process.

End of Section

Section 33 01 30

RELINING SEWER AND DRAIN PIPES

PART 1 – GENERAL

1.1 GENERAL PROVISIONS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all SECTIONS within DIVISION 1-GENERAL REQUIREMENTS, which are hereby made a part of this Section of Specifications.

1.2 DESCRIPTION OF WORK

A. Work Included: Provide labor, materials, and equipment necessary to complete the work of this Section, including but not limited to the following:

1. Rehabilitation of existing deteriorated sewers and drains as indicated in the contract documents by means of the installation of cured-in-place (CIPP) or “fold and form” pipelining that renders each pipe segment free of infiltration/inflow and structural defects.
2. Liners, including all thermosetting liners, must take the shape of the existing pipe after installation and shall not leave a gap or annular space between the liner and the pipe.
3. The pipe rehabilitation method shall not require excavation for the installation of the liner or to re-open existing service connections.
4. Cured-in-place liners and fold and form liners shall be cured using hot water, steam or ultraviolet light.
5. Liners shall be designed in accordance with ASTM F1216 for fully deteriorated pipe.

B. Related Work: The following items are not included in this Section and will be performed under the designated Sections:

1. Section 33 30 00 - SANITARY SEWERAGE UTILITIES for sanitary sewerage system requirements.
2. Section 33 40 00 - STORM DRAINAGE UTILITIES for storm drainage system requirements.
3. Section 22 13 16 - SANITARY WASTE AND VENT PIPING for building sanitary drain and vent requirements.

1.3 SUBMITTALS

A. Refer to Section 01 33 00 - SUBMITTAL PROCEDURES for submittal provisions and procedures.

B. The Contractor shall submit detailed design calculations of the liner including liner material, sizes of material, specification of materials, shop drawings including any special method or procedures or any other information deemed necessary by the Engineer including the following:

1. A statement containing the lining contractor's name, address, and years of experience in installing the type of lining proposed, and at least three references relating to the lining projects of the same type being proposed under this Contract.
2. A statement identifying the rehabilitation process/product by trade name as well as by the industry known generic name. This statement shall include a brief description of the material composition, physical properties, and manufacturer's recommendation for handling, storing and repair of pipe and fittings, as well as the process used to install and cure the liner.
3. A certification that the Contractor is an approved licensed installer of the rehabilitation method.
4. A letter of certification from the liner manufacturer in which all physical and chemical properties of the material to be used meets or exceeds the requirements of these specifications. These properties shall at least include the following:

    a. Instantaneous Tensile Strength (yield) in psi.
    b. Long-Term (50-yr loadings) Tensile Strength (yield) in psi.
    c. Instantaneous Tensile Strength (break) in psi.
    d. Long-Term (50-yr loadings) Tensile Strength (break) in psi.
    e. Instantaneous Flexural Modulus in psi.
    f. Long-Term Flexural Modulus in psi. Long-Term Flexural Modulus is defined as smaller of creep modulus or continuous loading modulus of elasticity (50 year).

5. Name and address of the resin manufacturer.
6. Detailed design calculations, including assumptions upon which the calculations are based. The calculations shall consider traffic loading; earth loads, hydrostatic loads, and shall be based on a long-term basis and shall include applicable technical data sheets. It shall be assumed that the existing pipe will contribute no appreciable strength to the completed lining. These calculations must be stamped by a Registered Professional Engineer in Massachusetts.
7. The selected "liner pipe" shall be designed based on the following applicable criteria:

    a. The dead load and live loads for the actual depth of cover.
    b. Saturated soil conditions using a soil weight of 120 pounds per cubic foot and a coefficient of friction Ku^1=0.130.
    c. Groundwater levels above the top of the pipe equal to actual conditions or stated conditions as indicated in the Contract Documents. Otherwise, it shall be to a height of ½ of the height distance from the crown of the pipe to the street or surface grade.
    d. Loss of hydraulic capacity shall not exceed 10%.

8. For Fold and Form type liners: the type of seal to be used at the manhole entry point.
9. The manufacturer's heating requirements and curing guidelines.

1.4 REFERENCE STANDARDS

A. The tube material, resin system and all other materials and installation procedures shall conform to the following documents:

1. ASTM F-1216 Standard Practice for the Installation of Cured-in-Place Pipe (CIPP) by Inversion Lining.

2. ASTM F-1743 Rehabilitation of existing pipelines and conduits by pulled-in-place installation of cured-in-place thermo-setting resin pipe.
3. ASTM D-5813 Cured-in-Place Thermosetting Resin Sewer Pipe.

1.5 EXAMINATION OF SITE AND DOCUMENTS

A. It is hereby understood that the Contractor has carefully examined the site and all conditions affecting work under this Section. No claim for additional costs will be allowed because of a lack of knowledge of existing conditions as indicated in the Contract Documents, or obvious from observation on the site.

B. Plans, surveys, measurements, and dimensions under which the work is to be performed are believed to be correct, but the Contractor shall have examined them for himself during the bidding period and formed his own conclusions as to the full requirements of the work involved.

1.6 QUALITY ASSURANCE

A. Environmental Compliance: Comply with applicable portions of local environmental agency regulations pertaining to sanitary sewerage systems.

B. Utility Compliance: Comply with the City of Worcester Department of Public Works regulations, standards, and guidelines pertaining to sanitary sewerage system installation and inspections.

C. Manufacturer's Qualifications: Firms regularly engaged in manufacturing of cured-in-place products of type, materials, and sizes required, whose products have been in satisfactory use in similar service for not less than five years.

D. Installer's Qualifications: Firms with at least five years of successful installation experience in commercial installation of cured-in-place product. In addition, the Installer must have successfully installed at least 100,000 feet of cured-in-place product in wastewater and storm drainage collection systems.

1.7 PROJECT CONDITIONS

A. Site Information: Perform site inspection and survey, research utility records, and verify existing utility locations and elevations. Verify that relining can be installed in compliance with Contract Drawings and referenced standards.

1.8 SEQUENCING AND SCHEDULING

A. Coordinate with interior building sanitary sewer and drainage system piping.

B. Coordinate with other utility work.

C. The Contractor is responsible for developing a sequence of work to maintain existing services in operation until the new services are operational.

D. The Contractor is responsible for coordinating and scheduling the inspection of the work by the jurisdictional authority. All permits and inspection costs and fees shall be included in the bid prices and no additional costs will be paid to the Contractor.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

A. All materials used in the liner installation shall be industry accepted materials for sewer/drain pipe rehabilitation and to the satisfaction of the Engineer. Liners for cured-in-place pipe shall be felt or fiberglass based or fiberglass based for ultraviolet curing. The lining shall be chemically resistant to internal exposure to sewage containing gases at normal levels for domestic sewage of hydrogen sulfide, carbon monoxide, carbon dioxide, methane, dilute sulfuric acid, external exposure to soil bacteria and any other chemical attack which may be due to materials in the surrounding ground.

B. The lining shall be continuous over the entire length between adjacent manholes and free as possible from visual defects such as foreign inclusions, dry spots, air bubbles, pinholes, pimples, wrinkles, and delamination. The lining shall be impervious and free of any leakage from the surrounding ground or from the ground to the inside of the rehabilitated pipe. Any defects which will affect, in the foreseeable future as determined by the Engineer, the integrity or strength of the lining, shall be repaired or the lining replaced at the Contractor's expense and to the satisfaction of the Engineer.

2.2 LINER REQUIREMENTS

A. Cured-in-Place Liners shall be manufactured and installed in accordance with ASTM F1216 latest version or ASTM F1743 latest version with the following minimum physical properties:

1. Tensile Strength: 3,000 psi (ASTM D638)
2. Flexural Stress: 4,500 psi (ASTM D790)
3. Modulus of Elasticity: 250,000 psi (ASTM D790)

B. Fold and Form Liners shall be manufactured and installed in accordance with the following:

1. Polyvinylchloride (PVC) liners shall conform to ASTM D-1784.
2. High-Density Polyethylene (HDPE) liners shall conform to ASTM D-1248
3. The minimum physical properties shall be as follows:

a. Tensile Strength: 3,500 psi (ASTM D638)
b. Flexure Stress: 4,100 (ASTM D790)
c. Flexural Modulus: 135,000 psi (ASTM D790)

2.3 TUBE SECTIONS

A. Acceptable Materials

1. Fiberglass (cured with ultraviolet light)
2. Felt (cured with hot water)

B. Tube Characteristics & Standards

1. At the time of manufacture, each lot of glass fiber or felt tube liner shall be inspected for defects and tested in accordance with applicable ASTM standards. At the time of delivery, the liner shall be homogeneous throughout, uniform in color, free of cracks, holes, foreign materials, blisters, and deleterious faults.

2. For testing purposes, a production lot shall consist of all liner having the same marking number. It shall include any and all items produced during any given work shift and must be so identified as opposed to previous or future production.
3. The Engineer may at any time direct the manufacturer to obtain compound samples and prepare test specimens in accordance with applicable ASTM standards.
4. An “inner liner” and “outer liner” film must be used for resin control (to prevent resin migration and contamination). The “inner film” and “outer film” must both be certified styrene gas barriers. The “inner liner” film must be removed during the installation process unless it is a permanent part of the system and is made an integral part of the carrier tube by bonding or fusing to the carrier tube.
5. The material shall be manufactured in such a manner as to result in a tight-fitting continuous liner after installation.
6. All wet-out or impregnation of the Tube shall be performed in an EPA-regulated, quality-controlled facility. Documentation of EPA permitting must be submitted. No “over the hole” or “on-site” set-out is allowed. For products that are cured with hot water, the wet-out must be conducted within 300 miles of the job site considering the time-sensitive characteristics of thermal-cured products.

C. Fiberglass Tube (Ultraviolet Light Curing Application)

1. The glass fiber tubing shall be seamless and spirally wound, including an exterior and interior film that protects and contains the resin used in the liner. The exterior film shall be provided with an Ultraviolet light blocker foil.
2. The Tube shall consist of a seamless, spirally wound glass fiber that is flexible and has strain values (expandable) of eight (8) to ten (10) percent. The tube shall not have a longitudinal seam, including a stitched seam, stitch-free-weld or bond, or stitch-free overlap. The tube shall be constructed to withstand installation pressures and have sufficient strength to bridge missing pipe sections.
3. The impregnated Tube shall have a uniform thickness, that when compressed at installation pressures will meet or exceed the Design thickness. If voids are present in the host pipe, the design wall thickness must still be met or exceeded.
4. The tube shall be sized such that when installed, it will tightly fit the internal circumference and length of the original pipe.
5. The glass fiber tube shall be saturated with the appropriate resin using a resin bath to allow for the lowest possible amount of air entrapment. Vacuum-suction impregnation methods are not allowed due to the introduction of air using this method. The liner shall then be formed into a spirally wound shape for the purpose of being seamless in its cured state. An inner and outer material shall be added that are both impervious to airborne styrene, with the outer material also having ultraviolet light blocking characteristics. The inner membrane shall be removed after the installation and curing processes are completed.
6. The wall color of the interior pipe surface of CIPP after installation shall be a light reflective color so that a clear detailed examination with closed-circuit television inspection equipment may be made.
7. The liner shall be seamless in its cured state to ensure homogeneous physical properties around the circumference of the cured liner.
8. The manufacturer shall test the raw materials and liner materials at various stages of manufacturing of every liner, including taking samples of every finished liner and conducting tests for e-modulus, tensile, wall thickness, and porosity.
9. Fiberglass materials shall be “direct sized” to enhance the fiberglass/resin bond. Certification of this coating and its compatibility with the resin system used is required.

D. Felt Tube (Hot Water Curing Application)

1. The Tube shall consist of one or more layers of absorbent felt fabric and meet the requirements of ASTM F1216 or ASTM F1743, Section 5.
2. For work performed under this specification, the following felt-based carrier tube materials shall be used: Non-woven polyester felt and Non-woven fiberglass filament reinforced polyester felt.
3. The Tube shall be constructed to withstand installation pressures and have sufficient strength to bridge missing pipe while meeting or exceeding the design wall thickness at all pipe locations during installation conditions and pressures.
4. The Tube shall be sized such that when installed will tightly fit the internal circumference and length of the original pipe. Overlapped layers of felt in longitudinal seams that cause lumps in the final product shall not be utilized.
5. The Tube shall be homogeneous across the entire wall thickness containing no intermediate or encapsulated electrometric layers. No material shall be included in the tube that may cause delaminating in the cured liner (CIPP). No dry or unsaturated layers shall be evident.
6. The wall color of the interior pipe surface of CIPP after installation shall be a light reflective color so that a clear detailed examination with closed-circuit television inspection equipment shall be made.
7. Seams in the felt tube shall be allowed, but the seams must be stronger than the non-seamed felt. Third-party test data documenting the strength of the seam is required.
8. The manufacturer shall test the raw materials and liner materials at various stages of manufacturing on every liner, including taking samples of every finished liner and conducting tests for e-modulus, tensile, wall thickness, and porosity.
9. The outside of the tube shall be marked for distance at regular intervals along its entire length, not to exceed 5 ft. Such markings shall include the Manufacturer's name or identifying symbol.

2.4 RESIN

A. The resin system shall be a corrosion resistant polyester or vinyl ester system including all required catalysts, initiators that when cured within the tube create a composite that satisfies the requirements of ASTM F1216, ASTM D5813 and ASTM F1743, the physical properties herein, and those which are to be utilized in the submitted and approved design of the CIPP for this project. The resin shall produce a CIPP that will comply with the structural and chemical resistance requirements of this specification.

PART 3 - EXECUTION

3.1 GENERAL INSTALLATION REQUIREMENTS

A. The liner shall be fabricated to a size that when installed will neatly fit the internal circumference of the pipe to be rehabilitated

B. The Contractor shall make allowance for any longitudinal or circumferential stretching of the liner during installation. The length of the liner shall be that deemed necessary by the Contractor to efficiently carry out the lining process at the inlet and outlet of the respective manholes.

C. The Contractor is responsible for verifying all lengths, exact pipe dimensions and sizes in the field before installation. Individual liner runs may be made over manhole to manhole sections as determined in the field by the Contractor and approved by the Engineer.

D. The pipe sizes indicated on the Contract Documents are normal pipe sizes. The Contractor shall be solely responsible for determining all sizes; shapes, lengths and all other information needed to fabricate the liner. No additional payment shall be made if removal of the liner is necessary or if the liner is unable to be installed due to incorrect sizing by the Contractor.

E. SAFETY: The Contractor shall carry out his operations in strict accordance with all OSHA and manufacturer's safety requirements

F. Containment of sewage and site cleanliness is the responsibility of the Contractor. Fines levied by State and Federal agencies in the event of a spill or unapproved discharge shall be the responsibility of the Contractor. Spill cleanup as well as site cleanup shall be conducted by and paid for by the Contractor. Any waste product from lining of the sewer and drain pipes shall be shall be collected and disposed according to State and Federal laws. All cleanup and associated costs are part of acceptance of the project, without which final payment will not be made.

3.2 PREINSTALLATION

A. Cleaning of Sewer and Drain Pipe: Prior to lining, it shall be the responsibility of the Contractor to clean debris out of the pipe in order to install the liner.

B. Inspections of Pipelines: The Contractor shall inspect by closed-circuit television the sections of sewer and drain pipes to be relined. Inspections of pipelines shall be performed by experienced personnel trained in locating breaks, obstacles, and service connections by closed-circuit television. The interior of the pipeline shall be carefully inspected to determine the location of any conditions which may prevent proper installation. These conditions shall be noted so they can be corrected. The inspection log shall note the precise location of all services. The Engineer shall receive a DVD and log for later reference. If it is unclear whether a service connection is active the Contractor will be responsible for dye testing services to determine if it is active or not. There will be no additional payment for dye testing of services.

C. Sewer Flow Control: The Contractor shall bypass the flow around the sections of pipe to be lined or as deemed necessary by the Engineer.

1. A line plug shall be inserted into the pipe upstream of the section to be lined. The plug shall be so designed that all or any portion of the sewage can be released. After the work has been completed, flow shall be restored to normal.
2. The by-pass shall be made by plugging an existing upstream manhole if necessary and pumping the sewage into a downstream manhole or adjacent system. When pumping and bypassing is required, the Contractor shall supply the pumps, conduits, and other equipment to divert the flow of sewage around the manhole section in which work is to be performed. The by-pass system shall be of sufficient capacity to handle existing flow plus additional flow that may occur.
3. The Contractor shall be responsible for furnishing the necessary labor and supervision to set up and operate the pumping and by-pass system. If pumping is required on a 24-your basis, engines shall be equipped in a manner to keep noise to levels below or equal to those required by the City of Worcester and the Owner.

4. All bypass systems shall be approved by the Engineer. Approval of the by-pass system by the Engineer shall in no way be construed as relieving the Contractor of any responsibility under this Contract as related to protection of the interest of the Commonwealth or the general public.
5. At the end of each working day, temporary tie-ins shall be made between the rehabilitated section and the existing system and the by-pass plug removed, unless the temporary system is to remain in place as approved by the Engineer.
6. When flow in a sewer line is plugged, blocked, or by-passed, sufficient precautions must be taken to protect the sewer lines from damage that might result from sewer surcharging. Further, precautions must be taken to ensure that sewer flow control operations do not cause flooding or damage to public or private property being served by the sewers involved.
7. Under no circumstances will the dumping of raw sewage on public or private property or in the municipal streets be allowed.
8. All costs associated with flow control shall be included with the pipelining costs and no additional costs will be paid to the Contractor.

D. Line Obstructions: It shall be the responsibility of the Contractor to clean the line of any obstructions, solids, protracting laterals, or collapsed pipe that will prevent the installation of the liner to the satisfaction of the Engineer.

1. If pre-construction inspection reveals an obstruction, such as a badly misaligned joint, then the Contractor shall make a point repair excavation to uncover and remove or repair the obstruction.
2. Protruding lateral shall be ground down to the face of the pipe to allow for a tight-fitting liner.
3. Excavations for point repairs and the removal of protruding laterals shall be approved in writing by the Engineer prior to the commencement of the work.
4. Line obstruction repairs shall be included with the pipelining costs and no additional costs will be paid to the Contractor.

3.3 INSTALLATION

A. Tube Insertion – Fiberglass/UV Cured Products

1. A slip sheet shall be installed on the bottom half of the pipe prior to liner insertion, for the purpose of smoothing out the bottom of the liner to increase flow characteristics.
2. The lining tube or outer film must be inserted into the pipe prior to inserting the liner unless it is manufactured on the exterior of the liner, which is a normal characteristic of most fiberglass CIPP liners.
3. A constant tension winch shall be used to pull the glass fiber liner into position in the pipe. Once inserted, end plugs shall be used to cap each end of the glass fiber liner to prepare for pressurizing the liner. The end plugs shall be secured with straps to prevent them from being expelled due to pressure. Liner restraints shall be used in manholes.
4. The glass fiber liner shall be cured with UV light sources at a constant inner pressure. When inserting the curing equipment in the liner, care should be taken to not damage the inner film material.
5. The UV light sources shall be assembled according to the manufacturer's specifications for the liner diameter. For the liner to achieve the required water tightness and specified mechanical properties, the following parameters must be controlled during the entire curing process, giving the Engineer a record of the

curing parameters over every segment of the entire length of the liner. This demonstrates that the entire liner is cured properly. The recording shall include:

a. Curing speed
b. Light source working & wattage
c. Inner air pressure
d. Exothermic (curing) temperature
e. Date and time
f. Length of liner

6. The recording of the curing parameters shall be accomplished using a computer and database that are tamper proof. During the curing process, infrared sensors will be used to record curing data that shall be submitted to the Engineer with a post-CCTV inspection on DVD.
7. The parameters for curing speed, inner air pressure and wattage are defined in the Quality Tracker UV curing protocol issued by the manufacturer. The optimal curing speed or travel speed of the energized UV light sources is determined for each length of liner based on liner diameter, liner thickness, and an exothermic reaction temperature.
8. The inner film material should be removed and discarded after curing to provide optimal quality of the final product.
9. Flushing of the cured fiberglass/UV cured CIPP liner (to reduce styrene residual) is required for fiberglass/UV cured CIPP products.

B. Tube Insertion/Inversion – Felt/Hot Water Cured Products

1. The resin impregnated tube shall be transported and stored in a refrigerated truck until it is installed in an existing pipe by using an application of water, air, or cable and winch to properly place the tube between the upstream and downstream manholes.
2. The praline tube, or outer film, shall be inserted into the pipe prior to inserting the liner.
3. The wet out felt tube shall be inserted, or inverted, through an existing manhole or other approved access. Liner installation head pressures (minimum and maximum for hold and cold conditions) shall not be exceeded, regardless of which method of installation (standpipe, pressure unit, etc.) is used.
4. Using the “Inversion Procedure”, the tube end shall initially be turned inside out and attached to a platform ring, standpipe, or as approved. The addition of water will be adjusted to sufficient height/pressure to cause the impregnated tube to invert from manhole to manhole and hold the tube tight against the existing pipe wall.
5. Using the “Insertion Procedure”, the tube is winched into position according to manufacturer’s recommendations. The addition of water will be adjusted to sufficient height/pressure to cause the calibration hose to invert from manhole to manhole and hold the tube tight against the existing pipe wall.
6. Liner restraints should be used in manholes.
7. After the installation of the liner is completed, the Contractor shall use hot water system capable of providing the required amount of heat uniformly throughout the section for a complete cure of the resin. All water obtained from a City of Worcester or Private fire hydrant shall be metered. The Contractor shall be responsible for obtaining said water meter. An air gap shall be provided between pipes/hosed connected to a fire hydrant and a storage tank/equipment used by the Contractor.
8. The curing temperature and duration schedule shall be as recommended by the resin/catalyst system manufacturer.

a. The heat source shall be fitted with suitable monitors to gauge the temperature of the incoming and outgoing heat supply.
b. The Contractor shall utilize a remote temperature sensing method to ensure adequate curing for every foot of liner in the pipe, considering the possibility of heat sinks. Temperatures monitored at the manholes do not guarantee an adequate representation of the temperatures for every foot of liner.

1) Temperatures from each remote sensing device shall be recorded by a strip-chart recorder on a continuous tape.
2) Graphs of the tape shall reflect readings from start of cure to completion of cure/draining of line.
3) Tapes for each segment shall be submitted upon completion of each section.
4) Initial cure may be considered complete when the remote sensing device(s) reflect that the cure temperatures, as recommended by the resin/catalyst system manufacturer, have been achieved.
5) Curing temperatures and duration shall comply with submitted data and shall include an adequate “cool down” as recommended by the resin manufacturer.

C. Cool Down

1. The Contractor shall cool the hardened liner to a temperature less than 100 degrees Fahrenheit, in accordance with the resin manufacturer’s recommendation, before relieving the water column or pressure.

a. Cool water may be added to the water column while maintaining circulation as water is drained from a small hole at the opposite end of the cured-in-place pipe so that a constant water column height is maintained until cool-down is completed.
b. Care shall be taken in the release of the water column so that a vacuum will not develop that could damage the newly installed liner.
c. Coupon samples shall be obtained for testing.

2. If styrene levels on the surface of the liner exceed EPA or wastewater treatment plant standards for stormwater or sanitary sewer pipes (respectively), the Contractor shall flush the line until styrene levels in flush-water are within the appropriate standard.
3. The Contractor shall provide whatever measures are required to prevent the movement or discharge of gases, liquids or solids associated with the liner material and process into adjacent buildings upstream or downstream of the sewer/drain being rehabilitated. The Contractor shall be responsible and liable for any damages or violations associated with such actions. The Contractor shall also be responsible for monitoring and protecting as required the discharge of any byproducts caused by the installation of the liner or the lining process.

D. Post Installation

1. For Fold and Form type liners: After installation of the liner a mechanical type sealing device capable of providing a watertight seal shall be installed at the manhole to seal the liner to the manhole wall. Grouting alone is not acceptable.
2. The type of seal shall be submitted as a shop drawing at the pre-construction meeting.

E. Service Connections

1. After the liner has been completely installed all existing active services shall be reopened.
2. The contractor shall keep precise information from the pre-lining DVD of the location of all services. The Contractor shall review the pre- and post-construction DVD to ensure that all services have been opened.
3. All existing inactive services shall not be reopened. The decision not to reconnect an existing service shall be approved by the Engineer.
4. Branch connections shall be re-opened without excavation, utilizing a remotely controlled cutting device, monitored by a CCTV. The Contractor shall certify a minimum of two complete functional cutters plus key spare components are on the job site before each installation or are in the immediate area of the job site and can be quickly obtained.
5. No additional payment will be made for excavations for the purpose of reopening connections and the Contractor will be responsible for all costs and liability associated with such excavation and restoration work.
6. The Contractor shall be required for a period of two years after the accepted completion of this work, to correct any improperly reopened services or any services which were not reopened.

F. Testing

1. The water tightness of the liner shall be gauged during the installation under a positive head.
2. After the work is completed, the Contractor shall submit a DVD showing the completed work including the restored condition.
3. CIPP samples shall be prepared for each installation designated by the Engineer or approximately 20% of the project's installations. Pipe physical properties shall be tested in accordance with ASTM F-1216 or ASTM F-1743, Section 8, using either method proposed. The flexural properties must meet or exceed the values listed in this specification, Table 1 of ASTM F-1216 or the values submitted to the Engineer by the Contractor for this project's CIPP wall design, whichever is greater.
4. Wall thickness of samples shall be determined as described in paragraph 8.1.6 of ASTM F-1743. The minimum wall thickness at any point shall not be less than 87½ % of the submitted minimum design wall thickness as submitted for this project.
5. Visual inspection of the CIPP shall be in accordance with ASTM F-1743, Section 8,6.

G. Gas and Odor Control

1. The Contractor is responsible for the control of all odors and gases produced as part of the installation and curing of the liner
2. The Contractor shall have an emergency response plan in place in the event of complaints of styrene gas entering a building that includes the proper testing equipment and air removal system. The following items shall be addressed by the Contractor:

    a. The Contractor shall flush out all pipes affected by the work with clean water immediately after the liner is cured.
    b. The Contractor shall have at least three 16-inch smoke ejectors available including an external power source.

c. If a service is being bypassed, then all openings on the service will be plugged during the curing process.

H. Video Taping

1. After work is completed, the Contractor shall video inspect the rehabilitated pipe sections and submit a DVD showing the rehabilitated sections after rehabilitation including the location of all service connections.

3.4 CLEAN UP

A. After the installation work has been completed, the Contractor shall clean up the entire project area and restore disturbed areas to as good a condition as existing prior to the work being performed.

B. The Contractor shall dispose of all excess material and debris not incorporated in the permanent installation.

End of Section

Section 33 10 00

WATER UTILITIES

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all SECTIONS within DIVISION 1 – GENERAL REQUIREMENTS, which are hereby made a part of this Section of Specifications.

1.2 DESCRIPTION OF WORK

A. Provide labor, materials, and equipment necessary to construct the exterior water system complete, including connections to existing pipelines and testing, all as indicated on the Drawings and as specified, including but not limited to the following:

1. Installation of ductile iron pipe, fittings, accessories, and appurtenant work, at the locations and to the lines and grades indicated on the Contract Drawings.
2. The installation of hydrants, gate valves and boxes and concrete thrust blocks.
3. Furnishing and installation of all materials required to connect to existing water mains, replace existing services, install new gate valves, remove existing gate valves, install corporation cocks, saddles, curb stops, service boxes, and abandoning of the existing water system (if applicable), all as shown on the Contract Drawings. All valves, 24 inches and larger shall be butterfly valves. All abandoned pipes shall be cut and capped at the main.
4. In accordance with 528 CMR 12.00, work on the fire protection system, including hydrants and exterior underground piping, shall be performed by a Licensed Fire Protection Sprinkler Systems Contractor. The fire protection exterior underground piping will terminate at the valved tee connection to the water distribution system. The tee and valve will not be considered part of the fire protection system work.

B. Unless otherwise indicated on the Drawings, exterior water lines shall be installed from a point 10 feet outside the building foundation walls to the potable water source

C. Related Work: The following items are not included in this Section and will be performed under the designated Sections.

1. Section 31 20 00 – EARTH MOVING for excavation, backfill, and compaction requirements.
2. Section 21 10 00 – FIRE PROTECTION for fire protection service piping.
3. Section 22 10 00 – PLUMBING for potable water service piping.

1.3 SUBMITTALS

A. Refer to Section 01 33 00 – SUBMITTAL PROCEDURES for submittal provisions and procedures.

1. Descriptive literature showing pipe dimensions, pipe and joint materials and dimensions, and other details for each class or type of pipe or product to be furnished for this contract. All pipe furnished under the contract shall be manufactured in accordance with these Specifications.

2. Product Data: Submit manufacturer's technical product data and installation instructions for potable water system materials and products.
3. Shop Drawings: The Contractor shall submit for review shop drawings or descriptive literature for potable water system, showing piping, fittings, couplings, valves, hydrants, materials, dimensions, restrained joint calculations, joints and other details, blocks, and anchors. All hydrants and valves furnished under the Contract shall be manufactured only in accordance with the Specifications and the approved Shop Drawings.
4. At project closeout, submit record drawings of installed potable water system piping and products, in accordance with requirements of Division 1. As-Built Drawings shall be complete and shall indicate the true measurement and location, horizontal and vertical, of all new construction. As-Built drawings shall be stamped and signed by a Massachusetts Licensed Land Surveyor or Licensed Professional Engineer. The as-built plans shall also be submitted electronically as an AutoCAD drawing file (release 2010 or higher).
5. Maintenance Data: Submit maintenance data and parts lists for water system materials and products. Include this data, product data, shop drawings, and record drawings in maintenance manual in accordance with requirements of Division 1.

1.4 REFERENCE STANDARDS

A. The following standards are applicable to the work of this Section to the extent referenced herein:

1. ASTM: American Society for Testing and Materials.
2. ANSI: American National Standards Institute.
3. AWWA: American Water Works Association.
4. AASHTO: American Association of State Highway and Transportation Officials.
5. Reference is made herein to the Commonwealth of Massachusetts, Department of Transportation (MassDOT), Formerly Massachusetts Highway Department (MHD) Standard Specifications for Highways and Bridges, latest edition, hereinafter referred to as the "Standard Specifications". All references to method of measurement, basis of payment, and payment items in the "Standard Specifications" are hereby deleted. References made to particular sections or paragraphs in the "Standard Specifications" shall include all related articles mentioned therein.
6. MassDOT, Construction Standards, latest Edition with amendments, hereinafter referred to as the “Construction Standards.”
7. Commonwealth of Massachusetts State Plumbing Code, latest edition.
8. Commonwealth of Massachusetts Regulations 528 CMR 12.00 Sprinkler Contractor Licensing Regulations.
9. Worcester Water Department Regulations.

1.5 EXAMINATION OF SITE AND DOCUMENTS

A. It is hereby understood that the Contractor has carefully examined the site and all conditions affecting work under this Section. No claim for additional costs will be allowed because of a lack of knowledge of existing conditions as indicated in the Contract Documents, or obvious from observation of the site.

B. Plans, surveys, measurements, and dimensions under which the work is to be performed are believed to be correct, but the Contractor shall have examined them for himself during the bidding period and formed his own conclusions as to the full requirements of the work involved.

1.6 QUALITY ASSURANCE

A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of potable water systems materials and products, of types and sizes required, whose products have been in satisfactory use in similar service for not less than five years.

B. Installer's Qualifications: Firm with at least three years of successful installation experience on projects with potable water piping work similar to that required for this project.

C. Water Purveyor Compliance: Comply with requirements of Purveyor supplying water to project, obtain required permits and inspections.

1.7 PROJECT CONDITIONS

A. Site Information: Perform site inspection and survey, research utility records, and verify existing utility locations and elevations. Verify that water system piping may be installed in compliance with Contract Drawings and referenced standards.

B. Interruption of Existing Water Distribution System: Do not interrupt service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary service according to the requirements indicated:

1. Notify Architect no fewer than two days in advance of proposed interruption of service.
2. Do not proceed with interruption of service without Architect’s written permission.

1.8 SEQUENCING AND SCHEDULING

A. Coordinate with interior building domestic water and fire protection system piping.

B. Coordinate with other utility work.

C. The Contractor is responsible for developing a sequence of work to maintain existing services in operation until the new services are operational.

D. The Contractor is responsible for coordinating and scheduling the inspection of the work by the jurisdictional authority. All permits and inspection costs and fees shall be included in the bid prices and no additional costs will be paid to the Contractor.

PART 2 - PRODUCTS

2.1 DUCTILE IRON PIPE AND FITTINGS

A. General: Provide piping materials and factory fabricated piping products of sizes, types, pressure ratings, and capacities as indicated. Where not indicated, provide proper selection as determined by Engineer to comply with installation requirements. Provide pipe fittings and accessories of same materials and class as pipes with joining method, as indicated. The piping shall be manufactured by an established manufacturer of good reputation in the industry and in a permanent plant adapted to meet all the design requirements of the pipe.

1. Ductile iron pipe shall be that of a manufacturer who can demonstrate at least five years of successful experience in manufacturing ductile iron pipe. The pipe shall be equipped with push on type, restrained joint, or mechanical joints, as required.
2. All ductile iron water pipe shall conform to American Water Works Association (AWWA) C150 and AWWA C151.

3. The ductile iron pipe shall be Class 52 and furnished in minimum nominal 18-foot lengths, with Push-on or Mechanical Joints as manufactured by U.S. Pipe and Foundry Company, Atlantic States Cast Iron Pipe Co., Clow Corporation, or approved equal with gaskets conforming to AWWA C111 "Rubber Gasket Joints". A minimum of two brass wedges per joint shall be used to maintain conductivity and facilitate lock-on.
4. All ductile iron pipes shall be rated for a minimum operating pressure of 350 psi.
5. The exterior of ductile iron pipe shall be coated with a layer of arc-sprayed zinc per ISO 8179. The mass of the zinc applied shall be 200 g/m2 of pipe surface area. A finishing layer asphaltic topcoat shall be applied to the zinc. The mean dry film thickness of the finishing layer shall not be less than 3 mils with a local minimum not less than 2 mils. The zinc coating system shall conform to ISO 8179-1 “Ductile iron pipes-External zinc-based coating-Part 1: Metallic zinc with finishing layer. Second edition 2004-06-01.”
6. The ductile iron water pipe shall be double cement lined inside and then asphalt seal coated in accordance with AWWA C104 and AWWA C151. The pipe shall be furnished along with necessary materials and equipment recommended by the manufacturer for use in joining pipe lengths and fittings.
7. All water pipe shall be encased in polyethylene film when the trench is backfilled with control density fill.
8. Fittings shall be ASTM A-536 ductile iron with mechanical joint fittings. All fittings 3 inches through 48 inches in diameter shall meet or exceed the requirements of AWWA C110. Compact fittings shall be ductile iron meeting or exceeding the requirements of AWWA C153. Fittings shall have the same lining and coating as the pipe specified above. All fittings shall be marked with the weight and shall have distinctly cast upon them the pressure rating, the manufacturer's identification, nominal diameter of openings and the number of degrees or fraction of the circle on all bends. All fittings 4 through 24 inches shall be Class 350. All fittings greater than 24 inches shall be as specified above except they shall be Class 250. Compact fittings shall only be used in sizes 4 through 24 inches. Fittings shall conform to the weights, excluding accessories, and dimension shown in the latest edition of the Handbook of Ductile Iron Pipe and come complete with all joint accessories as required. All accessories (gland, gaskets, T-bolts, and nuts) shall be in accordance with AWWA C111. All mechanical joint bolts (T-bolts) shall be Cor-Ten or equal.
9. In order to provide positive joint restraint, valve anchor tees/valves and restrained joints shall be used on fire services and on the 6-inch branch connections for hydrants.
10. Caps and plugs installed in all new work as indicated on the Contract Drawings shall be provided with a threaded corporation or bleeder valve so that air and water pressure can be relieved prior to future connection.
11. Contractor shall provide all adapters and fittings such as transition couplings, as determined in the field, necessary to complete all cross connections, whether or not specifically stated in the Contract Drawings and Specifications.
12. All pipe shall be marked with the class, thickness designation, and initials of the manufacturer.
13. If required the manufacturer shall supply the Engineer with certificates of compliance with these Specifications and certification that each piece of ductile iron pipe has been tested at the foundry with the Ball Impression Test, Ring Bending, or equal.
14. Thrust blocks shall be used at all bends and fittings as shown on the details. In addition, all bends and fittings shall be restrained with Megalug Series 1100 mechanical joint restraint. In the event that the use of thrust blocks is not practical or allowed, the Contractor shall provide an alternate method of joint restraint, at no additional cost to the owner, as approved and/or as directed by the Engineer. Restraint length calculations and restrained joint locations shall be provided by the contractor and submitted to the engineer for review. Restraint length values shall be calculated per the manufacturer’s standards.

a. Restraint for standardized mechanical joints shall be incorporated in the design of the follower gland and shall impart multiple wedging actions against the pipe, increasing its resistance as the pressure increases. The assembled joint shall maintain its flexibility after burial and shall maintain its integrity by a controlled and limited expansion of each joint during the wedging action. Restraining glands shall be manufactured of high strength ductile iron conforming to the requirements of ASTM A536, Grade 65-45-12. Wedging mechanisms shall be manufactured of ductile iron, heat treated to a hardness of 370 BHN minimum. Dimensions of the gland shall be such that it can be used with the standardized mechanical joint bell and tee head bolts conforming to the requirements of ANSI/AWWA A21.11/C111 and ANSI/AWWA A21.53/C153 of latest revision. Twist-off nuts shall be incorporated in the design of the wedge activation screws to ensure proper torque. The mechanical joint restraining device shall have a water working pressure rating of 350 psi minimum (in sizes 4" thru 16") with a safety factor of at least 2:1 against separation when tested in a dead-end situation.

b. Restraint for push-on ductile iron pipe shall consist of a wedge action restraint ring on the spigot joined to a split ductile iron ring behind the bell. The restraint ring shall have individually actuated wedges that increase their resistance to pull-out as pressure or external forces increase. The restraint ring and its wedging components shall be made of minimum grade 65-45-12 ductile iron conforming to ASTM A536. The wedges shall be heat treated to a minimum hardness of 370 BHN. Torque limiting twist off nuts shall be used to ensure proper actuation of the restraining wedges. The split ring shall be made of a minimum grade of 65-45-12 ductile iron conforming to ASTM A536. The connecting tie rods that join the two rings shall be made of low alloy steel that conforms to ANSI/AWWA C111/A21.11. The assembly shall have a rated pressure with a minimum two to one safety factor of 350 PSI in the sixteen-inch size and below 250 PSI in the eighteen through thirty-six-inch sizes. Push on joints on ductile iron pipe shall be restrained with Megalug Series 1700 restraint harness.

15. Insulation shall be manufactured by Thermal Pipe Systems, Atlas Insulation, or Insulated Piping Systems Inc., or other approved manufacturer. Insulation shall be factory foamed-in-place polyurethane foam insulation having nominal thickness of 1 1/2-inch, with an in-place density of 2.5 pcf, and a "K" factor of 0.16 BTU*in./hr.*°F*sq. ft. Straight joints between insulated pipe lengths and the end sections of non-insulated pipe shall be sealed with heat shrinkable wrap-around polyethylene as supplied by manufacturer and installed in field by Contractor. Insulation jacket shall be 20-gauge corrugated aluminum preformed to be fastened with stainless steel screws and bands. Jacket shall have one layer of one mil polyethylene film with a protective coat of 40-pound virgin Kraft paper to act as a moisture and galvanic corrosion barrier.
16. Pipe for use with split couplings shall be as specified except that the ends shall not have bells or beads but shall have cast or machined shoulders or grooves as necessary for the couplings to be used and shall conform to the specifications of the manufacturer of the couplings. If split couplings are used with grooved ductile-iron pipe, the minimum pipe wall thickness shall be as follows:

Nominal Pipe Size (In.)	Thickness Class
4-12	53
14-18	54
20	55
24	56

17. Pipe for use with sleeve-type couplings shall be as specified except that the ends shall be plain (without bells or beads). The ends shall be cast or machined at right angles to the axis.

B. COUPLINGS AND ADAPTERS FOR DUCTILE IRON PIPE

1. Sleeve type couplings for plain end pipe shall be provided with plain rubber gaskets and steel, tee head bolts with nuts. Couplings shall be Dresser style 38 or 138, furnished preassembled, as manufactured by Dresser Industries, Inc., Smith Blair, Coupling Systems, Inc., or equal.
2. Couplings or adapters as required for connecting existing pipe to new pipe or new pipe to new pipe shall be furnished as required and designed for compatibility with the pipe and operating pressures encountered. Couplings shall be Dresser Style 162 as manufactured by Dresser Industries Inc., or equal. Flanged adapters shall be Dresser Style 128, or equal. Couplings for ductile iron to cast iron pipe shall be Style 53, and for ductile iron to transite pipe shall be style 153, as manufactured by Dresser Industries, Inc., or as manufactured by Smith Blair, Coupling Systems, Inc. or equal. Transition couplings shall be Style 162 as manufactured by Dresser Industries, Inc. or approved equal.
3. Split couplings may be used for connecting gray cast iron or ductile iron. If split couplings are used with grooved ductile iron pipe, the minimum pipe wall thickness shall be as specified. Split couplings shall be made of malleable iron and shall be suitable for use with grooved-end or shouldered-end, cast iron pipe. They shall be Victaulic couplings made by the Victaulic Company of America, Elizabeth, New Jersey; Gruvagrip couplings made by Gustin-Bacon Manufacturing Company, Kansas City, Missouri; Groove couplings made by Eastern Malleable Iron Company, Pittsburgh, Pennsylvania; or equal products.
4. Flexible Couplings: Sleeve type couplings for plain end ductile iron pipe shall be provided with plain rubber gaskets and steel, track head bolts with nuts.
5. Couplings shall be furnished pre-assembled by the manufacturer.
6. Couplings shall be given a shop coat compatible with the same outside coating as the pipe specified above.
7. All couplings shall be furnished with the pipe stop removed.
8. Couplings shall be provided with gaskets of a composition suitable for exposure to the liquid within the pipe. The gaskets shall have metallic tips to provide electrical continuity through the joint.
9. The Contractor shall provide suitable filling rings where the layout of the flanged piping is such as to necessitate their use. In materials, workmanship, facing, and drilling, such rings shall conform to the 125-pound ANSI Standard. Filling rings shall be of suitable length with nonparallel faces and corresponding drilling, if necessary, to ensure correct assembly of the adjoining piping or equipment.
10. Couplings for exposed pipe shall be of steel and shall be Dresser Style 38, Smith-Blair Style 411, Baker Allsteel, or equal. The couplings shall be provided with steel bolts and nuts.
11. At the Contractor's option, flexible connections in the piping shall be sleeve-type couplings, split couplings or mechanical joint pipe as herein specified.

C. INSPECTION, TESTS, AND ACCEPTANCE FOR DUCTILE IRON PIPE

1. All pipe delivered to the job site shall be accompanied by test reports certifying that the pipe and fittings conform to "AWWA Standard for Ductile Iron Pipe, for Water and Other Liquids" (AWWA H3) and (AWWA C151).

2. All tests shall be made in accordance with the methods prescribed by the above mentioned AWWA Standards, and the acceptance or rejection shall be based on the test results.
3. Pipe which does not conform to the requirements of this contract shall be immediately removed and replaced by the Contractor.
4. All ductile iron pipe to be installed under this Contract may be inspected at the foundry for compliance with these Specifications by an independent testing laboratory selected by the Owner. The Contractor shall require the manufacturer's cooperation in these inspections. The cost of foundry inspection of all pipe approved for this Contract, plus the cost of the inspection of a reasonable amount of disapproved pipe, will be borne by the Owner.

D. FLANGED JOINTS FOR DUCTILE IRON PIPE

1. For flanged joints, gaskets shall be ring gaskets of rubber with cloth insertion. Gaskets twelve (12)-inches in diameter and smaller shall be 1/16-inch thick, gaskets larger than twelve (12)-inch shall be 3/32-inch thick.
2. Flanged joints shall be made with bolts, bolt studs with a nut on each end, or studs with nuts where the flange is tapped. The number and size of bolts shall conform to the same ANSI Standard as the flanges. Bolts and nuts shall, except as otherwise specified or noted on the Contract Drawings, be Grade B conforming to the ASTM Standard Specification for Carbon Steel, Externally and Internally Threaded Standard Fasteners, Designation A307. Bolts and studs shall be of the same quality as machine bolts. Flanged ductile iron pipe from 3 to 48-inches in diameter shall be classified by Underwriters Laboratories Inc. in accordance with AWWA C115.

2.2 RESILIENT WEDGE GATE VALVES

A. Resilient wedge gate valves shall be iron body, resilient seated type. The valves shall be designed for 250 psi working pressure and 400 psi test pressure.

B. Valves are to have O ring seals and a non-rising stem. Valves shall have a 2-inch operating nut. Valves shall open right (clockwise).

C. Resilient gate valves shall meet the most recent version of the AWWA standard specification AWWA C509.

D. Resilient wedge valves shall have mechanical joint ends.

E. Valves shall be as manufactured by U.S. Pipe and Foundry Company Metroseal 250, American Flow Control Model AFC2500, or Mueller Resilient Wedge Gate Valves.

F. Valve boxes shall be cast iron, asphalt coated, sliding, heavy pattern type, consisting of three (3) pieces; a flanged bottom piece, a flanged top piece, and a cover with two (2) lifting holes and the word "water" cast on the top. A minimum 6-inch overlap is required between sliding sections. The valve box shall be designed and constructed to prevent direct transmission of traffic loads to the pipe or valve. The inside diameter of boxes shall be at least 4 1/2 inches and lengths shall be as necessary to suit ground elevation. The top of the cover shall be flush with the top of the box rim. Box covers shall be round frame and cover.

G. Valves shall be connected directly to valve anchor tees at all hydrant branches.

2.3 TAPPING SLEEVES AND VALVES

A. Tapping sleeves shall be of ductile iron construction, meeting ASTM A536 Grade 65-45-12. Side flange seals shall be O-Ring type of round, oval or rectangular cross-section shape. Sizes 12" and smaller must be capable of working on Class ABCD pipe diameters without changing either half of sleeve. Sizes 14" and larger must be specified to which class is needed. All sleeves are to include the end joint accessories and split glands necessary to assemble sleeve to pipe. Sleeve shall be coated with asphaltic varnish in compliance with NSF-61.

B. Tapping valves shall conform to the requirements specified above for gate valves except that all Tapping sleeves and valves shall consist of a ductile iron flanged by mechanical joint sleeves and a tapping type gate valve with one flange and one mechanical joint end. The Contractor shall be responsible for verifying the outside diameter of the pipe to be tapped.

C. The valve shall be provided with an oversized seat to permit the use of full-size cutters. Before backfilling, all exposed portions of any bolts used to hold the two halves of the sleeves together shall be heavily coated with two coats of bituminous paint comparable to Inertol No. 66 Special Heavy. Sleeves shall be of ductile iron furnished with O-ring gaskets.

D. Bolts on bonnet and stuffing box shall be stainless steel (316 stainless steel), stuffing boxes shall be "O" ring type as indicated. Gaskets shall cover the entire flange surface.

2.4 HYDRANTS

A. General: Provide Hydrants as indicated. The Hydrants shall be manufactured by an established manufacturer of good reputation in the industry and in a permanent plant adapted to meet all the design requirements of the hydrant.

1. Fire hydrants shall meet or exceed AWWA C-502, latest revision and shall comply with Factory Mutual Research Corporation and Underwriters' Laboratories UL 246 Standard and specific requirements and design standards per Kennedy Valve drawing no. 80783. Rated water working pressure shall be 200 psi, test pressure shall be 400 psi.
2. The main valve closure shall be of the compression type, opening against the pressure and closing with the pressure.
3. Hydrants shall be of the breakaway type: The upper barrel shall connect to the lower barrel with a breakable traffic flange and 8 bolts and nuts. This connection shall allow 360-degree rotation of the upper nozzle section.
4. The main valve opening shall be 5-1/4 inch and be designed so that removal of seat, drain valve mechanism, internal rod and all working parts can be removed through top of hydrant. These parts shall be removable without disturbing the ground line joint or the nozzle section of the hydrant. The bronze seat shall be threaded into mating threads of bronze for easy field removal.
5. The draining system of the hydrant shall be bronze and activated by the main stem without use of auxiliary rod, toggles, pins, etc. The drain mechanism shall be completely closed after no more than three turns of the operating nut in the opening direction. There should be a minimum of (2) inside ports and (4) drain port outlets to the exterior of the hydrant. Drain shut off to be by direct compression closure.
6. The operating nut, main stem, coupling and main valve assembly shall be capable of withstanding input torque of 200 ft. lbs. in opening or closing directions. There shall be an internal top housing with triple O-Rings to seal operating threads from the waterway and accommodate an anti-friction washer.

7. Fire hydrants shall have 6-inch mechanical joint inlet connections to the main, two 2 ½-inch hose connections, 180-degrees apart, and one 4 ½-inch steamer connection. The hose and steamer connections shall have National Standard Thread. The standpipe shall have an 8 ½-inch minimum diameter. All nozzle caps shall be cast iron and shall be secured to the hydrant barrel with chains.
8. Hydrant shall be marked with an arrow and the word "open" to indicate the direction to turn the stem to open the hydrant. Hydrants shall open to the right (clockwise) and have a bronze operating nut that shall be pentagonal in shape, 1-1/2 inch from point to opposite flat.
9. The upper barrel shall be ductile iron with markings identifying size, model and year of manufacture. The lower barrel shall be ductile iron.
10. The hydrant shall have a minimum working pressure of 200 psi. Hydrant design shall be of positive automatic drain type to prevent freezing.
11. Hydrants shall be thoroughly cleaned and given two (2) shop or field coats of paint in accordance with AWWA C502 and the instruction of the paint manufacturer. Paint color shall be the standard hydrant color of the City of Worcester (high-visibility yellow).
12. If the hydrant is delivered with the manufacturer's standard color, the hydrant shall be given one (1) matching field coat of alkyd gloss enamel. If the hydrant is delivered with no standard color, the hydrant shall be given two (2) coats of alkyd gloss enamel according to the colors specified by the City of Worcester.
13. All exposed metal surfaces will be painted.
14. Hydrant paint shall be as manufactured by Sherman-Williams, PPG Industries, Pittsburgh, PA; Koppers Company, Inc., Pittsburgh, PA; Tnemec Company, Inc. Kansas City, MO; or approved equal.
15. Alkyd gloss enamel shall be Series 54-300 by PPG; Glamortex by Koppers; 2H-Tneme by Tnemec or approved equal.
16. Hydrants shall be Kennedy Guardian K81D or equal and approved by the City of Worcester.

B. HYDRANT SAFETY FLANGE REPAIR KIT

1. Safety flange repair kits shall come complete with stem coupling, safety flange, flange gasket, replacement bolts and nuts and hydrant lubricating oil.
2. Safety flange repair kits shall be compatible with hydrant furnished.

C. HYDRANT EXTENSION KITS

1. Extension kits shall come complete with extension barrel, extension stem, stem coupling and hardware, flange, flange gasket, 8 bolts and nuts and hydrant lubricating oil.
2. Extension kits shall be compatible with hydrant furnished.

2.5 SERVICE TUBING, CORPORATIONS, STOPS, SADDLES, AND VALVE BOXES

A. Service tubing shall meet the requirements of Federal Specification WW-T 7996 and shall conform to ASTM Specification B75, B68 and B88 as they apply to Type K Copper Tubing.

B. Copper Tube Size (CTS) Polyethylene Tubing for domestic water uses shall conform to AWWA C901, ASTM D3350, and ASTM D2737 and shall have a working pressure rating of 200 psi. Tracer wire shall be attached to the tubing and connected to upstream piping of the associated water meter for the water service, as applicable.

C. The Contractor shall furnish and install, including necessary taps and connections, corporation stops, CTS Polyethylene Tubing, curb stops and wastes.

D. The corporation stops shall meet the most recent revision of the AWWA standard "Threads for Underground Service Line Fittings." (AWWA C800).

E. Corporation stops shall be sized as shown on the drawings and be brass compression-type with CC thread (Mueller Brand with compression nut with set screw). Corporation stops shall open [right].

F. Curb Stops: Curb stops shall be sized as shown on the drawings and be brass compression-type with drain (Mueller Brand with compression nut with set screw). Curb stops shall open [right].

G. Tapping Saddles: Service connections shall be tapped with Size 2” X 8” double strap service saddles.

H. Fittings and Boxes: Service boxes shall be cast iron. Extension service boxes of the required length and having slide-type adjustment shall be installed at all service box locations. The boxes shall have housings of sufficient size to completely cover the curb stop and shall be complete with identifying covers

I. Service boxes shall be 2 ½” Buffalo Style, heavy cast iron, tar-coated, sliding type, consisting of three (3) pieces; a flanged bottom piece, a flanged top piece and bolted cover with the word "water" cast on the top. A minimum 6-inch overlap is required between sliding sections. The boxes lengths shall be as necessary to suit ground elevation.

2.6 IDENTIFICATION

A. Detectable Underground Warning Tapes: Acid and alkali-resistant polyethylene plastic film warning tape, 6-inches wide by 4-mils. minimum thickness, with continuously printed caption in black letters "CAUTION - xxxxx LINE BURIED BELOW." The text and color of the tape shall be as shown in the table below. The tape shall have a metallic core encased in a protective jacket for corrosion protection and be detectable by a metal detector when the tape is buried up to 2.5-feet deep.

Color	Utility
Safety Red	Electric
High Visibility Safety Yellow	Gas, Oil, Steam
Safety Alert Orange	Telephone, Communications, Cable Television
Safety Precaution Blue	Water System, Irrigation
Safety Green	Sanitary Sewer, Storm Sewer
White	Proposed Excavation

PART 3 - EXECUTION

3.1 INSPECTION

A. General: Examine areas and conditions under which potable water system's materials and products are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Engineer.

B. The Contractor is responsible for the provisions and all test requirements specified in herein. In addition, all pipe and appurtenances may be inspected at the plant for compliance with these specifications by an independent testing laboratory.

C. All tests shall be made in accordance with the methods prescribed by the above-mentioned AWWA Standards, and the acceptance or rejection shall be based on the test results.

D. Inspection of the pipe and appurtenances may also be made after delivery. The pipe and appurtenances shall be subject to rejections at any time on account of failure to meet any of the specifications requirements, even though samples may have been accepted as satisfactory at the place of manufacture.

E. Pipe which does not conform to the requirements of this contract shall be immediately removed and replaced by the Contractor at no cost to the Owner.

3.2 HANDLING PIPE

A. The Contractor shall take care not to damage pipe by impact, bending, compression, or abrasion during handling, and installation. Joint ends of pipe especially shall be kept clean.

B. Pipe shall be stored above ground at a height no greater than 5-feet, and with even support for the pipe barrel.

C. Only nylon protected slings shall be used for handling the pipe. No hooks, chains or bare cables will be permitted.

D. Gaskets shall be shipped in cartons and stored in a clean area, away from grease, oil, heat, direct sunlight and ozone-producing electric motors.

3.3 INSTALLATION OF PIPE AND PIPE FITTINGS

A. The Contractor shall provide all adapters and fittings such as transition couplings, as determined in the field, necessary to complete all cross connections, whether or not specifically stated in the Contract Drawings and Specifications.

B. Care shall be taken in loading, transportation, and unloading to prevent injury to the pipe or coatings. Pipe or fittings shall not be dropped. All pipe and fittings shall be examined before placement, and no piece shall be installed which is found to be defective. Any damage to the pipe coatings shall be repaired as directed by the Engineer or Owner’s Representative.

C. If any defective pipe is discovered after it has been placed, it shall be removed and replaced with a sound pipe in a satisfactory manner by the Contractor, at his own expense. All pipe and fittings shall be kept clean until they are used in the work, be thoroughly cleaned before placement, and when placed, shall conform to the lines and grades required. Ductile iron pipe and fittings shall be installed in accordance with requirements of AWWA Standard Specification C600 except as otherwise provided herein. A firm even bearing throughout the length of the pipe shall be constructed by compacting sand gravel borrow around the pipe and up to 18 inches above the pipe.

D. Blocking will not be permitted.

E. A minimum horizontal separation of ten (10) feet shall be maintained between an existing, proposed or relocated sewer and the new water main. The distance shall be measured edge to edge. In cases where it is not practical to maintain a ten-foot separation, it is permitted to install a water main closer to a sewer, provided that the water main is laid in a separate trench or on an undisturbed earth shelf located eighteen (18) inches above the top of sewer. Where the horizontal clearance is less than ten (10) feet or the vertical clearance is less than eighteen (18) inches and the sewer crosses under the water main, both water main and sewer main shall be constructed of mechanical joint cement-lined ductile iron pipe for a

distance of 10-feet on either side of the crossing. One (1) full length of water pipe shall be centered over the sewer at the crossing. If the sewer crosses over the water main, regardless of the vertical separation, both pipes shall be concrete encased for a distance of ten (10) feet to either side of the respective centerline.

F. Provide minimum cover over piping of 5-feet below finished grade.

G. Extend water systems from the water main located within the public way and terminate potable water piping 10-feet 0-inches from the building foundation. Provide temporary pipe plug for piping extension into building if required by construction progress.

H. All pipes shall be sound and clean before placement. When pipe laying is not in progress, including lunchtime, the open ends of the pipe shall be temporarily closed by watertight plug or other acceptable means. Alignment shall be maintained during placement. The deflection at joints shall not exceed sixty percent of that recommended by the manufacturer. Fittings, in addition to those shown on the plans, shall be provided, if required, in crossing utilities, which may be encountered upon opening the trench. Solid sleeves shall be used only where allowed by the Engineer.

I. When cutting pipe is required, the cutting shall be done by machine, leaving a smooth cut at right angles to the axis of the pipe. Cut ends of pipe to be used with a push-on type bell shall be beveled to conform to the manufactured spigot end. Cement lining shall be inspected for damage and shall be remortared as required to ensure a continuous lining.

J. Mechanical joint restraints shall be used for all valves, bends, hydrants and piping section less than 50 feet. The contractor shall restrain all pipe runs to the lengths indicated on the approved restrained joint calculation shop drawings.

K. Jointing of ductile iron push on pipe and fittings shall be done in accordance with the printed recommendations of the manufacturer and as specified. The last 8 inches of the outside of the spigot end of pipe and the inside of the bell end of pipe shall be thoroughly cleaned. The joint surfaces and the gasket shall be painted with a lubricant just prior to making up the joint. The spigot end shall then be gently pushed home into the bell. The position of the gasket shall be checked to ensure that the joint has been properly made and is watertight. Care shall be taken not to exceed the manufacturer's recommended maximum deflection allowed for each joint.

1. Jointing Ductile Iron Pipe (Push-On Type): Push-on joints shall be made in strict accordance with the manufacturer's instructions. Pipe shall be laid with bell ends looking ahead. A rubber gasket shall be inserted in the groove of the bell end of the pipe, and the joint surfaces cleaned and lubricated. The plain end of the pipe to be entered shall then be inserted in alignment with the bell of the pipe to which it is to be joined and pushed home with a jack or by other means. After joining the pipe, a metal feeler shall be used to make certain that the rubber gasket is correctly located.
2. Jointing Mechanical Joint Fittings: Mechanical joints at valves, fittings, and where designated shall be installed in accordance with the "Notes on Method of Installation" under ANSI Specification A 21.11 and the instructions of the manufacturer. To assemble the joints in the field, the Contractor shall thoroughly clean the joint surfaces and rubber gasket with soapy water before tightening the bolts. Bolts shall be tight to the specified torque. Under no condition shall extension wrenches or pipes over handles or ordinary ratchet wrenches be used to secure greater leverage.

L. Installation and jointing of ductile iron pipe shall be in accordance with AWWA C600, Sections 9b and 9c, latest revision, as applicable.

M. Service tubing shall be installed with minimum 6-inches of sand bedding and 12-inches sand cover. Service tubing shall have a minimum total cover of 5 feet.

3.4 INSTALLATION OF VALVES AND APPURTENANCES

A. Cleaning and Prime Coating Valves and Appurtenances (Except Epoxy Coated Valves)

1. Prior to shop prime coating, all surfaces of the valves and appurtenances shall be thoroughly clean, dry, and free from all mill-scale, rust, grease, dirt, paint and other foreign substances to the satisfaction of the Engineer or Owner's Representative.
2. All ferrous surfaces shall be sand-blasted or pickled according to SSPC-SP6 or SSPC-SP8, respectively.
3. All gears, bearing surfaces and other surfaces not to be painted shall be given a heavy coat of grease or other suitable rust resistant coating unless otherwise specified herein. This coating shall be maintained as required to prevent corrosion during any period of storage and installation and shall be satisfied through the time of final acceptance.

B. Installation

1. All valves and appurtenances shall be installed in the location shown, true to alignment and rigidly supported. Any damage to the above items shall be repaired before they are installed.
2. Care shall be taken to prevent damage to valves and appurtenances during handling and installation. All materials shall be carefully inspected for defects in workmanship and materials, all debris and foreign material cleaned out of valve openings, etc., and all operating mechanisms operated to check their proper functioning, and all nuts and bolts checked for tightness. Valves and other equipment that does not operate easily, or are otherwise defective, shall be repaired or replaced.

C. Shop Painting Valves and Appurtenances

1. Interior and exterior surfaces of all valves which are not factory epoxy coated shall be given two coats of shop finish of an asphalt varnish conforming to AWWA C504 for Varnish Asphalt. The pipe connection openings shall be capped to prevent the entry of foreign matter prior to installation.

D. Buried Valves

1. Install valves as indicated with stems pointing up. Provide valve box over underground valves. Buried valves and boxes shall be set with the operating stem vertically aligned in the center of the valve box. Valves shall be set on a firm foundation and supported by tamping selected excavated material under and at the sides of the valve.

E. Valve Boxes

1. Valve boxes shall be installed vertically, centered over the operating nut, and if they are in the limits of the roadway or within limits where the plowing of snow will take place in the winter, the tops of the boxes shall be set ½" below the top of the finished grade. In locations where these boxes are not likely to be disturbed, the tops shall be set flush with the adjoining ground. Boxes shall be adequately supported during backfilling to maintain vertical alignment.

F. Corporation Cocks

1. The tapping machine shall be rigidly fastened to the pipe as near the horizontal diameter as possible. The length of travel of the tap should be so established that when the stop is inserted and tightened with at 14" wrench, not more than one to three threads will be exposed on the outside. When a wet tapping machine is used, the corporation stop shall be inserted and tightened in accordance with the manufacturer's specifications.

3.5 INSTALLATION OF HYDRANTS

A. Hydrants and hydrant branches shall be tested at 175 psi and chlorinated as specified in this specification.

B. Hydrants shall be installed in conformance to AWWA C 600, Section 11, latest revision, using thrust blocks and restrained joints in accordance with the details shown on the Contract Drawings.

C. Hydrants, as detailed on the Contract Drawings, shall be set at the locations designated by the Engineer and shall be bedded on a firm foundation. A drainage pit 2-feet 6-inches in diameter and to the limits shown on the Contract Drawings shall be filled with crushed stone and satisfactorily compacted. During backfilling, additional crushed stone shall be brought up around, and 6-inch over the drain port. Each hydrant shall be set in true vertical alignment and shall be properly braced. Thrust blocks shall be placed between the back of the hydrant inlet and undisturbed soil at the end of the trench. Hydrant shall be set upon a slab of concrete not less than 4-in thick and 15-in square.

D. Hydrants shall be set plumb with the steamer nozzle facing the roadway and the center of the operating nut located 18-inches back from the face of curb or edge of pavement.

E. Hydrants shall be set such that the bottom of the breakaway feature shall be a minimum of 2-inches and a maximum of 4-inches above finish grade.

F. Once installed, hydrants shall be painted once again by the Contractor. Hydrants shall be painted in accordance with the Owner's requirements.

G. All ironwork to be set below ground, after being thoroughly cleaned, shall be painted with two coats of asphalt varnish as specified in AWWA C502, latest revision and ironwork to be left above ground shall be shop painted with two coats of paint.

H. Thrust Blocks: Concrete thrust blocks shall be placed between the back of the hydrant inlet and undisturbed soil at the end of the trench. Minimum bearing area shall be as shown on the Contract Drawings. Felt paper shall be placed as shown on the Contract Drawings. Care must be taken to ensure that concrete does not plug the drain ports.

3.6 BACKFILLING

A. General: Conduct excavation and backfill operations for utility installations in accordance with Section 312000 – EARTH MOVING, local requirements, and the contract documents.

B. Initial backfill shall be placed evenly on both sides of the pipe to distribute the load and not to cause movement or deflection of the pipe.

3.7 FIELD QUALITY CONTROL

A. Testing of Water Main/Service:

1. Prior to pressure testing, the entire line shall be water jetted to remove any rocks or debris that may have inadvertently entered the pipe during construction.
2. The Contractor in accordance with AWWA C651-99 specifications or latest revision will make pressure and leakage tests thereof, to determine that the ductile iron pipe is structurally safe and free of excess leakage. Pipeline shall be subject to a hydrostatic test of 150 pounds per square inch (psi) or 150% of the static pressure, whichever is greater. The Contractor shall furnish all equipment, materials, and labor for testing. Testing shall be done between valved off sections in approximately 1000-foot maximum section of the main. The Contractor shall furnish at his own expense the water needed for all water main testing.
3. Once the pipeline section has been filled at normal pressure and all entrapped air removed from the line, the Contractor shall raise the pressure to the approved test pressure by a special pressure pump taking water from a small tank of proper dimensions for satisfactorily measuring the rate of pumpage into the pipeline. The pipe shall maintain this pressure, within 5 psi, for a minimum of two hours during which time the line shall be checked for leaks. The measured water leakage shall not exceed the maximum allowed leakage as determined by the following equation for the section under test:

$$L = SDP^{1/2} / (133{,}200)$$

Where:
L = Allowable leakage, gallons per hour
S = Length of pipe section tested, feet
(1,000-foot maximum)
D = Nominal pipe diameter, inches.
P = Average test pressure (psi)

Should leakage exceed this rate, the Contractor shall immediately locate the leak or leaks and repair same at his expense. Pipe shall be flushed and chlorinated when leakage does not exceed above standard. Approval does not absolve the Contractor from his responsibility if leaks develop within the new main or water services (to curb box) later within the period of warranty.

B. Testing of Fire Protection Service:

1. Testing of fire protection services shall conform to the most current NFPA requirements.
2. Flush, test, and inspect all FP piping installed by this contractor. Above ground piping testing and flushing shall not occur until:

   a. The underground pipe pressure testing and flushing have been witnessed, and
   b. The underground material and test certificates have been submitted and approved.

3. Inspect, and witness the flushing and testing of all FP-only underground piping installed by the site contractor (site contractor to perform actual underground flushing and pressure testing.). Provide an NFPA 13 underground test and materials certificate based on witnessing the work.

   a. General Contractor shall certify that the site contractor has thoroughly flushed the main underground loop per the following criteria prior to flushing the FP-only service line:

b. All main underground loop piping shall be flushed out an open, 4" hydrant butt, or maximum-15'-long, 4" hose, Flush out the hydrant closest to the mid-point of the loop.
c. 1 side of the main underground loop piping shall be flushed at a time, to ensure maximum water velocity thru that half-loop.
d. Flush for a minimum of 30 seconds per 100 ft of underground pipe.

4. Flushing FP-only service line into building:

a. The FP service line shall be flushed out a hose manifold that provides a combined, minimum 45 square inches of free-cross-sectional area. Options include:
1) 3, 4" hoses
2) 7, 3" hoses
3) 10, 2-1/2" hoses.

b. Maximum length per hose: 50 ft.
c. Flush for a minimum of 30 seconds per 100 ft of FP-only underground length.

C. Chlorinating and Flushing:

1. Prior to chlorination, the Contractor shall properly flush mains. In general, flushing shall be performed at a flow rate required to achieve a minimum velocity of 2.5-feet per second (approximately 900 GPM in a 12-inch diameter main and 400 GPM in 8-inch diameter main). Flushing shall be performed for a sufficient period of time to allow for a minimum of 3 volume changes of water in the main (approximately 20 minutes per 1,000-foot of 8-inch main at the above flow rate).
2. Chlorinating shall be accomplished by pumping a chlorine solution into the mains. Water shall be allowed to enter the new water mains until the mains are full of a solution containing 25-ppm available chlorine. The valves shall then be closed and the chlorinated water allowed to stay in the mains for 24 hours. At the end of this period, the chlorine residual shall be at least 10 mg/l. If it is less than 10 mg/l measured, Contractor shall flush and re-chlorinate the mains at no cost to the Owner. All valves and hydrants shall be operated to ensure their proper disinfection and shall be manipulated to prevent super chlorinated water from entering the existing distribution system. After this period, the Contractor shall flush the mains until clear, clean water is being discharged.
3. Chlorinating and flushing shall be done in accordance with AWWA C651-99 Specifications.
4. Twenty-four hours after the main has been flushed with chlorinated water, bacteriological samples shall be taken. Water samples shall be taken from corporation stops along the length of the water main. A minimum of two (2) samples shall be taken, per 3,000-foot of pipe or on each street, whichever is greater, each in duplicate, in sterile bottles and sent to a State-approved private laboratory for analyses. The Contractor shall perform all necessary work including delivery of samples to a certified laboratory, and shall include the cost of sampling and analysis in his bid price. The results of the tests on these samples will determine the acceptance of the work and allow these new mains to be connected to the District's system. The failure of any sample to pass the laboratory tests shall require the Contractor to re-flush and re-chlorinate the mains and resample and test the water until acceptable results are obtained, all at no additional cost to the Owner.
5. The Contractor shall submit a Disinfection report detailing the following:

a. Type and form of disinfectant used.
b. Date and time of disinfectant injection start and time of completion.
c. Test locations.
d. Initial and 24-hour disinfectant residuals (quantity in treated water) in ppm for each outlet tested.
e. Date and time of flushing start and completion.
f. Disinfectant residual after flushing in ppm for each outlet tested.

6. The Contractor shall submit a Bacteriological Report detailing the following:

a. Date issued, project name, and testing laboratory name, address, and telephone number.
b. Time and date of water sample collection.
c. Name of person collecting samples.
d. Test locations.
e. Initial and 24-hour disinfectant residuals in ppm for each outlet tested.
f. Coliform bacteria test results for each outlet tested.
g. Certification that water conforms, or fails to conform, to bacterial standards.

7. Contractor shall note that work under this Contract shall NOT be considered completed until satisfactory installation and testing of the water mains have been completed.

3.8 FINAL INSPECTION

A. Final inspection and acceptance of pipe, valves, appurtenances, and hydrants shall be made by the Owner's Representative and the utility owner having jurisdiction over the particular system. Prior to placing the systems in service, all components shall be inspected, with the Owner’s Representative present, to ensure that no debris or other contaminants are present. If necessary, the Contractor shall clean and flush piping.

B. The Contractor is responsible for coordinating and scheduling the inspection of the work by local jurisdictional authorities. No additional payment will be made for inspections and permits required in the performance of the work.

End of Section

Section 33 21 00
IRRIGATION WATER SUPPLY WELLS

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. The General provisions of the Contract, including General and Supplementary General Conditions, and Division 1 General Requirements and Division 01 General Requirements, apply to work specified in this section.

B. Carefully examine all of the Contract Documents for requirements which affect the work of this Section. The exact scope of work of this section cannot be determined without a thorough review of all Specification Sections and other Contract Documents.

C. Refer to Drawings for further definition of location, extent, and details of work described in this Section.

D. Cooperate and coordinate with other trades in executing work as described in this Section.

E. Where referred to, Standard Specifications, Recommendations of Technical Societies, and/or Manufacturer's Associations, plus Codes of Federal, State, and Local Agencies shall include all amendments current as of date of issue of these Specifications.

F. In all cases when conflicts exist between information contained in this Section and in other parts of the Contract Documents, the Contractor shall assume that the most expensive solution is required.

G. In all cases, when a question exists to the level of quality required for a product and/or installation, the highest quality is required.

1.2 SCOPE

A. Provide all labor, materials, tools, and equipment, including, drilling, testing equipment, well casing system, screen and packing material, testing, electric and control cabinet, meter, discharge piping, and connection to the public power supply to develop a fully functional and operational irrigation water supply well.

B. The Contractor is responsible for the purchase of installation of all fixed items, and providing all non-fixed items.

C. This Section includes the following:
   1. Well development requirements.
   2. Rotary drilled or Reverse-rotary drilled water supply wells.
   3. Well casing and component requirements.
   4. Well pump and discharge plumbing requirements.
   5. Power supply requirements.

1.3 QUALITY ASSURANCE

A. Reference Standards:
   1. The latest edition of the following standards, as referenced herein, shall be applicable.
      a. Massachusetts Highway Department Standard Specifications most recent edition)
      b. "Standard Specifications for Highway Materials and Methods of Sampling and Testing, American Association of State Highway and Transportation Officials (AASHTO)."

c. City of Worcester Engineering and Department of Public Works Standards and Specifications.
d. Massachusetts Rules And Regulations Governing The Enforcement Relating To The Drilling Of Drinking Water Wells
e. Well Driller Qualifications: An experienced water supply well driller licensed in the jurisdiction where Project is located.
f. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
g. Comply with AWWA A100 for water supply wells.

1.4 PERFORMANCE REQUIREMENTS

A. Well development target Performance Capacity:
1. Target safe yield: 15 to 20 gallons per minute.
2. Target discharge flow pressure at pitless adaptor: 75 pounds per square inch.

1.5 ACTION SUBMITTALS

A. Well Development Data Sheets:

1. Location sketch.
2. Depth data.
3. Earth material log including material and depth encountered.
4. Well diameter:
5. Discharge pipe size;
6. Safe Yield and length of test flow.

B. Product Data: For each type and size of well pump indicated.

C. Shop Drawings: Show layout and connections for well pumps.

1. Include wiring diagrams.
2. Include connection to public electric supply, meter/control cabinet, meter, main shutoff, etc.

D. Informational Submittals
1. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS
A. Operation and maintenance data.

1.7 PROJECT CONDITIONS
A. Well Drilling Water: Provide temporary water and piping for drilling purposes. Provide necessary piping for water supply.

B. Erosion Control and Pollution Prevention: Provide necessary test discharge protection and erosion control to prevent well hole contamination and downstream erosion and sedimentation.

PART 2 - PRODUCTS

2.1 WELL CASINGS

A. Steel Casing: AWWA C200, single ply, steel pipe with threaded ends and threaded couplings for threaded joints.

B. Pitless Adapter: Fitting, of shape required to fit onto casing, with waterproof seals.

C. Well Seals: Casing cap, with holes for piping and cables, that fits into top of casing and is removable, waterproof, and vermin proof.

2.2 GROUT

A. Cement: ASTM C 150, Type II.
B. Aggregates: ASTM C 33, fine and coarse grades.
C. Water: Irrigation.

2.3 WATER WELL SCREENS

A. Screen Material: Fabricated of ASTM A 666, Type 304 stainless steel, welded; with continuous-slot, V-shaped openings that widen inwardly or tube; with slotted or perforated surface and designed for well-screen applications].
   1. Screen Couplings: Butt-type, stainless-steel coupling rings.
   2. Screen Fittings: Screen, with necessary fittings, closes bottom and makes tight seal between top of screen and well casing.
   3. Maximum Entering Velocity: 0.1 fps (0.03 m/s).

2.4 PACK MATERIALS

A. Coarse, uniformly graded filter sand, maximum 1/8 inch (3 mm) in diameter or Fine gravel, maximum 1/4 inch (6 mm) in diameter.

2.5 SUBMERSIBLE WELL PUMPS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

C. Basis-of-Design Product: Subject to compliance with requirements, provide a comparable submersible pump system meeting the target requirements by one of the following:

   1. American Turbine Pump Co.
   2. ITT Industries; Goulds Pumps.
   3. Johnston Pump Company.
   4. Sterling Fluid Systems (USA) Inc.; Peerless Pump.
   5. USFilter/EMU Products.

D. Description: Submersible, vertical-turbine well pump complying with HI 2.1-2.2 and HI 2.3; with the following features:

   1. Impeller Material: Stainless steel.
   2. Motor: Capable of continuous operation under water, with protected submersible power cable.
   3. Column Pipe: ASTM A 53/A 53M, Schedule 40, galvanized-steel pipe with threaded ends and cast-iron or steel threaded couplings.
   4. Discharge Piping: ASTM D 2239, SIDR Numbers 5.3, 7, or 9 PE pipe; made with PE compound number required to give pressure rating not less than 160 psig (1100 kPa). Include NSF listing mark "NSF pw."
      a. Insert Fittings for PE Pipe: ASTM D 2609, made of PA, PP, or PVC with serrated, male insert ends matching inside of pipe. Include bands or crimp rings.

E. Capacities and Characteristics:
   1. Capacity: 15 to 20 gpm
   2. Discharge Head: 75 psig at the pitless adaptor.
   3. Discharge Size: 1 ¼”
   4. Motor Horsepower: as required
   5. Lift: based on well development
   6. Pressure Rating: 75 psi at pitless adaptor

7. Volts: based on local available power supply
8. Phases: based on local available power supply
9. Full-Load Amperes: based on local available power supply
10. Minimum Circuit Ampacity: based on local available power supply
11. Maximum Overcurrent Protection: based on local available power supply

2.6 ELECTRICAL ENCLOSURE & CABINETS

A. Provide one (1) outdoor NEMA 3R primed and painted steel, to contain meter, panel board, disconnect, a single dual receptacle GFI, and irrigation controller, lighting

B. Contractor to size cabinet to coordinate with sizes of panelboard and equipment to be installed within cabinets. Dimensions shown are typical and are for reference only. Cabinet to include all equipment shown or implied and all equipment shall be installed inside of cabinet without physical conflicts and per NEC. Cabinet to be sized for all necessary conduits, whether active, spare or future as listed on panelboard schedules.

C. Cabinets to be manufactured from 14 gauge minimum stainless steel with 12 gauge steel panel, mounted inside. Cabinets to have integral keyed locking mechanism, keyed alike, with provision for pad-lock. Cabinets shall be ventilated type and factory painted black powder-coat. Cabinets to have door hold-open latches. .

2.7 CAST-IN-PLACE CONCRETE FOUNDATION

A. Provide the materials, labor and equipment necessary for the installation of the following cast-in place concrete foundations, in accordance with these Specifications, Contract Drawings, Utility & Town requirements and all applicable codes & regulations.

B. Electrical Metering Cabinet Foundation: complete with reinforcing rebar, ground rods, grounding connectors, conduit entrances, etc. as shown and as directed by Owner or Engineer. Contractor responsible for coordinating foundation dimensions to be 6-inches wider than cabinet.

C. Foundations shall be built with 3,000 psi. minimum concrete, on a base of crushed stone, washed (#57) and sand, as shown.

D. Reinforcing rod to be #3 or #4 (as shown) grade 60 bars and shall conform to ASTM A- 615 (latest revision). Reinforcing rods shall not be installed any closer than 2” from the face of the concrete.

E. Provide grounding in the form of two (2) 5/8” diameter x 8’-0” long copperweld ground rods for each foundation, connected with a loop of #1/0-#4/0 Awg bare copper stranded ground wire (as shown), leaving a 3 foot long tail to ground the enclosure, etc.

2.8 RACEWAYS

A. Rigid Metallic Conduit: UL6 and ANSI C80.1.

B. Flexible Metallic Conduit: UL1. Liquidtight flexible metal conduit shall be used in wet locations.

C. Polyvinyl Chloride (PVC) Conduit, electrical, gray, Schedule 40 or Schedule 80 as specified, meeting the requirements of UL 651 and NEMA TC-2. Outdoor duct banks shall be in accordance with Section 26 05 43.

D. Minimum size of conduit shall be 3/4”. Unless indicated on Drawings, conduit sizes can be sized in accordance with National Electric Code (NEC). Conduit bends shall not have kinks or flats, and shall not be less than standard radii.

E. Rigid Galvanized Steel (RGS) conduit shall be used for all power, control signal, and instrumentation wiring, except where noted. Conduit shall be fully threaded at both ends and each

length shall be furnished with one threaded coupling. All 90 degree conduit sweeps shall be RGS for all entry and exit into concrete pads and at riser poles, with ground bushings connected to new grounding with minimum #4Awg ground wire for conduit grounding bushings.

F. Conduits shall be made electrically continuous at coupling and connections to boxes and cabinets by means of joining fasteners or copper bond wires. Conduit shall be connected to grounded structural steel or the ground network. After assembly all conduit locknuts, all EMT coupling fittings, and all bond wire screws shall be set up tight before installation of wiring. Insulated metallic bushings shall be used on all conduits entering panel cabinets, pull-boxes, and wiring gutters, except on branch lighting circuits.

G. Expansion fittings shall be provided on all conduits as required by the latest edition of the National Electrical Code, and as required by local and state codes. This includes, but is not limited to, vertical conduit risers coming from below-grade.

2.9 WIRE AND CABLE

A. Unless otherwise noted, conductors for power, lighting, and grounding *above grade* shall be No. 12 through No. 8 AWG, NEC type THWN/THHN, meeting the requirements of UL 83. Conductors for power and lighting shall be no smaller than No. 12 AWG.

B. Conductors for power, lighting, grounding, and control *below grade* (and in wet locations) shall be No. 2 AWG and larger, NEC type XHHW (or XHHW-2), meeting the requirements of NEMA WC7 and ICEA S-66-524. Where allowed, and as indicated on the Contract Drawings NEC type UF cable may also be used, as approved by the Engineer and local Wiring Inspector.

C. All conductors shall be annealed copper, 98% conductivity, Class B stranded, except conductors used for power and lighting circuits No. 10 AWG and smaller which may be solid. All conductors should be rated for 600 volts or less, with a thermal rating of 90° C.

D. The outside covering of all wiring for power, lighting, grounding, and control uses shall be color coded to identify polarity as follows:

	208Y/120 V. 3 Phase	240D/120 V 3 Phase	480Y/277 V 3 Phase
Phase A	Black	Black	Brown
Phase B	Red	Red	Orange
Phase C	Blue	Orange	Yellow
Neutral	White	White	Gray
Ground	Green	Green	Green

2.10 WIRE AND CABLE CONNECTORS AND DEVICES

A. Wire and cable connectors and devices shall meet the requirements of UL 486.

B. Connectors, including miscellaneous nuts, bolts, and washers shall be silicon bronze. Ferrous materials shall not be used.

2.11 PANELBOARDS

A. Panel boards: NEMA PB1, and UL 67.

B. Panel boards shall be door-in-door construction with copper bus. Circuit breakers shall be molded case, thermal magnetic, bolt-on type rated as noted, and rated to match panel board voltage and interrupting rating.

C. Provide panel boards sized for available power, pump size and GFI receptacle for power supply to programmable irrigation controller.

PART 3 - EXECUTION

3.1 PREPARATION

A. Pilot-Hole: Drill pilot-hole and determine suitable well depth and well size. Submit data test analysis to Owner for review.

3.2 INSTALLATION

A. Construct well using rotary drilling or reverse-rotary drilling method.

B. Take samples of substrata formation at 10-foot (3-m) intervals and at changes in formation throughout entire depth of each water supply well. Carefully preserve samples on-site in glass jars properly labeled for identification.

C. Excavate for mud pit or provide aboveground structure, acceptable to authorities having jurisdiction, to allow settlement of cuttings and circulation of drill fluids back to well without discharging to on-site waterways.

D. Enlarge pilot hole and install permanent casing, screen, and grout. Install first section of casing with hardened steel driving shoe of an OD slightly larger than casing couplings if threaded couplings are used.

E. Set casing and liners round, plumb, and true to line.

F. Join casing pipe as follows:
   1. Ream ends of pipe and remove burrs.
   2. Remove scale, slag, dirt, and debris from inside and outside casing before installation.
   3. Cut bevel in ends of casing pipe and make threaded joints.

G. Mix grout in proportions of 1 cu. ft. (0.03 cu. m) or a 94-lb (42.6-kg) sack of cement with 5 to 6 gal. (19 to 23 L) of water. Bentonite clay may be added in amounts of 3 to 5 lb/cu. ft. (1.4 to 2.3 kg/0.03 cu. m) for a 94-lb (42.6-kg) sack of cement. If bentonite clay is added, water may be increased to 6.5 gal./cu. ft. (25 L/0.03 cu. m) of cement.

H. Place grout continuously, from bottom to top surface, to ensure filling of annular space in one operation. Do not perform other operations in well within 72 hours after grouting of casing. When quick-setting cement is used, this period may be reduced to 24 hours.

I. Provide permanent casing with temporary well cap. Install with top of casing 12 inches above finished grade.

J. Develop wells to maximum yield per foot of drawdown.
   1. Extract maximum practical quantity of sand, drill fluid, and other fine materials from water-bearing formation.
   2. Avoid settlement and disturbance of strata above water-bearing formation.
   3. Do not disturb sealing around well casings.
   4. Continue developing wells until water contains no more than 2 ppm of sand by weight when pumped at maximum testing rate.

K. Install submersible well pumps according to HI 2.1-2.4 and provide access for periodic maintenance.
   1. Before lowering permanent pump into well, lower a dummy pump that is slightly longer and wider than permanent pump to determine that permanent pump can be installed. Correct alignment problems.
   2. Before lowering permanent pump into well, start pump to verify correct rotation.
   3. Securely tighten discharge piping joints.
   4. Connect motor to submersible pump and locate near well bottom.
      a. Connect power cable while connection points are dry and undamaged.
      b. Do not damage power cable during installation; use cable clamps that do not have sharp edges.
      c. Install water-sealed surface plate that will support pump and piping.
      d.

L. Piping installation requirements:.
   1. Provide 24” stub out at pitless with threaded cap to future connection.

3.3 WELL-ABANDONMENT

A. Should well yield less than suitable results follow well-abandonment procedures of authorities having jurisdiction. Restore ground surface to finished grade.

3.4 FIELD QUALITY CONTROL

A. Test Preparation: Clean water supply wells of foreign substances. Swab casings using alkalis, if necessary, to remove foreign substances.

B. Perform tests and inspections and prepare test reports.

C. Tests and Inspections:
   1. Plumbness and Alignment Testing: Comply with AWWA A100.
   2. Furnish samples of water-bearing formation to testing laboratory and well-screen manufacturer for mechanical sieve analysis.
   3. Prepare reports on static level of ground water, level of water for various pumping rates, and depth to water-bearing strata.
   4. Performance Test Preparation: Start well pump and adjust controls and pressure setting. Replace damaged and malfunctioning controls and equipment.
   5. Performance Testing: Conduct final pumping tests after wells have been constructed, cleaned, and tested for plumbness and alignment.
      a. Arrange to conduct tests, with seven days' advance notice, after test pump and auxiliary equipment have been installed. Note water-level elevations referred to for each assigned datum in wells.
      b. Provide discharge piping to conduct water to locations where disposal will not create a nuisance or endanger adjacent property. Comply with requirements of authorities having jurisdiction.
      c. Provide and maintain equipment of adequate size and type for measuring flow of water, such as weir box, orifice, or water meter.
      d. Measure elevation to water level in wells.
      e. Perform two bailer or air-ejection tests to determine expected yield. Test at depths with sufficient quantity of water to satisfy desired yields.
      f. Test Pump: Variable capacity test pump with capacity equal to maximum expected yields at pressure equal to drawdown in wells, plus losses in pump columns and discharge pipes.
      g. Start and adjust test pumps and equipment to required pumping rates.
      h. Record readings of water levels in wells and pumping rates at **30**-minute maximum intervals throughout 24-hour minimum period.
      i. Record maximum yields when drawdown is 60 inches above top of suction screens after designated times.

j. Operate pumping units continuously for eight hours after maximum drawdown is reached.
k. Record returning water levels in wells and plot curves of well recovery rates.
l. Remove sand, stones, and other foreign materials that may become deposited in wells after completing final tests.

3.5 CLEANING

A. Follow water supply well disinfection procedures required by authorities having jurisdiction before testing well pumps.

3.6 PROTECTION

A. Water Quality Protection: Prevent well contamination, including undesirable physical and chemical characteristics.

B. Ensure that mud pit will not leak or overflow into streams or wetlands. When well is accepted, remove mud and solids in mud pit from Project site and restore site to finished grade.

C. Provide casings, seals, sterilizing agents, and other materials to eliminate contamination; shut off contaminated water.

D. Exercise care to prevent breakdown or collapse of strata overlaying that from which water is to be drawn.

E. Protect water supply wells to prevent tampering and introducing foreign matter. Retain temporary well cap until installation is complete.

3.7 POWER SUPPLY

A. Coordinate with and pay associated fees for connection to utility company power supply system at nearest power supply pole.

B. Install electrical system, components, raceways, cables, grounds, etc to all State, Local and Utility company requirements.

C. Install electrical enclosure cabinet foundation with finish surface 6” above surrounding grade. Conduit shall penetrate the slab vertically and in a location that places conduit at back face of inside cabinet.

D. Provide required labeling in panel box and on inside face of cabinet door.

END OF SECTION 33 21 00

Section 33 30 00

SANITARY SEWERAGE UTILITIES

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all SECTIONS within DIVISION 1 – GENERAL REQUIREMENTS, which are hereby made a part of this Section of Specifications.

1.2 DESCRIPTION OF WORK

A. Work Included: Provide labor, materials, and equipment necessary to construct the sanitary sewer system complete, including connection to existing structures and testing, as indicated on the Drawings and as specified.

B. Unless otherwise indicated on the Drawings, building sewer service lines shall be installed from a point 10 feet outside the building foundation walls to the point of disposal.

C. Related Work: The following items are not included in this Section and will be performed under the designated Sections:

1. Section 31 10 00 – SITE CLEARING for site clearing, removal of trees, stumps and other vegetation, topsoil stripping, stockpiling, clearing and grubbing, and removal of site surface and utility improvements.
2. Section 31 20 00 – EARTH MOVING for excavation, backfill, and compaction required for sanitary sewerage system piping and structures.
3. Section 22 13 16 – SANITARY WASTE AND VENT PIPING for building sanitary drain and vent requirements.

1.3 SUBMITTALS

A. Refer to Section 01 33 00 – SUBMITTAL PROCEDURES for submittal provisions and procedures.

1. Product Data: Submit manufacturer's technical product data and installation instructions for sanitary sewer system materials and products.
2. Submit descriptive literature for piping, fittings, couplings, and appurtenances showing dimensions, pipe and joint materials, and other details for each class or type of pipe or product to be furnished for this contract. All pipe furnished under the contract shall be manufactured in accordance with these Specifications.
3. Shop Drawings: The precast concrete structure shop drawing submittals for the manholes, septic tanks, dosing chambers, tight tanks, grease traps, wet wells, and valve pits shall contain erections drawings showing connections, cast-in items, waterproofing details, lifting hooks, and productions drawings showing elevations, sections, and details indicating sizes and quantities of reinforcement.
4. Submit shop drawings for structure hatches and frames and covers.
5. The Contractor shall submit buoyancy calculations for sanitary sewerage structures assuming groundwater is one (1) foot below finish grade. If buoyancy is an issue the structure(s) shall be modified to prevent uplift. All buoyancy calculations and precast concrete structure designs shall be prepared and stamped by a professional Civil Engineer licensed in the Commonwealth of Massachusetts.

6. Material Certificates: Provide copies of material certificates signed by material producer and Contractor, certifying that each material item complies with, or exceeds specified requirements.
7. Prior to the acceptance of the sanitary sewerage system, the Contractor shall submit to the Engineer, for review and approval, As-Built Drawings that indicate the true measurement and location, horizontal and vertical, of all new construction. As-Built drawings shall be stamped and signed by a Massachusetts Licensed Land Surveyor or Licensed Professional Engineer. The as-built plans shall also be submitted electronically as an AutoCAD drawing file (release 2010 or higher).
8. Prior to the acceptance of the sanitary sewerage system, the Contractor shall submit the results of the leakage tests, pipe deflection measurements, and the video inspection reports.

1.4 REFERENCE STANDARDS

A. The following standards are applicable to the work of this Section to the extent referenced herein:

1. ASTM: American Society for Testing and Materials.
2. ANSI: American National Standards Institute.
3. Reference is made herein to the Commonwealth of Massachusetts, Department of Transportation (MassDOT), formerly known as the Massachusetts Highway Department (MHD) Standard Specifications for Highways and Bridges, latest edition, hereinafter referred to as the “Standard Specifications”. All references to method of measurement, basis of payment, and payment items in the “Standard Specifications” are hereby deleted. References made to particular sections or paragraphs in the “Standard Specifications” shall include all related articles mentioned therein.
4. MassDOT Construction Standards, latest edition with amendments, hereinafter referred to as the “Construction Standards”.
5. Town/City Sewer Department Regulations.

1.5 EXAMINATION OF SITE AND DOCUMENTS

A. It is hereby understood that the Contractor has carefully examined the site and all conditions affecting work under this Section. No claim for additional costs will be allowed because of a lack of knowledge of existing conditions as indicated in the Contract Documents, or obvious from observation on the site.

B. Plans, surveys, measurements, and dimensions under which the work is to be performed are believed to be correct, but the Contractor shall have examined them for himself during the bidding period and formed his own conclusions as to the full requirements of the work involved.

1.6 QUALITY ASSURANCE

A. Environmental Compliance: Comply with applicable portions of local environmental agency regulations pertaining to sanitary sewerage systems.

B. Utility Compliance: Comply with the City of Worcester Sewer Department regulations, standards, and guidelines pertaining to sanitary sewerage system installation and inspections.

C. Sanitary sewerage system installation shall be in conformance with the latest edition of TR-16, Guides for the Design of Wastewater Treatment Works.

D. Plumbing Code Compliance: Comply with the applicable portions of the latest editions of the Massachusetts Plumbing Code and National Standard Plumbing Code pertaining to the selection and installation of sanitary sewerage system materials and products.

E. Subsurface Disposal System Code Compliance: Comply with the applicable portions of the Commonwealth of Massachusetts State Environmental Code Title V, 310 CMR 15.00, latest revision and the local Board of Health Regulations pertaining to the installation of sanitary sewerage system materials and products.

F. Manufacturer's Qualifications: Firms regularly engaged in manufacturing of sanitary sewer system products of type, materials, and sizes required, whose products have been in satisfactory use in similar service for not less than five years.

G. Installer's Qualifications: Firms with at least three years of successful installation experience on projects with sanitary sewer work similar to that required for the project.

1.7 PROJECT CONDITIONS

A. Site Information: Perform site inspection and survey, research utility records, and verify existing utility locations and elevations. Verify that sewerage system structures and piping may be installed in compliance with Contract Drawings and referenced standards.

B. Interruption of Existing Sanitary Sewer Service: Do not interrupt service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary service according to the requirements indicated:

1. Notify Architect no fewer than two days in advance of proposed interruption of service.
2. Do not proceed with interruption of service without Architect's written permission.

1.8 SEQUENCING AND SCHEDULING

A. Coordinate with interior building sanitary sewerage system piping.

B. Coordinate with other utility work.

C. The Contractor is responsible for developing a sequence of work to maintain existing services in operation until the new services are operational.

D. The Contractor is responsible for coordinating and scheduling the inspection of the work by the jurisdictional authority. All permits and inspection costs and fees shall be included in the bid prices and no additional costs will be paid to the Contractor.

PART 2 - PRODUCTS

2.1 PRECAST CONCRETE VAULTS AND TANKS

A. The precast reinforced concrete vault and tank structures shall be designed by a Massachusetts Registered Professional Engineer employed by the Contractor, in accordance with the applicable sections of the following references.

1. Commonwealth of Massachusetts State Building Code, latest edition.
2. American Concrete Institute, ACI 318 "Building Code Requirements for Reinforced Concrete."
3. AASHTO, "Standard Specification for Highway Bridges."

4. Precast Concrete Institute, “Manual for Quality Control for Plants and Production of Precast and Prestressed Concrete Products, MNL-116.

B. The structures shall be designed for the following loads and possible combinations thereof:

1. Lateral soil pressure=60 PCF (H), where H is the height from grade as shown on the Contract Drawings, to the point of the structure being considered.
2. Soil weight shall be assumed to be 120 PCF.
3. AASHTO HS-20-44 loading.
4. Weight of precast concrete structure.
5. Initial handling and erection loading, including design of galvanized lifting hooks using safety factor = 4.0.

C. Investigate buoyancy and soil bearing considerations assuming the groundwater elevation is one-foot below the ground surface.

D. Concrete shall have a minimum 28-day compressive strength of 5,000 psi using Type II or III Portland cement with 8% maximum content of tricalcium aluminate, ASTM C150. A “normal dosage” of air-entraining agent shall be added to the concrete during the mixing cycle. Reinforcement shall be deformed billet-steel ASTM A615 or 7-wire strand ASTM A416, Grade 270 (if prestressed).

E. Dimensions and opening sizes and locations shall be as indicated on the Contract Drawings.

F. Pipe Connections: Vault and tank structures shall have pipe openings to accept the type of pipe specified. Pipe opening shall be minimum size require to receive the pipe and shall be accurately set to conform to the required line and grade. Sewer pipe shall be joined to the wall of the concrete structure with flexible pipe sleeves as indicated on the drawings. Flexible pipe sleeves shall be cast in the walls of the structure during the manufacturing process. Flexible pipe sleeves shall be NPC Kor-N-Seal Pipe-to-Manhole Connector as manufactured by Trelleborg Pipe Seals Milford, Inc., Milford, NH; Z-Lok as manufactured by A-Lok Products, Inc., Tullytown, PA; Tylox CIB Series Cast-In Boot Connector as manufactured by Hamilton Kent, Winchester, TN; or approved equal.

G. Bituminous Waterproofing: The exterior surfaces of precast concrete structures shall be given two heavy coats of bituminous waterproofing material. The material shall be No. 35-J-10 Hi Building Bituminous Coating made by Mobil Chemical Company, Edison, NJ; Bitumastic Super Service Black made by Koppers Company, Inc., Pittsburgh, PA; Bitumastic 300M made by Caroline Company, St. Louis, MO; Sonoshield HLM 5000 as manufactured by BASF Corporation Building Systems, Shakopee, MN; or acceptable equivalent products. The waterproofing material shall be applied by brush or spray and in accordance with the instructions of the manufacturer. Time shall be allowed between coats to permit sufficient drying so that the application of the second coat has no effect on the first coat.

H. Brick Masonry: Bricks shall be sound, hard, uniformly burned, regular, and uniform in shape and size. Underburned or salmon brick shall not be acceptable. Only whole brick shall be used.

1. Bricks for raising manhole and catch basin frames to finished grade shall conform to ASTM C32, Grade MS.
2. Mortar shall be in conformance with ASTM C270, Type M. The mortar shall be composed of one part Portland cement, 3-1/2 parts sand, and ¼ parts hydrated lime, by volume. Portland cement shall be ASTM C150, Type II; hydrated lime shall be Type S conforming to ASTM D207.

3. Sand shall be washed, cleaned, screened, well-graded with all particles passing a No. 4 sieve, and conform to ASTM C33.

2.2 PRECAST CONCRETE MANHOLES

A. General: Provide precast reinforced concrete structures as indicated and complying with ASTM C 478.

B. Manhole Top: Precast concrete of concentric cone, eccentric cone, or flat slab top type, as necessary for the installation as indicated in the Contract Drawings. Tops shall be designed to meet H20 loadings.

C. Base and Riser Sections: Precast concrete, with base riser section with integral floor. Diameter, base and riser thicknesses shall be as indicated on the Contract Drawings.

D. Cement: Type II.

E. Concrete strength: 4,000 psi minimum.

F. Precast concrete sections shall have tongue and groove joints.

G. Horizontal Joints: Joints between sections of concrete structures shall be sealed with a flexible, watertight joint, made with preformed butyl rubber joint sealant conforming to ASTM C990 or with a rubber gasket joint conforming to ASTM C443. Sealants and/or gaskets shall be installed in accordance with the manufacturer's written instructions.

H. Manhole Steps: Steps for manholes shall be non-skid raised edge-front steel reinforced polypropylene plastic type with at least 13-inch wide stepping surface. Steps shall meet the requirements of ASTM C-478 and AASHTO M-199. Steel shall be 1/2-inch grade 60 conforming to ASTM A615 encapsulated with molded copolymer polypropylene. The polypropylene shall conform to ASTM D-4101. Rungs shall protrude no more than 6 inches from the wall. The portion of the legs to be embedded in the precast section shall have fins and be tapered to ensure a secure bond. Steps shall start a foot above the shelf of the manhole floor and continued twelve inches on center spacing up through the completed height of the unit. The steps shall finish no lower than twenty-four (24)-inches below the rim elevation. Placement into precast walls shall be by a method recommended by the supplier of the precast manhole sections. Steps shall be installed per the manufacturer's specifications.

I. Pipe Connections: Sewer manhole shall have pipe openings to accept the type of pipe specified. Pipe opening shall be minimum size require to receive the pipe and shall be accurately set to conform to the required line and grade. Sewer pipe shall be joined to the wall of the concrete manhole with flexible manhole sleeves as indicated on the drawings. Flexible manhole sleeves shall be cast in the walls of the manholes during the manufacturing process. Flexible manhole sleeves shall be NPC Kor-N-Seal Pipe-to-Manhole Connector as manufactured by Trelleborg Pipe Seals Milford, Inc., Milford, NH; Z-Lok as manufactured by A-Lok Products, Inc., Tullytown, PA; Tylox CIB Series Cast-In Boot Connector as manufactured by Hamilton Kent, Winchester, TN; or approved equal.

J. Bituminous Waterproofing: The exterior surfaces of precast manholes shall be given two heavy coats of bituminous waterproofing material. The material shall be No. 35-J-10 Hi Building Bituminous Coating made by Mobil Chemical Company, Edison, NJ; Bitumastic Super Service Black made by Koppers Company, Inc., Pittsburgh, PA; Bitumastic 300M made by Caroline Company, St. Louis, MO; Sonoshield HLM 5000 as manufactured by BASF Corporation Building Systems, Shakopee, MN; or acceptable equivalent products.

The waterproofing material shall be applied by brush or spray and in accordance with the instructions of the manufacturer. Time shall be allowed between coats to permit sufficient drying so that the application of the second coat has no effect on the first coat.

K. Sanitary Sewer Brick Masonry: Bricks shall be sound, hard, uniformly burned, regular, and uniform in shape and size. Underburned or salmon brick shall not be acceptable. Only whole brick shall be used.

1. Bricks for channels and shelves shall conform to ASTM C32, Grade SS except that the mean of five tests for absorptions shall not exceed 8 percent and no individual brick exceed 11 percent.
2. Brick for raising manhole frames to finished grade shall conform to ASTM C32, Grade MS.
3. Mortar shall be in conformance with ASTM C270, Type M. The mortar shall be composed of one part Portland cement, 3-1/2 parts sand, and ¼ parts hydrated lime, by volume. Portland cement shall be ASTM C150, Type II; hydrated lime shall be Type S conforming to ASTM D207.
4. Sand shall be washed, cleaned, screened, well-graded with all particles passing a No. 4 sieve, and conform to ASTM C33.

L. In sewer manholes, the invert channel within the structure shall be an inverted arch with bricks laid as stretchers and on edge and so constructed as to conform in shape to the lower half of the pipe. The shelf in manholes shall consist of bricks laid flat and the top of the shelf shall be at the elevation of the top of the pipe, as indicated on the Contract Drawings, and shall be sloped to flow toward the channel.

M. Inverts in sewer manholes shall conform accurately to size of the adjoining pipe. Side inverts and main inverts where the direction changes shall be laid out in smooth curves of the longest possible radius which is tangent, within the manhole, to the centerline of the adjoining pipelines.

N. Sewer manholes shall be constructed with drop connections when the proposed invert of the connection is at least 2 feet above the manhole invert. All drop connections will be of the external type. The drop pipe shall be constructed of SDR 35 PVC sewer pipe. The drop piping and horizontal cleanout sections will be sized the same as the sewer main piping and shall enter the manhole at the invert elevation of the main. The drop portion of the piping shall be secured with anchor straps. The drop piping shall be encased with control density fill.

O. For all manhole depths greater than 10 feet, the inside diameter of the manholes shall be at least 5’-0”.

P. Safety landings shall be installed inside manholes greater than 16 feet in depth.

Q. When installing manholes on existing lines and when flows cannot be diverted, drop-over manholes shall be used. Drop-over manholes shall be precast with openings cast in the sidewalls of sufficient size to fit over the existing line(s) to remain in service. Drop-over manholes shall be set on a precast or cast-in-place concrete base slab. Drop-over manholes shall be manufactured to the same requirements and dimensions as standard manholes.

2.3 CONCRETE BLOCK MANHOLES

A. Concrete block manholes shall only be utilized when it is not feasible to utilize a precast concrete manhole and then only with written approval from the Owner’s Representative.

B. Concrete block manholes shall be minimum 48 inches inside diameter and built of standard solid manhole barrel blocks set on a cast-in-place cement concrete base or precast concrete sectional base plate. The upper 2 feet of masonry shall be built using batter blocks. All joint spaces shall be completely filled, horizontal and vertical. All block shall be thoroughly wet before joining. A leveling course of two bricks at the top shall be used to meet proper grade. Cement concrete blocks shall be machine made solid segments conforming to the requirements for Concrete Masonry Units for Construction of Catch Basin and Manholes, ASTM C139. Blocks shall be 6 inches in width with the inside and outside surfaces curved to the necessary radius and so designed that the interior surfaces of the structures shall be cylindrical. The top batter courses shall be designed to reduce uniformly the inside section of the structure to the top size and shape. The blocks used in the top course shall be designed to produce a surface 8 inches in width upon which to seat the frame.

2.4 MANHOLE FRAMES AND COVERS

A. Manhole frames and covers shall be of cast iron conforming to the requirements of AASHTO M306 and shall be manufactured by East Jordan Iron Works, Inc. (EJIW), LebBron Foundry, or approved equal. Manhole frames and covers shall be equal to EJIW 1056Z frame and EJIW 1056A cover or LeBaron LC239/L23C-1. Manhole covers shall be supplied with a closed pick hole and shall show the working “Worcester, A Town June 14, 1722: A City February 29, 1848” cast into said cover. Frames and covers shall be designed to accept H20 loads. Frame height shall be 8 inches.

2.5 PVC PIPE

A. General: Provide pipes of the following materials of class indicated. Provide pipe fittings and accessories of same materials and class as pipes with joining method, as indicated. The piping shall be manufactured by an established manufacturer of good reputation in the industry and in a permanent plant adapted to meet all the design requirements of the pipe.

B. PVC Sewer Pipe

1. PVC (Polyvinyl Chloride) Gravity Sewer Pipe and Fittings: ASTM D3034, SDR 35, for elastomeric gasket joints. Pipe 18 to 36 inches in diameter shall conform to ASTM F679, T-1 heavy wall. The pipe shall have an SDR ration of 35 and a pipe stiffness of 46 psi.
2. Joints: PVC pipe shall have an integral wall bell and spigot push-on joint with elastomeric gaskets secured in place in the bell of the pipe. The bell shall consist of an integral wall section with solid cross-section elastomeric gasket, factory assembled, securely locked in place to prevent displacement during assembly. Pipe joints shall conform to ASTM D3212 and elastomeric gaskets shall conform to ASTM F477.
3. Spigot pipe ends shall be supplied with bevels from the manufacturer to ensure proper insertion. Each spigot end shall have an “assembly stripe” imprinted thereon to which the bell end of the mated pipe will extend upon proper joining of the two pipes.
4. PVC gravity sewer fittings and accessories shall be as manufactured and furnished by the pipe supplier or approved equal and have bell and spigot configurations compatible with that of the pipe.

C. PVC Sewer Force Main Pipe

1. PVC Pressure Pipe (Force Main): ASTM D2241, SDR 21, for elastomeric gasket joints. PVC resin compound shall conform to ASTM D1784 and rubber gaskets shall conform to ASTM D1869 and F477. Pipe shall be provided in 20-foot nominal lengths.

2. Fittings: Fittings shall be made of PVC compound meeting ASTM D1784. Fittings shall be Class 200 and conform to the requirements of SDR 21. Fittings joint gaskets shall conform to ASTM F477.
3. Thrust blocks shall be used at bends and fittings as shown on the details. In the event that the use of thrust blocks is not practical, the Contractor shall provide an alternate method of joint restraint, at no additional cost, as approved and/or directed by the Engineer.
4. If restrained joints are to be used in lieu of thrust blocks, restraint length values shall be calculated per the manufacturer's standards. Restraint length calculations and restrained joint locations shall be provided by the Contractor and sent to the Engineer for review.

2.6 DUCTILE IRON PIPE AND FITTINGS

A. General: Provide pipes of the following materials of class indicated. Provide pipe fittings and accessories of same materials and class as pipes with joining method, as indicated. The piping shall be manufactured by an established manufacturer of good reputation in the industry and in a permanent plant adapted to meet all the design requirements of the pipe.

1. Ductile iron pipe shall be that of a manufacturer who can demonstrate at least five years of successful experience in manufacturing ductile iron pipe. The pipe shall be equipped with push on type, restrained joint, or mechanical joints, as required.
2. All ductile iron drain pipe shall conform to American Water Works Association (AWWA) C150 and AWWA C151.
3. The ductile iron pipe shall be Class 52 and furnished in minimum nominal 18-foot lengths, with Push-on or Mechanical Joints as manufactured by U.S. Pipe and Foundry Company, Atlantic States Cast Iron Pipe Co., Clow Corporation, or approved equal with gaskets conforming to AWWA C111 "Rubber Gasket Joints".
4. The ductile iron sewer pipe shall be PROTECTO 401 Ceramic Epoxy lined and the pipe exterior asphalt seal coated in accordance with AWWA C104.
5. The pipe shall be furnished along with necessary materials and equipment recommended by the manufacturer for use in joining pipe lengths and fittings.
6. Fittings shall be short body ductile iron Class 350 Mechanical Joint, conforming to ANSI Specification AWWA C153, latest edition, for pipe sizes 16 inches and smaller, and Class 350 standard Mechanical Joint fittings conforming to AWWA C110, latest edition, for pipe sizes 16 through 24 inches, unless specifically stated otherwise in the Specifications or on the Contract Drawings. Fittings shall have the same lining and coating as the pipe specified above. All fittings shall be marked with the weight and shall have distinctly cast upon them the pressure rating, the manufacturer's identification, nominal diameter of openings and the number of degrees or fraction of the circle on all bends. Fittings greater than 24 inches shall be as specified above except they shall be Class 250. All accessories (gland, gaskets, T-bolts, and nuts) shall be in accordance with AWWA C111. All mechanical joint bolts (T-bolts) shall be Cor-Ten or equal.
7. Contractor shall provide all adapters and fittings such as transition couplings, as determined in the field, necessary to complete all cross connections, whether or not specifically stated in the Contract Drawings and Specifications.
8. All pipes shall be marked with the class, thickness designation, and initials of the manufacturer.
9. If required the manufacturer shall supply the Engineer with certificates of compliance with these Specifications and certification that each piece of ductile iron pipe has been tested at the foundry with the Ball Impression Test, Ring Bending, or equal.
10. Pipe for use with sleeve-type couplings shall be as specified except that the ends shall be plain (without bells or beads). The ends shall be cast or machined at right angles to the axis.

B. INSPECTION TESTS AND ACCEPTANCE FOR DUCTILE IRON PIPE

1. All pipe delivered to the job site shall be accompanied by test reports certifying that the pipe and fittings conform to "AWWA Standard for Ductile Iron Pipe, for Water and Other Liquids" (AWWA H3) and (AWWA C151).
2. All tests shall be made in accordance with the methods prescribed by the above mentioned AWWA Standards, and the acceptance or rejection shall be based on the test results.
3. Pipe which does not conform to the requirements of this contract shall be immediately removed and replaced by the Contractor.
4. All ductile iron pipe to be installed under this Contract may be inspected at the foundry for compliance with these Specifications by an independent testing laboratory selected by the Owner. The Contractor shall require the manufacturer's cooperation in these inspections. The cost of foundry inspection of all pipe approved for this Contract, plus the cost of the inspection of a reasonable amount of disapproved pipe, will be borne by the Owner.

C. SLEEVE COUPLINGS FOR DUCTILE IRON PIPE

1. Sleeve couplings and accessories shall be pressure rated at least equal to that of the pipe. Couplings shall be cast iron and shall be Dresser Style 53 or 153, Rockwell Style 441, Baker Series 4245 or acceptable equivalent product. The couplings shall be provided with Cor-Ten bolts and nuts or approved equal.
2. After assembly, all exterior surfaces including the bolts and nuts shall be thoroughly coated with two coats of heavy-duty protective coating. The interior of the coupling shall be epoxy coated. Coating shall be a minimum of 10 mils. and a maximum of 20 mils. dry film thickness thermosetting epoxy.

2.7 CLEANOUTS

A. General: Provide cast-iron ferrule and countersunk brass cleanout plug, with round cast-iron access frame and heavy-duty, secured, scoriated cast-iron cover.

B. The sewer cleanouts shall be minimum 6-inch diameter or sized to match the service pipe, whichever is greater. The cleanout shall be complete with a flush mount over. The cleanout cover shall be clearly marked “SEWER” and shall be minimum eight inches in diameter or two inches greater than the cleanout size, whichever is greater. Cleanouts shall include a watertight cap.

2.8 SEWER COUPLINGS

A. Sewer Couplings shall be pressure rated at least equal to that of the pipe. The coupling sleeve shall be 1/4-inch minimum thickness elastomeric polyvinyl chloride with a minimum tensile strength of 1500 psi. The sleeve shall fit snugly onto the pipe to be joined and be resistant to common chemicals present in sewerage. Adjustable pipe clamps shall consist of a slotted band that mate with the worm gear screw and a screw housing all manufactured of stainless steel, and suitable for underground service.

2.9 SANITARY SEWER PUMP STATION

A. Precast Concrete Chambers

1. The wet well and valve pit shall be precast concrete structures of the dimensions shown on the Contract Documents. Refer to Sections 2.1 and 2.2 for precast concrete structure material requirements.

2. The wet well and valve pit shall each receive two coats of bituminous damp proofing on both the inside and outside surfaces of the structures.
3. All inlet and outlet connections to the wet well and valve pit shall be watertight and shall be installed at the elevations as shown on the Contract Documents.

    a. The connections shall be sealed with modular, mechanical seals, consisting of rubber links shaped to continuously fill the annular space between the pipe and the wall openings. The pressure plates shall be molded of glass reinforced nylon. Hardware shall be mild steel with a 60,000 psi minimum tensile strength and 2-part Zinc Dichromate coating per ASTM B-633 and Organic Coating, tested in accordance with ASTM B-117 to pass a 1,500-hour salt spray test (or 316 Stainless Steel).
    b. Sleeves shall be provided at all wall openings for piping. The sleeves shall be steel made from heavy-wall welded or seamless pipe cast into the wall of the wet well and valve pit. A full circle water stop plate acts a positive seal and anchor to prevent thrust movement. The 2" collar/water stop shall be continuously welded on both sides. The sleeves shall be hot dip galvanized coated.

4. The Contractor shall submit buoyancy calculations for sewer pump station structures assuming groundwater is one foot below finish grade. If buoyancy is determined to be an issue the structure(s) shall be modified to prevent uplift. All buoyancy calculations and sewer pump station structure designs shall be prepared and stamped by a Professional Engineer licensed in the Commonwealth of Massachusetts.

B. Access Hatches

1. The access hatches shall be manufactured by the Bilco Company, Halliday Products, U.S.F. Fabrication, or approved equal.
2. Wet well and valve pit access doors shall be installed where indicated on the plans. The access doors shall be pre-assembled from the manufacturer.
3. The cover shall be reinforced to support H-20-wheel loading. Operation of the cover shall be smooth and easy with controlled operation throughout the entire arc of opening and closing. Operation of the cover shall not be affected by the temperature. The entire door, including all hardware components, shall be highly corrosion resistant. The cover shall be ¼" steel diamond pattern.
4. The channel frame shall be ¼" extruded steel with bend down anchor tabs around the perimeter. A continuous EPDM gasket shall be mechanically attached to the steel frame to create a barrier around the entire perimeter of the cover and significantly reduce the amount of dirt and debris that may enter the channel frame.
5. The hinges shall be specifically designed for horizontal installation and shall be through bolted to the cover with tamperproof Type 316 stainless steel lock bolts and shall be through bolted to the frame with Type 316 stainless steel bolts and locknuts.
6. Provide a 1-1/2" drain coupling located in the right front corner of the channel frame.
7. Lifting Mechanisms: The manufacturer shall provide the required number and size of compression spring operators enclosed in telescopic tubes to provide, smooth, easy, and controlled cover operation throughout the entire arc of opening and to act as a check in retarding downward motion of the cover when closing. The upper tube shall be the outer tube to prevent accumulation of moisture, grit, and debris inside the lower tube assembly. The lower tube shall interlock with a flanged support shoe fastened to a formed ¼" gusset support plate.
8. A removable exterior turn/lift handle with a spring-loaded ball detent shall be provided to open the cover and the latch release shall be protected by a flush, gasketed, removable screw plug.
9. Hardware:

a. Hinges: Heavy forged Type 316 stainless steel hinges, each having a minimum ¼" diameter Type 316 stainless steel pin, shall be provided and shall pivot so the cover does not protrude into the channel frame.
b. Cover shall be equipped with a hold arm which automatically locks the cover in the open position.
c. Cover shall be fitted with the required number and size of compression spring operators. Springs and spring tubes shall be Type 316 stainless steel.
d. A Type 316 stainless steel snap lock with fixed handle shall be mounted on the underside of the cover.
e. Hardware shall be Type 316 stainless steel throughout.

10. Finishes: Factory finish shall be mill finish aluminum with bituminous coating applied to the exterior of the frame.

C. Sanitary Sewer Pump System

1. Pumps shall be of the submersible type with 2-vane enclosed impeller. All openings in the pump impeller and volute case shall be large enough to pass a 3" diameter sphere. The Contractor shall furnish and install a complete non-clog pumping system consisting of submersible non-clog pumps and lift-out rail system, valves, controls, access covers and all other appurtenances to make a complete system. Pumps, control panel, and rail packages shall all be supplied by the same pump supplier.
2. The Contractor shall provide a duplex pump assembly consisting of two non-clog submersible pumps with a discharge flange that is 4-inch standard. Pump and motor assembly shall be FM listed for Class 1, Group D hazardous location service. A non-witness performance test on each pump at the pump manufacturer shall be performed to guarantee pump performance. The results of the tests shall be submitted to the designer for review and comment. Each pump shall have a capacity of 120 gallons per minute (gpm) at a total dynamic head (TDH) of 12.0 feet and shall use a 1.5 HP motor operating at 1150 RPM.
3. Motor

a. The pump motor shall be of the sealed submersible type rated 1.5 horsepower at 1150 RPM, 60 Hertz. The motor shall be three phase 208 volts. Three phase motors shall be NEMA B type.
b. Stator winding shall be of the open type with Class H inverter duty insulation good for 356ºF (180ºC) maximum operating temperature. Winding housing shall be filled with clean high dielectric oil that lubricates bearings and seals and transfers heat from windings and rotor to outer shell. Air-filled motors which do not have the superior heat dissipating capabilities of oil-filled motors shall not be considered equal.
c. Motor shall have two heavy-duty ball bearings to support pump shaft and take radial and thrust loads and a sleeve guide bushing directly above the lower seal to take radial load and act as flame path for seal chamber. Ball bearings shall be designed for 50,000 hours B-10 life. Stator shall be heat shrunk into motor assembly.
d. A heat sensor thermostat shall be attached to and embedded in the winding and be connected in series with the motor starter contactor coil to stop motor if temperature of winding is more than 248ºF (120°C). Thermostat to reset automatically when motor cools to safe operating temperature. Three heat sensors to be used on three phase motors.
e. Common motor pump shaft shall be of 416 stainless steel.

4. Seals

a. Motor shall be protected by two mechanical seals mounted in tandem with a seal chamber between the seals. Seal chamber shall be oil filled to lubricate seal face and to transmit heat from shaft to outer shell.
b. Seal face shall be carbon and ceramic and lapped to a flatness of one light band.
c. A double electrode shall be mounted in the seal chamber to detect any water entering the chamber through the lower seal. Water in the chamber shall cause a red light to turn on at the control box. This signal shall not stop the motor but shall act as a warning only, indicating service is required.

5. Impeller

a. The impeller shall be ductile iron and of the 2-vane solids handling enclosed type. Vane inlet tips shall be carefully rounded to prevent stringy material from catching the vanes. Pump-out vane shall be used in front and back chamber. Impeller shall be dynamically balanced. Impeller shall be driven by stainless steel shaft key and impeller held in place with lock screw and washer.
b. Impeller and motor shall lift off as a unit without disturbing discharge piping.

6. Pump Case

a. The volute case shall be of cast iron and have a flanged centerline discharge. Discharge flange shall be 4-inch standard with bolt holes straddling centerline.
b. A bronze wear ring shall be pressed into the case for guiding the impeller neck and to prevent corrosion freeze-up. Wear ring shall be held from rotating by locking with a stainless-steel set screw in end of ring.

7. Pump and Motor Castings

a. All castings shall be of high tensile cast iron and shall be treated with phosphate and chromate rinse. All fasteners shall be 302 stainless steel.

8. Bearing End Cap

a. Upper motor bearing cap shall be a separate casting for easy mounting and replacement.

9. Power Cables

a. Power cord and control cord shall be double sealed. The power and control conductor shall be single strand sealed with epoxy potting compound and then clamped in place with rubber seal bushing to seal outer jacket against leakage and to provide for strain pull. Cords shall withstand a pull of 300 pounds to meet FM requirements.
b. Insulation of power and control cords shall be type SOOW. Both control and power cords shall have a green carrier ground conductor that attaches to motor frame.

10. Lift-Out Rail System

a. Each submersible pump shall be provided with a lift-out slide rail system as supplied by the same pump supplier. The lift out rail system shall be compatible with pumps supplied. The lift-out rail system shall be of non-sparking design and shall be listed for explosion-proof service.
b. Each lift-out system shall consist of a ductile iron discharge base, brass faced pump attaching and sealing plate, brass pump guide plate, and cast-iron elbow.

All exposed nuts, bolts, and fasteners shall be 300 series stainless steel. No fabricated steel parts shall be used.

c. The discharge elbow shall be 4”x4”. The elbow shall bolt onto the base and have standard 125 lb. flanges.
d. A sealing plate shall be attached to the pump. A simple downward sliding motion of the pump and guide plate on the guide rails shall cause the unit to be automatically connected and sealed to the base. The mating face of the sealing plate and base shall be machined to provide a metal-to-metal, leak-proof seal at all operating pressures.
e. The guide rails shall consist of two rail pipes used to guide the pump from the surface to the discharge base connection. The guide rails shall be 1-1/2” schedule 40 stainless steel pipe. The weight of the pump shall bear solely on the discharge base and not on the guide rails. Rail systems which require the pump to be supported by legs which might interfere with the flow of solids into the pump suction will not be considered equal. The guide rails shall be firmly attached to the access hatch frame. Systems deeper than 21 feet shall use an intermediate guide for each 21 feet of wet well depth.
f. An adequate length of stainless steel lifting chains shall be supplied for removing the pumps. The chains shall be of sufficient length and shall include an adequate number of lifting rings to provide ease of pump removal.

11. Piping

a. The piping in the wet well, valve vault, and sanitary sewer force main cleanout manhole shall be flanged ductile iron pipe in the sizes indicated on the Contract Drawings. Flanged pipe shall be made with a minimum Class 53 thickness pipe in accordance with AWWA/ANSI C151/A21.51 and flanges screwed on, faced and drilled in accordance with AWWA/ANSI C110/A21.10 and AWWA/ANSI C115/A21.15. Flanged fittings shall be ductile iron in accordance with ANSI/AWWA C110/A21.10 and 125# ANSI B16.1 faced and drilled. All exterior piping from the valve vault to the cleanout manhole and from the cleanout manhole to the discharge manhole shall be PVC, SDR-21. The discharge piping shall exit the valve vault with at least 5 feet of cover. The Contractor shall supply the necessary fittings to transition from ductile iron piping to PVC piping.

12. Valves

a. Resilient wedge gate valves shall be flanged, ductile iron body, resilient seated type. The valves shall be designed for 250-psi working pressure and 400-psi test pressure. Valves shall have O ring seals and a non-rising stem. Valves shall meet or exceed the requirements of AWWA C-509 and C-515 and will be UL listed and FM approved. Valves shall have wheel handle operators.
b. Check valves shall be flanged, of the full body type, with a domed access cover and be of the swing type. The valve shall be designed, manufactured and tested in accordance with the requirements of AWWA C-508.

1) The valves shall be provided with flanges in accordance with ANSI B16.1, Class 125.
2) The valve body shall be full flow equal to nominal pipe diameter at all points through the valve. The 4 in. (350mm) valve shall be capable of passing a 3 in. (75mm) sphere. The seating surface shall be on a 45-degree angle to minimize disc travel. A threaded port with pipe plug shall be provided on the bottom of the valve to allow for field installation of a backflow actuator or oil cushion without special tools or removing the valve from the line.

3) The top access port shall be full size, allowing removal of the disc without removing the valve from the line. The access cover shall be domed in shape to provide flushing action over the disc for operating in lines containing high solids content. A threaded port with pipe plug shall be provided in the access cover to allow for field installation of a mechanical, disc position indicator.
4) The disc shall be of one-piece construction, precision molded with an integral O-ring type sealing surface, and contain alloy steel and nylon reinforcement in the flexible hinge area. The flex portion of the disc shall be warranted for twenty-five years. Non-Slam closing characteristics shall be provided through a short 35-degree disc stroke and a memory disc return action to provide a cracking pressure of 0.25 psig.
5) The valve disc shall be cycle tested 1,000,000 times in accordance with ANSI/AWWA C508 and show no signs of wear, cracking, or distortion to the valve disc or seat and shall remain drop tight at both high and low pressures.
6) The valve body and cover shall be constructed of ASTM A536 Grade 65-45-12 ductile iron.
7) The disc shall be precision molded Buna-N (NBR), ASTM D2000-BG.
8) A screw-type backflow actuator shall be provided to allow opening of the valve during no-flow conditions. Buna-N seals shall be used to seal the stainless-steel stem in a Lead-Free bronze bushing. The backflow device shall be of the rising-stem type to indicate position. A stainless-steel T-handle shall be provided for ease of operation.
9) A mechanical indicator shall be provided to provide disc position indication on the valves. The indicator shall have continuous contact with the disc under all operating conditions to assure accurate disc position indication.
10) The valve shall be provided with a bottom mounted oil dashpot (oil cushion) to provide hydraulic control of the final 10% of valve closure and reduce valve slam and water hammer normally associated with rapid flow reversal conditions on pump shut down. The dashpot shall consist of a high-pressure hydraulic cylinder, adjustable external flow control valve, oil reservoir, pressure gauge, stainless steel air inlet valve, and piping designed to control the closing speed of the last 10% of travel in 1-5 seconds. A threaded brass dashpot bushing unit with a grease fitting for lubrication shall connect the cylinder to the valve and shall have an air gap to prevent hydraulic fluid from entering the valve and contaminating the water system. A snubber rod fitted with O-ring seals and rod wiper scrapers shall make contact with the lower portion of the disc's stainless-steel strike plate.
11) Check valves shall have a working pressure rating of 250psi. All valves shall be hydrostatically tested and seat tested to demonstrate zero leakage.
12) The exterior and interior of the valve shall be coated with an NSF/ANSI 61 approved fusion bonded epoxy coating.
13) Check valves shall be suitable for horizontal mounting.

13. Float Switches

a. Pump(s) on, off, and alarm levels shall be controlled by non-mercury mechanical float switches. Switches shall consist of a non-mercury mechanical float switch sealed in a corrosion-resistant polypropylene housing with a minimum of 18-gauge, 2 wire, SJOW/A jacketed cable. The cable shall be of sufficient length to reach the junction box with no splices. The level controls shall be suspended from a stainless-steel bracket so that adjustment or replacement may be done without the use of any tools. Level controls shall be UL/CSA listed. The float switches shall be set at the elevations indicated on the Contract Drawings.

14. Three Phase Duplex Control Panel

    a. A NEMA 3R steel three-phase duplex control panel shall be mounted on the new Animal Science Building as indicated on the Contract Documents. The Contractor shall provide all necessary hardware, conduit, and cables to connect the control panel to the power supply from the building and to the pump station wet well.
    b. All electrical components shall be mounted in a NEMA 3R galvanized steel enclosure. The enclosure shall be 14-gauge galvanized steel and shall have a hasp for padlocking.
    c. A separate hinged dead front inner door shall be provided in the enclosure. All control switches, lights, and overload resets shall be mounted through the inner door. The pump circuit breaker and control circuit breaker shall be mounted with operating handles through the inner door and shall have locking tabs that prevent the inner door from being opened with the breakers in the “ON” position.
    d. Both the inner door and the back panel shall be a minimum of 14-gauge galvanized steel and shall be painted on both sides with a white enamel finish.
    e. Equipment mounted in the control panel shall include: pump circuit breaker, control circuit breaker, alarm circuit fuse, control circuit fuse, I.E.C. rated motor starter with 3-pole ambient compensated bi-metal overload relay for each pump, two (2) pump hand-off-auto switches, alarm test switch, two (2) pump run lights, seal leak lights, alternator relay (solid state), control circuit transformer with primary fusing, override relay, terminal blocks, lead/lag alternate selector switch, ground lugs, and all necessary wiring and brackets.
    f. The control panel shall be fitted with a red Lexan (polycarbonate) alarm light. The light shall be approximately 3” high by 3-1/2” diameter. The globe shall be mounted on top of the enclosure with a neoprene gasket. The lens cannot be removed from the exterior of the enclosure. The lens may be removed by entering the interior of the enclosure and removing four (4) #8 screws. The bulb shall be 25-watt minimum high intensity-medium base type. The bulb shall be easily replaced by removing a thumb screw from the support bracket on the interior of the panel.
    g. The alarm shall have a bright glow and flash during high water conditions. The alarm light will go out when the water level drops.
    h. An elapsed time meter shall be provided for each pump to record the actual running time of the motor. The elapsed time meter shall be energized by an auxiliary contact from the motor starter or contactor and be wired in parallalel with the pump run light. The elapsed time meter shall have a maximum reading of 99,999.99 hours and be non-resettable.
    i. A set of dry contacts shall be provided for the remote monitoring of a panel function. Functions may include high water, low water, seal failure, or pump running conditions. The dry contacts shall close upon the detection of said condition. Contacts shall be rated for 3 amps.
    j. The panel shall contain a control circuit transformer, which shall reduce the control circuit voltage to 24 volts. The 24 volts shall be supplied to all lights, switches, relays, and floats.
    k. Intrinsically safe relays shall be provided for the float switches in the wet well. The float switches shall be incapable of releasing sufficient electrical or thermal energy under normal conditions to cause ignition of a specific hazardous atmospheric mixture suitable for use in Division I locations. The intrinsically safe relay shall read circuits up to 3,000 ohms resistance. The power transmitted through the float switch shall be held to a maximum of 12 vdc and 3 ma. The duplex panel shall use three relays (pump off-on, override, high water).

l. A lightning arrestor shall be supplied in the Control Panel. The arrestor shall protect the equipment from overvoltages caused by lightning discharges. The arrestor shall be rated at 650 volts RMS L-G.
m. An acknowledge alarm circuit with horn shall be provided to indicate an alarm condition. The horn shall be energized by either the alarm float switch or the alarm test switch and operate in conjunction with the alarm light. The horn shall be weatherproof and be rated for 103 db at 10 ft. There shall be an exterior acknowledge switch that will silence the horn but allow the light to remain flashing during an alarm condition.
n. A low-level cutoff and alarm circuit shall be supplied in the control panel. The circuit shall override the entire system and prevent pump operation below a pre-determined level. The circuit shall also signal the panel alarm. The circuit shall use a normally closed float switch.
o. The Control Panel shall contain a phase monitor/relay. The monitor/relay shall protect pump motors against phase loss, under voltage, and phase reversal conditions. When incorrect phase sequence or phase loss occurs or if the three-phase voltages fall below the drop out voltages (field adjustable), the monitor/relay shall drop out the pumps and signal the panel alarm. The pumps and alarm shall return to normal after the condition(s) are corrected.
p. The Control Panel shall contain seal leak circuitry. The seal leak circuitry shall contain a test switch and light that will allow the integrity of the circuit to be tested.
q. All internal wiring shall be neat and color coded. Each wire shall be different color or stripe (except for ground), and all incoming wires shall terminate into a box clamp type terminal block. All control wires shall be 14 Ga. Type TEW rated for 105 degrees Celsius.
r. A schematic diagram (showing wire color) shall be permanently fastened to the inside of the enclosure. An Installation and Service Manual shall also be included with each control panel.
s. The control panel shall be U.L. listed as an assembly.

15. Control System

a. The control system for the pump chamber shall have the capability to perform the following tasks: start lead pump (Pump Number 1) when water level reaches lead pump “On” elevation, start lag pump (Pump Number 2) when water level reaches lag pump “On” elevation, turn the operating pump(s) off when the water level reaches pump(s) “Off” elevation in wet well, activate an alarm when the level reaches a high water level, and activate an alarm condition if the water level reaches a low level in the chamber. All alarm and pump on and off levels shall be activated by float switches placed at the elevations shown on the Contract Drawings. The control panel also shall be capable of alternating starts of Pump Number 1 and 2. The high-water alarm condition shall activate an alarm horn and an alarm beacon mounted on the top of the control cabinet. Within the control panel, lights shall be provided and labeled for each of the alarm conditions to make it possible to determine what caused the alarm. The Contractor is responsible for providing a fully functioning system as described.

16. Alarm Signaling

a. The Contractor shall provide alarm signaling as indicated for the pump station at the control panel. Any and all alarm conditions from the pump chamber shall be relayed to the annunciator panel as a single "Pump Chamber Alarm Condition”. The annunciator panel shall be mounted in the building in a location as indicated on the Electrical Drawings.

2.10 IDENTIFICATION

A. Detectable Underground Warning Tapes: Acid and alkali-resistant, polyethylene plastic film warming tape, 6-inches wide by 4-mils minimum thickness, with continuously printed caption in black letters “CAUTION – xxxxx LINE BURIED BELOW.” The text and color of the tape shall be as shown in the table below. The tape shall have a metallic core encased in a protective jacket for corrosion protection and be detectable by a metal detector when the tape is buried up to 2.5 feet deep.

Color	Utility
Safety Red	Electric
High Visibility Safety Yellow	Gas, Oil, Steam
Safety Alert Orange	Telephone, Communications, Cable Television
Safety Precaution Blue	Water System, Irrigation
Safety Green	Sanitary Sewer, Storm Sewer
White	Proposed Excavation

PART 3 - EXECUTION

3.1 GENERAL INSTALLATION

A. General Locations and Arrangements: Contract Drawings indicate the general location and arrangement of the underground sanitary sewer system piping. Location and arrangement of piping layout take into account many design considerations. Install the piping as indicated, to the extent practical. Any modifications to the layout of the sewer system shall be submitted to the Engineer for review and approval at least five days prior to the start of the affected work.

B. Install piping beginning at low point of systems, true to grades and alignment indicated with unbroken continuity of invert. Place bell ends of piping facing upstream. Install gaskets, seals, sleeves, and couplings in accordance with manufacturer's recommendations, accepted practices, and utility owner’s requirements. Maintain swab or drag in line and pull past each joint as it is completed.

C. All piping shall be laid in the dry. Adequate measures shall be taken to prevent floatation of pipe in the trench.

D. Whenever encountered within the trench, existing abandoned water, sewer, and/or drain lines shall be removed within the trench limits, unless otherwise noted. The remaining portion of the abandoned lines shall be plugged at all open ends.

E. When bell and spigot pipes are used, bell holes shall be dug in the bedding to accommodate the bells. They shall be deep enough to ensure that the bell does not bear on the bottom of the hole but shall be excessively wide in the longitudinal direction of the installation.

F. Use manholes for changes in direction, except where a fitting is indicated. Use fittings for branch connections, except where direct tap into existing sewer is indicated.

G. Use proper size increasers, reducers, and couplings, where different size or material of pipes and fittings are connected. Reduction of the size of piping in the direction of flow is prohibited without the written approval of the Engineer.

H. Install piping pitched down in direction of flow as indicated on the Contract Drawings.

I. Extend sanitary sewerage system piping to connect to building sanitary drains, of sizes and in locations indicated on the Contract Drawings.

J. Install piping in accordance with governing authorities having jurisdiction, except where more stringent requirements are indicated.

K. Acceptance of Pipe: Acceptance will be on the basis of tests specified herein before. The quality of all materials used in the pipe, the process of manufacture, and the finished pipe shall be subject to review by the Engineer. Inspection may be made at the place of manufacture, or on the work site after delivery or at both places and the pipe shall be subject to rejection at any time on account of failure to meet any of the specification requirements, even though sample pipe units may have been accepted as satisfactory at the place of manufacture. All pipe which is rejected shall be immediately removed from the project site by the Contractor.

L. Pipe Storage: Pipe sections shall not be stored on areas over the newly laid pipe or other pipelines which might be damaged by the superimposed load, and storage sections shall be restricted to approved areas.

M. Handling Pipe: Each pipe unit shall be handled into its position in the trench only in such manner and by such means, as the Engineer accepts as satisfactory. The Contractor will be required to furnish suitable devices to permit satisfactory support of all parts of the pipe unit when it is lifted.

N. Laying Pipe: Except where a concrete cradle or envelope is required, the pipe shall be laid in a crushed stone cradle. In trenches, no blocking or supporting of the piping by concrete, stones, bricks, wooden wedges, or method other than bedding the pipe on crushed stone will be permitted. Each length of pipe shall be shoved home against the pipe previously laid and held securely in position. Joints shall not be "pulled" or "cramped" without approval of the Engineer.

O. Jointing Pipe: After the pipe are aligned in the trench and are ready to be jointed, all joint surfaces shall be cleaned.

P. Alignment and Placement: All pipe shall be laid with extreme care as to grade and alignment. Each pipe shall be so laid as to form a close joint with the next adjoining pipe and bring the inverts continuously to the required grade.

1. Stakeout of drain work and setting of line and grade is the responsibility of the Contractor.
2. The Contractor shall establish centerline and offset stakes at each manhole, plus one intermediate centerline and offset stake as a checkpoint between manholes. Laser aligning shall not be used to establish a continuous line in excess of 400-feet.

Q. Cleaning: Care shall be taken to prevent earth, water, and other materials from entering the pipeline. As soon as possible after the pipe and manholes are completed, the Contractor shall clean out the pipeline and manholes being careful to prevent soil, water, and debris from entering any existing sewer system.

1. Place plugs in end of uncompleted conduit at end of day or whenever work stops.
2. Flush lines between manholes to remove collected debris.

R. Review of Completed Sanitary Sewer System: The completed sewer system shall be visually inspected by the Owner's Representative. If the visual observation of the completed sewer or any part thereof shows any pipe, manhole, or joint to be of defective work or material, the defect shall be replaced or repaired as directed by the Engineer or the Owner's Representative. The Contractor shall coordinate and provide site access for inspection. All repairs or replacement of deficient or incomplete work shall be performed by the Contractor at no cost to the Owner.

3.2 INSTALLATION OF SEWER MANHOLES

A. The bases shall be supported on a compacted level foundation of gravel borrow a minimum of 12 inches thick. Crushed stone may be substituted for gravel borrow if field conditions at the bottom of the excavation are wet.

B. The Contractor shall install the manholes as soon as the pipe laying reaches the location of the manhole.

C. The Contractor shall accurately locate each manhole and set accurate templates to conform to the required line and grade. Any manhole which is not installed in the correct location or oriented improperly shall be removed and rebuilt in its proper location, alignment, and orientation at no additional cost to the Owner.

D. Manhole risers and tops shall be installed using approved butyl rubber sealant or rubber gasket for sealing joints of manhole risers and tops; jointing shall be performed in accordance with the manufacturer's recommendations. Manhole risers and tops shall be installed level and plumb. Water shall not be permitted to rise over newly made joints, nor until after inspection as to their acceptability. All jointing shall be done in a manner to ensure watertight joints.

E. Openings shall be provided in the precast concrete manhole risers to receive entering pipes and these openings shall be made at the place of manufacture. Connection of sanitary pipes to manholes shall be made by means of a flexible rubber sleeve/boot cast integral with the structure sidewall.

F. Care shall be taken to ensure the openings are made to permit setting of the entering pipe at its correct elevation as indicated or directed. Manhole risers and tops shall be installed so the manhole steps shall be in alignment.

G. All holes used for handling shall be thoroughly plugged with non-shrink grout.

H. Cutting or tampering in the field, for purpose of creating new sidewall openings or altering existing openings, will not be permitted without approval of the Engineer.

I. All interior manhole joints where the sealing material is not flush with the inside wall shall be grouted with non-shrink mortar and finished by hand/wet-brush.

J. Clean all debris, mortar, and soil from the bottom of all structures prior to final acceptance of the project.

3.3 INSTALLATION OF PRECAST CONCRETE TANKS AND VAULTS

A. The bases shall be supported on a compacted level foundation of gravel borrow a minimum of 12 inches thick. Crushed stone may be substituted for gravel borrow if field conditions at the bottom of the excavation are wet.

B. The precast base shall be placed level at the specified grade. The entire base should be in contact with the underlying compacted granular material. Subsequent sections, complete with joint seals, shall be installed in accordance with the precast concrete manufacturer's recommendations. Structure sections shall be installed level and plumb. Water shall not be permitted to rise over newly made joints, nor until after inspection as to their acceptability. All jointing shall be done in a manner to ensure watertight joints.

C. Adjustment of the structure can be performed by lifting the upper sections free of the excavated area, re-leveling the base, and re-installing the sections. Damaged sections and gaskets shall be repaired or replaced as necessary. Once the structure has been constructed, any lift holes shall be plugged watertight with mortar or non-shrink grout. Any precast structure which is not installed in the correct location or oriented improperly shall be removed and rebuilt in its proper location, alignment, and orientation at no additional cost to the Owner.

D. Inlet and outlet pipes should be securely set into the structure using approved pipe seals (flexible boot connections, where applicable) so that the structure is watertight. Care shall be taken to ensure that the openings are made to permit setting of the entering pipe at its correct elevation as indicated or directed. Cutting or tampering in the field, for purpose of creating new sidewall openings or altering existing openings, will not be permitted.

E. Grade rings shall be installed to set the frame and cover at the required elevation. The grade rings shall be laid in a full bed of mortar with successive units being joined using sealant recommended by the manufacturer. Frames for the cover shall be set in a full bed of mortar at the elevation specified.

F. Clean all debris, mortar, and soil from the bottom of all structures prior to final acceptance of the project.

3.4 STRUCTURE REBUILT

A. When in the opinion of the Engineer or Owner's Representative, an existing masonry structure walls show deterioration, the structure shall be rebuilt. The casting and deteriorated masonry shall be removed in a careful and neat manner until only a sound condition remains. Concrete blocks shall be used to rebuild the structure. The new masonry construction, replacing of the casting, and other incidental work shall be performed as specified above.

1. The Contractor's base bid shall include rebuilding 10 vertical linear feet of existing manhole structures.

3.5 SETTING MANHOLE FRAMES AND COVERS

A. Manhole frames shall be set with tops conforming accurately to the grade of the pavement or finished ground surface as indicated on the Contract Drawings or as directed.

B. Brick shall be used to bring the frame and cover to the required elevation.

1. Frames shall be set concentric with the opening in the top of the manhole on a minimum 12 inches of brick in a full bed of mortar. A thick ring of mortar extending to the outer

edge of brick or concrete shall be placed all around the bottom flange of the cast iron frame. The mortar shall be smoothly finished to a height of 5 inches above the flange for 8-inch frames and sloped to shed water away from the frame.

2. Completed brick installation shall be coated with mortar at least a ¾ inch thick on the outside to provide a fully sealed and watertight collar between the top manhole section and the cover frame.
3. Only clean bricks shall be used in brickwork to adjust frame elevations. The brick shall be moistened by suitable means.

C. The castings of structures located within the pavement area shall not be completely set to the established grade until the bottom course of pavement has been laid. The final set of all other castings shall be performed at the proper stage of construction.

D. Manhole covers shall be left in place in the frame until completion of other work at the manholes.

3.6 PVC PIPE

A. General: Install piping in accordance with governing authorities having jurisdiction, except where more stringent requirements are indicated.

B. PIPE HANDLING

1. All pipe and fittings shall be carefully handled from the truck onto the ground and into the trench or excavation so as to prevent damage to the pipe. Pipes shall be kept free of dirt and foreign material, especially on the inside. Joint ends of pipe shall especially be kept clean.
2. Pipe stored on site shall be protected from direct sunlight and suitably ventilated.
3. Pipe or fittings shall not be dropped. All pipe or fittings shall be examined before laying, and no piece shall be installed which is found to be defective.

C. ALIGNMENT AND PLACEMENT OF PVC PIPE

1. Bedding material for the pipe must be installed with care in the area around the pipe. Bedding material must be placed to provide uniform and adequate support under pipe. Do not use blocking to bring pipe up to grade.
2. Provide bell holes at each joint to permit joint to be assembled properly while maintaining uniform pipe support.
3. Place and consolidate the bedding material under the pipe haunch to provide adequate side support while avoiding both vertical and lateral displacement of pipe.
4. Initial backfill must be completed to a point at least 12-inches over the top of the pipe and be hand placed. Use little or no tamping of initial backfill directly over the top of pipe. Compaction methods may be utilized during final backfilling.
5. No length of pipe shall be laid until the proceeding lengths of pipe have been thoroughly embedded in place, to prevent movement or disturbance of the pipe alignment.
6. Full lengths of pipe shall be used in the installation except that partial lengths may be used at the entrance to structures, and to accommodate the required locations of service connection fittings.
7. Pipe entrances to structures shall be cut flush with the inside face of the structure and cut ends of the pipe surface within the structure shall be properly rounded and finished so that there will be no protrusion, ragged edges or imperfections that will impede or affect the hydraulic characteristics of the sewage flow. The method of cutting and finishing shall be subject to the approval of the Engineer.

8. The Contractor shall protect the installation at all times during construction. The movement of construction equipment, vehicles and loads over and adjacent to any pipe shall be performed at the Contractor's own risk.
9. Sewer pipes shall be laid to the required grades by use of a laser and target system, unless otherwise specifically approved by the Engineer.
10. Separation Between Sewer Lines and Water Lines:

    a. A minimum horizontal separation of ten (10) feet shall be maintained between proposed sewer lines and existing water lines. The distance shall be measured edge to edge. In cases where it is not practical to maintain a ten-foot separation, it is permitted to install a sewer line closer to a water line, provided that the sewer line is laid in a separate trench or on an undisturbed earth shelf located eighteen (18) inches above the top of sewer. In either case, the elevation of the top of the sewer shall be at least 18 inches below the bottom of the water line.
    b. Whenever sewers must cross underwater lines, the sewer shall be laid at such an elevation that the top of the sewer is at least 18 inches below the bottom of the water line. When the elevation of the sewer cannot be varied to provide the 18 inches of vertical clearance, the water line shall be relocated to provide this separation or reconstructed with mechanical –joint pipe for a distance of 10 feet on each side of the sewer. One full length of water pipe shall be centered over the sewer so that both joints will be as far from the sewer as possible.
    c. When it is impossible to obtain horizontal and/or vertical separation as indicated above, both the water line and sewer line shall be constructed of mechanical joint ductile iron pipe for a distance of ten (10) feet to either side of the respective centerline. The water line shall be cement lined and the sewer line shall be provided with ceramic epoxy lining for sewer applications. Both pipes shall be pressure tested by an approved method to assure water tightness or both pipes shall be encased in control density fill. One (1) full length of water pipe shall be centered over the sewer at the crossing.

11. Jointing of PVC sewer pipe and fittings shall be done in accordance with the printed recommendations of the manufacturer and as specified. The bell end of the pipe shall be thoroughly cleaned. The joint surfaces and the gasket shall be lubricated prior to making up the joint. The position of the gasket shall be checked to ensure the joint has been properly made and is watertight. Care shall be taken not to exceed the manufacturer's recommended maximum deflection allowed for each joint.
12. PVC pipe shall be pushed home by hand or with the use of bar and block. The use of power equipment, such as a backhoe bucket, is not acceptable.
13. Field-cut pipe ends shall be cut square and the pipe surface beveled to the size and shape of a factory-finished beveled end. All sharp edges shall be rounded off.
14. Detectable warning tape shall also be installed 2-feet below the existing ground surfaces for later use in locating the pipe's exact position.

3.7 PLACEMENT OF DUCTILE IRON PIPE AND FITTINGS

A. Care shall be taken in loading, transportation, and unloading to prevent injury to the pipe or coatings. Pipe or fittings shall not be dropped. All pipe and fittings shall be examined before placement, and no piece shall be installed which is found to be defective. Any damage to the pipe coatings shall be repaired as directed by the Engineer.

B. If any defective pipe is discovered after it has been placed, it shall be removed and replaced with a sound pipe in a satisfactory manner by the Contractor, at his own expense. All pipe and fittings shall be kept clean until they are used in the work, be thoroughly cleaned before placement, and when placed, shall conform to the lines and grades required. Ductile iron

pipe and fittings shall be installed in accordance with requirements of AWWA Standard Specification C600 except as otherwise provided herein. A firm even bearing throughout the length of the pipe shall be constructed by compacting gravel borrow around the pipe and up to the spring line.

1. Blocking will not be permitted.

C. All pipes shall be sound and clean before placement. When pipe laying is not in progress, including lunchtime, the open ends of the pipe shall be temporarily closed by watertight plug or other acceptable means. Alignment shall be maintained during placement. The deflection at joints shall not exceed sixty percent of that recommended by the manufacturer. Fittings, in addition to those shown on the plans, shall be provided, if required, in crossing utilities, which may be encountered upon opening the trench. Solid sleeves shall be used only where allowed by the Engineer.

D. When cutting pipe is required, the cutting shall be done by machine, leaving a smooth cut at right angles to the axis of the pipe. Cut ends of pipe to be used with a push-on type bell shall be beveled to conform to the manufactured spigot end.

E. The Contractor shall take care not to damage pipe by impact, bending, compression, or abrasion during handling, and installation. Joint ends of pipe especially shall be kept clean.

F. Pipe shall be stored above ground at a height no greater than 5 feet and with even support for the pipe barrel.

G. Only nylon protected slings shall be used for handling the pipe. No hooks, chains or bare cables will be permitted.

H. Gaskets shall be shipped in cartons and stored in a clean area, away from grease, oil, heat, direct sunlight and ozone-producing electric motors.

I. Jointing of ductile iron push on pipe and fittings shall be done in accordance with the printed recommendations of the manufacturer and as specified. The last 8 inches of the outside of the spigot end of pipe and the inside of the bell end of pipe shall be thoroughly cleaned. The joint surfaces and the gasket shall be painted with a lubricant just prior to making up the joint. The spigot end shall then be gently pushed home into the bell. The position of the gasket shall be checked to ensure that the joint has been properly made and is watertight. Care shall be taken not to exceed the manufacturer's recommended maximum deflection allowed for each joint.

1. Jointing Ductile Iron Pipe (Push-On Type): Push-on joints shall be made in strict accordance with the manufacturer's instructions. Pipe shall be laid with bell ends looking ahead. A rubber gasket shall be inserted in the groove of the bell end of the pipe, and the joint surfaces cleaned and lubricated. The plain end of the pipe to be entered shall then be inserted in alignment with the bell of the pipe to which it is to be joined and pushed home with a jack or by other means. After joining the pipe, a metal feeler shall be used to make certain that the rubber gasket is correctly located.
2. Jointing Mechanical Joint Fittings: Mechanical joints at valves, fittings, and where designated shall be installed in accordance with the "Notes on Method of Installation" under ANSI Specification A 21.11 and the instructions of the manufacturer. To assemble the joints in the field, the Contractor shall thoroughly clean the joint surfaces and rubber gasket with soapy water before tightening the bolts. Bolts shall be tight to the specified torque. Under no condition shall extension wrenches or pipes over handles or ordinary ratchet wrenches be used to secure greater leverage.

J. Installation and jointing of ductile iron pipe shall be in accordance with AWWA C600, Sections 9b and 9c, latest revision, as applicable.

K. Ductile iron pipe installed within 5-feet of gas lines shall be fully encased with polyethylene material. Polyethylene shall be 8 millimeters thick and comply with AWWA C 105.

3.8 CLEANOUTS

A. Install cleanouts and extensions from sewer pipe to grade as indicated on the Contract Drawings. Set cleanout frame and cover in concrete 18 by 18 by 6-inches deep, except where location is in bituminous or concrete paving. Set top of cleanout 1-inch above surrounding earth grade or flush with grade when installed in paving.

3.9 SEWER COUPLINGS

A. Couplings which are factory manufactured shall be installed at all connections from existing pipe to proposed pipe unless the existing pipe is the same material as the proposed pipe and the bell and spigot end of the pipes to be connected are compatible and free from defects. All sewer couplings shall be installed in accordance with the manufacturer's recommendations for the types of pipe to be connected.

3.10 TAP CONNECTIONS

A. Make connections to existing piping and underground structures so that finished work will conform as nearly as practicable to the requirements specified for new work. The contractor shall verify the location, size, invert, and type of existing pipes at all points of connection prior to making the connections.

B. Make branch connections from side into existing piping by installing a wye or T-wyes, and couplings manufactured for use with the same type of pipe as indicated on the Contract Drawings. The Contractor shall install a 45-degree wye branch or 90-degree tee fittings in the sewer pipe at all locations where building sewer service pipe connections are shown on the Drawings. Connections of the sewer service pipes shall be made into the wye branches or tees by means of 45-degree bends. The connections shall be made thoroughly watertight and concrete shall be placed under each connection to bear on undisturbed earth and firmly support the connection.

C. Protect existing piping and structures to prevent concrete or debris from entering while making tap connections. Remove debris, concrete, or other extraneous material that may accumulate.

D. Connections to existing sewer facilities shall be performed in accordance with the requirements of the City of Worcester. The Contractor shall comply with all such requirements, including securing of all required permits and paying the costs thereof.

3.11 INSTALLATION OF PUMP SYSTEM

A. General: Install all equipment in accordance with manufacturer's instructions.

B. Wet Well and Valve Vault: Install precast pump chamber and precast valve vault on a compacted level foundation of structural fill a minimum 12 inches thick over the compacted subgrade. Crushed stone may be substituted for structural fill if field conditions at the bottom of the excavation are wet. The chambers shall be set level and plumb.

C. Equipment: Install all chamber equipment in accordance with manufacturer's instructions. Seal chamber penetration with modular, mechanical seals, consisting of rubber links shaped to continuously fill the annular space between the pipe and the wall openings.

D. Force Main: Install force main as shown on the Contract Drawings. Lay piping at slopes that will not create high or low points between the valve vault and the receiving sewer manhole. Concrete thrust blocks shall be installed at all fittings and other locations as indicated on the Contract Drawings and as directed by the Engineer. Minimum bearing area shall be as shown on the Contract Drawings. Thrust blocks shall bear against undisturbed material and shall be provided with wooden side forms. In the event that the use of thrust blocks is not practical, the Contractor shall provide an alternate method of joint restraint, at no additional cost, as approved and/or as directed by the Engineer.

E. Testing: Provide the services of a manufacturer's trained technician to start-up and test the system. Pumps shall be throttled with the gate valves to create sufficient TDH to reduce discharge rate to 120 gallons per minute. The performance of the system for lead pump, lag pump, high water alarm, and alternation, and reset shall be demonstrated to the approval of the Engineer.

3.12 INSTALLATION OF IDENTIFICATION

A. Install continuous plastic underground warning tape during back-filling of trench for underground sanitary sewerage system piping. Locate tape two-feet below finished grade, directly over piping.

3.13 BACKFILLING

A. General: Conduct excavation and backfill operations for structure and pipe installations in accordance with Section 312000 – EARTH MOVING, local requirements, and the contract documents.

B. Initial backfill shall be placed evenly on both sides of the pipe to distribute the load and not to cause movement or deflection of the pipe.

3.14 FIELD QUALITY CONTROL

A. Testing: Perform testing of completed piping in accordance with local authorities having jurisdiction and the following:

1. Testing shall be witnessed by the Owner's Representative and the local authority.
2. The test shall be by vacuum or by water exfiltration as described herein:
3. Vacuum Testing of Precast Concrete Manholes

a. The vacuum test shall be conducted on each manhole in accordance with ASTM C1244. Test results will be judged by the length of time it takes for the applied vacuum to drop from 10 inches of mercury to 9 inches. If the time is less than that listed in Table 1 of ASTM C1244, the manhole will have failed the test. Test times from Table 1 are excerpted below.

TABLE 1

Minimum Test Times for Various Manhole Diameters

	Diameter (Inches)		
Depth (Feet)	48	60	72
	Times (Seconds)		
0-12	30	39	49
12-16	40	52	67
16-20	50	65	81
20-24	59	78	97
26-30	74	98	121

b. If the manhole fails the initial test, the Contractor shall locate the leaks and make the proper repairs. Leaks may be filled with a wet slurry of accepted quick setting material. If the manhole should again fail the vacuum test, additional repairs shall be made, and the manhole water tested as specified below.

4. Water Exfiltration Testing of Precast Concrete Manholes

a. After the manhole has been assembled in place, all lifting holes shall be filled and pointed with an approved non-shrinking mortar. All pipes and other openings into the manhole shall be suitably plugged and the plugs braced to prevent flow out. The test shall be made prior to placing the shelf and invert. If the groundwater table has been allowed to rise above the bottom of the manhole, it shall be lowered for the duration of the test.

b. The manhole shall be filled with water to the top of the cone section. If the excavation has not been backfilled and observation indicates no visible leakage, that is, no water visibly moving down the surface of the manhole, the manhole may be considered to be satisfactorily watertight. If the test, as described above, is unsatisfactory as determined by the Owner's Representative and/or the City of Worcester Inspector or if the manhole excavation has been backfilled, the test shall be continued. A period of time may be permitted if the Contractor so wishes, to allow for absorption by the manhole. At the end of this period, the manhole shall be refilled to the top of the cone, if necessary, and a measuring time of at least 8 hours begun. At the end of the test period, the manhole shall be refilled to the top of the cone, measuring the volume of water added. This amount shall be extrapolated to a 24-hour loss rate and the leakage determined on the basis of depth. The leakage for each manhole shall not exceed one gallon per vertical foot for a 24-hour period. If the manhole fails this requirement, but the leakage does not exceed 3 gallons per vertical foot per day, repairs by approved methods may be made as required by the Owner's Representative and/or City of Worcester Inspector to bring the leakage within the allowable rate of one gallon per foot per day. Leakage due to a defective section or joint or exceeding the 3-gallon per vertical foot per day shall be cause for rejection of the manhole. It shall be the Contractor's responsibility to uncover the rejected manhole as necessary and to disassemble, reconstruct or replace it as required by the Owner's Representative. The manhole shall then be retested and, if satisfactory, interior joints shall be filled and pointed.

c. No adjustment in the leakage allowance will be made for unknown causes such as leaking plugs, absorption, etc. It shall be assumed that all loss of water during the test is a result of leaks through joints or through the concrete. Furthermore, the Contractor shall take any steps necessary to assure the Owner's Representative and/or City of Worcester Inspector that the water table is below the bottom of the manhole throughout the test.
d. If the groundwater table is above the highest joint in the manhole, and there is no leakage into the manhole, as determined by the Owner's Representative and/or the City of Worcester Inspector, such a test can serve to evaluate water-tightness of the manhole. However, if the Owner's Representative and/or the City of Worcester Inspector is not satisfied with the results, the Contractor shall lower the water table and carry out the test as described hereinbefore.

5. Leakage Testing of Gravity Sewer Piping and Fittings

a. On completion of a section of sewer, including building connections, the Contractor shall install suitable bulkheads as required, dewater and test the sewer for leakage.
b. Unless otherwise approved, the section shall be tested using low-pressure air test procedures. If circumstances permit, the Owner's Representative and/or the City of Worcester Inspector may allow testing by infiltration or exfiltration in lieu of air testing.
c. The air test procedures shall conform to the Uni-Bell Recommended Practice for Low-Pressure Air Testing of Installed Sewer Pipe, UNI-B-6. The starting air pressure for the test shall be 4 psig (greater than the average groundwater back pressure of any groundwater above the pipe, but not greater than 9.0 psig). The minimum duration permitted for the prescribed low-pressure air exfiltration pressure drop between two consecutive manholes shall not be less than provided in Table I or Table II of UNI-B-6. Note that UNI-B-6 suggests that use of the 0.5 psig pressure drop is more efficient since the time requirements are half of the 1.0 psig-pressure drop.
d. Using the air pressure test, if there has been no leakage (zero psig drop) after one hour of testing, the section undergoing test shall have passed.
e. If either infiltration or exfiltration testing is permitted by the Engineer, the test shall be conducted for at least 24 hours. The amount of infiltration or exfiltration shall not exceed 100 gallons per inch diameter per mile of sewer per 24 hours.
f. The infiltration test measures leakage into a section of sewer and may be used only where the groundwater level is one foot or more above the crown of the section of sewer pipe at its upper end and at least one foot above the top of building connections and chimneys. For making the infiltration tests, underdrains, if used, shall be plugged and other groundwater drainage shall be stopped to permit the groundwater to return to its normal level insofar as practicable. Allowances shall be made for water that may enter the sewer through pipe connections and inlets during the infiltration test.
g. Where the groundwater level is less than 1 foot above the top of the pipe at its upper end, the exfiltration test may be used. The sewers shall be subjected to an internal pressure by plugging the pipe at the lower end and then filling the pipelines and manholes with clean water to a height of 2 feet above the highest point in the system to be tested, including main pipeline, service connections, and chimneys. When slopes between manholes are steep, the Contractor shall ensure that this test can be accomplished without danger of forcing stoppers from wye or tee branches.
h. The rate of exfiltration from the sewers shall be determined by measuring the amount of water required to maintain the water level at the elevation established at the beginning of the test.

i. The Contractor shall construct such weirs or other means of measurements as may be required, shall furnish water, and shall do all necessary pumping to enable the test to be properly made.
j. The Contractor shall be responsible for the satisfactory water tightness of the entire section of sewer. Should the sections under test fail to meet the requirements, the Contractor shall do all work of locating and repairing leaks and retesting as the Engineer may require without additional compensation. A plan of the method of repairing any leaks that are found shall be submitted to the Engineer for review.

6. Pressure sewers (force mains) shall be hydro-tested to a pressure of 300 psi (1.5 times the working pressure). Testing procedure shall be as specified in AWWA C600-99 and C900-97 (or latest revisions)-Standard Hydrostatic Test Method of (CIP/DIP and PVCP) Sewer Force Mains, further as modified by the required test time shall be one (1) hours, the required pressure shall be 1.5 times the working pressure of the pipe and the allowable leakage shall not exceed “A” in the following formula:

$$A=DL(P^{0.5})/1333,200$$

Where: A=The allowable leakage in gallons

D=The Diameter of pipe in inches being tested

L=The Length of pipe in feet being tested

P=The Pressure in pounds per square inch utilized for the test

7. Pipe Deflection Measurement

a. In accordance with ASTM D3034, no less than 30 days after completion of the PVC sewer pipe installation, the Contractor shall test the pipeline for deflection using a "go/no-go" deflection mandrel having a minimum of nine evenly spaced arms or prongs. The "go/no-go" gauge shall be hand pulled through all sections of the pipeline by the Contractor. The Contractor shall submit drawings of the "go/no-go" gauge to the Owner’s Representative and/or the City of Worcester Inspector for approval prior to testing. Complete dimensions of the gauge for each diameter of pipe to be tested shall be in accordance with ASTM D3034.
b. Any section of pipe found to exceed 7.5 percent deflection shall be deemed a failed pipe and shall be excavated and replaced by the Contractor at his own expense.

8. Video Inspections: Seven days after the completion of the backfilling of each section of new pipe, as defined as a length of pipe between two manholes, the Contractor shall provide a televised inspection of the pipe to be submitted to the Designer. The Owner’s Representative shall be present during the recording. The recording shall be in DVD color format with audio and shall show a clear picture of the inside of the new pipe. If the Designer determines that the DVD is unacceptable for review the contractor shall re-televise the line until an acceptable DVD has been submitted. In the event that the pipe is not acceptable for any reason relating to the proper construction of the pipe according to these specifications, the Contractor will be responsible to re-excavate and repair the defects to the satisfaction of the Designer at no additional cost.

B. Cleaning: Clear interior of piping and structures of dirt and other superfluous material as work progresses. Maintain swab or drag in piping and pull past each joint as it is completed.

1. In large, accessible piping, brushes and brooms may be used for cleaning.
2. Place watertight plugs in ends of uncompleted pipe at end of day or whenever work stops. If water is in the trench when work is resumed, the plug shall not be removed until the trench has been dewatered and all danger of water entering the pipe eliminated.
3. Flush piping between manholes to remove collected debris.

C. Interior Inspection: Inspect piping to determine whether line displacement or other damage has occurred.

1. Make inspections after pipe between manholes has been installed and approximately 2 feet of backfill is in place, and again at completion of project.
2. If inspection indicates poor alignment, debris, displaced pipe, infiltration or other defects, the Contractor shall correct such defects and reinspect.

D. Prior to acceptance of the sanitary sewerage system, the Contractor shall submit the following to the Architect and to the local authority:

1. System As-Built Plan stamped by a Professional Land Surveyor or Engineer Registered in the Commonwealth of Massachusetts.
2. Video inspection DVDs and report: The report shall document the observations of the video inspections.
3. Deflection test report: The report shall fully describe the test procedures and list the test results. The report shall be signed by the Contractor’s superintendent.
4. Leakage test report: The report shall fully describe the test procedures and list the test results. The report shall be signed by the Contractor’s superintendent.

3.15 FINAL INSPECTION

A. Final inspection and acceptance of the sanitary sewer system shall be made by the Owner's Representative and the utility owner having jurisdiction of the particular system.

B. Prior to placing the systems in service, all components shall be inspected, with the Owner’s Representative present, to ensure that no debris or other contaminants are present. If necessary, the Contractor shall clean the structures and flush piping.

C. The Contractor is responsible for coordinating and scheduling the inspection of the work by local jurisdictional authorities. No additional payment will be made for inspections and permits required in the performance of the work.

End of Section

Section 33 40 00
STORM DRAINAGE UTILITIES

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all SECTIONS within DIVISION 1 – GENERAL REQUIREMENTS, which are hereby made a part of this section of Specifications.

1.2 DESCRIPTION OF WORK

A. Work Included: Provide labor, materials, and equipment necessary to construct the storm drainage system complete, including connections to existing structures and testing, as indicated on the Drawings and as specified.

B. Unless otherwise indicated on the Drawings, building drain service lines shall be installed from a point 10 feet outside the building foundation walls to the point of disposal.

C. Related Work: The following items are noted and included in this Section and will be performed under the designated sections:

1. Section 31 20 00 – EARTH MOVING for excavation, backfill, & compaction requirements.
2. Section 22 14 00 – FACILITY STORM DRAINAGE for building storm drainage piping.

1.3 SUBMITTALS

A. Refer to Section 01 33 00 – SUBMITTAL PROCEDURES, for submitted provisions and procedures.

1. Product Data: Submit manufacturer's technical product data and installation instructions for storm drain system materials and products.
2. Submit descriptive literature for piping, fittings, couplings, and appurtenances showing pipe dimensions, pipe and joint materials and dimensions, and other details for each class or type of pipe or product to be furnished for this contract. All pipe furnished under the contract shall be manufactured in accordance with these Specifications.
3. Submit shop drawings for storm drain systems, showing piping and manhole materials and sizes.
4. Submit shop drawings of complete layout of detention/retention structures, including all fittings and appurtenances.
5. The precast concrete structure shop drawing submittals for the manholes, catch basins, vaults, and tanks shall contain erection drawings showing connections, cast-in items, waterproofing details, lifting hooks, and production drawings showing elevations, sections, and details indicating sizes and quantities of reinforcement.
6. Submit shop drawings for structure frames, grates, and covers.
7. Filter fabric: Submit the manufacturer's information.
8. For trench drains submit shop drawings showing a schematic plan of the entire trench drain system, listing all parts being provided with exact centerline dimensions suitable for installation. Copies of the manufacturer’s recommended method of installation and assembly shall be submitted for review.

9. For water quality structures and stormwater quality filter treatment structures submit shop drawings for the structure and performance. Shop drawings shall detail the structures precast concrete components, inserts, and castings. Where an external bypass is required, the manufacturer shall provide calculations and designs for all structures, piping and any other required material applicable to the proper functioning of the system, stamped by a Professional Engineer.
10. The Contractor shall submit buoyancy calculations for storm drainage structures assuming groundwater is one (1) foot below finish grade. If buoyancy is an issue the structure(s) shall be modified to prevent uplift. All buoyancy calculations and precast concrete structure designs shall be prepared and sealed by a professional Civil Engineer licensed in the state of Massachusetts.
11. Prior to the acceptance of the storm drainage system, the Contractor shall submit to the Engineer, for review and approval, As-Built Drawings that indicate the true measurement and location, horizontal and vertical, of all new construction. As-Built drawings shall be stamped and signed by a Massachusetts Licensed Land Surveyor or Licensed Professional Engineer. The as-built plans shall also be submitted electronically as an AutoCAD drawing file (release 2010 or higher).
12. Prior to acceptance of the storm drainage system, the Contractor shall submit the results of the pipe deflection measurements and the video inspection reports.

1.4 REFERENCE STANDARDS

A. The following standards are applicable to the work of this Section to the extent referenced herein:

1. ASTM: American Society for Testing and Materials.
2. ANSI: American National Standards Institute.
3. AASHTO: American Association of State Highway and Transportation Officials.
4. Reference is made herein to the Commonwealth of Massachusetts, Department of Transportation (MassDOT), Formerly Massachusetts Highway Department (MHD) Standard Specifications for Highways and Bridges, latest edition, hereinafter referred to as the "Standard Specifications". All references to method of measurement, basis of payment, and payment items in the "Standard Specifications" are hereby deleted. References made to particular sections or paragraphs in the "Standard Specifications" shall include all related articles mentioned therein.
5. MassDOT Construction Standards, latest Edition with amendments, hereinafter referred to as the “Construction Standards.”

1.5 EXAMINATION OF SITE AND DOCUMENTS

A. It is hereby understood that the Contractor has carefully examined the site and all conditions affecting work under this Section. No claim for additional costs will be allowed because of a lack of knowledge of existing conditions as indicated in the Contract Documents, or obvious from observation of the site.

B. Plans, surveys, measurements, and dimensions under which the work is to be performed are believed to be correct, but the Contractor shall have examined them for himself during the bidding period and formed his own conclusions as to the full requirements of the work involved.

1.6 QUALITY ASSURANCE

A. Environmental Compliance: Comply with applicable portions of local environmental agency regulations pertaining to storm drain systems.

B. Utility Compliance: Comply with the City of Worcester regulations, standards, and guidelines pertaining to storm drainage system installation and inspections.

C. Plumbing Code Compliance: Comply with applicable portions of Massachusetts Plumbing Code and National Standard Plumbing Code, latest editions, pertaining to selection and installation of storm drain system's materials and products.

D. Manufacturer's Qualifications: Firms regularly engaged in manufacturing of storm drain system's products of types, materials, and sizes required, whose products have been in satisfactory use in similar service for not less than five years.

E. Installer's Qualifications: Firms with at least three years of successful installation experience on projects with storm drain work similar to that required for the project.

1.7 PROJECT CONDITIONS

A. Site Information: Perform site inspection and survey, research utility records, and verify existing utility locations and elevations. Verify that storm drainage system structures and piping may be installed in compliance with Contract Drawings and referenced standards.

B. Interruption of Existing Storm Drainage System: Do not interrupt service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary service according to the requirements indicated:

1. Notify Architect no fewer than two days in advance of proposed interruption of service.
2. Do not proceed with interruption of service without Architect’s written permission.

1.8 SEQUENCING AND SCHEDULING

A. Coordinate with interior building storm drain system piping.

B. Coordinate with other utility work.

C. The Contractor is responsible for developing a sequence of work to maintain existing services in operation until the new services are operational.

D. The Contractor is responsible for coordinating and scheduling the inspection of the work by the jurisdictional authority. All permits and inspection costs and fees shall be included in the bid prices and no additional costs will be paid to the Contractor.

PART 2 - PRODUCTS

2.1 PRECAST CONCRETE VAULTS AND TANKS

A. The precast reinforced concrete vault and tank structures shall be designed by a Massachusetts Registered Professional Engineer employed by the Contractor, in accordance with the applicable sections of the following references:

1. Commonwealth of Massachusetts State Building Code, latest edition.

2. American Concrete Institute, ACI 318 "Building Code Requirements for Reinforced Concrete."
3. AASHTO, "Standard Specifications for Highway Bridges."
4. Precast Concrete Institute, "Manual for Quality Control for Plants and Production of Precast and Prestressed Concrete Products, MNL-116."

B. The structures shall be designed for the following loads and possible combinations thereof:

1. Lateral soil pressure = 60 PCF (H), where H is the height from grade, as shown on the Contract Drawings, to the point of the structure being considered.
2. Soil weight shall be assumed to be 120 PCF.
3. AASHTO HS-20-44 loading.
4. Weight of precast concrete structure.
5. Initial handling and erection loadings, including design of galvanized lifting hooks using a safety factor = 4.0.

C. Investigate buoyancy and soil bearing considerations assuming the groundwater elevation is one-foot below the ground surface.

D. Concrete shall have a minimum 28-day compressive strength of 5,000 psi using Type II or III Portland cement with 8% maximum content of tricalcium aluminate, ASTM C150. A "normal dosage" of air-entraining agent shall be added to the concrete during the mixing cycle. Reinforcement shall be deformed billet-steel ASTM A615 or 7-wire strand ASTM A416, Grade 270 (if prestressed).

E. Dimensions and opening sizes and locations shall be as indicated on the Contract Drawings.

F. Pipe Connections: Vault and tank structures shall have pipe openings to accept the type of pipe specified. Pipe opening shall be minimum size required to receive the pipe and shall be accurately set to conform to the required line and grade. Sewer pipe shall be joined to the wall of the concrete structure with flexible pipe sleeves as indicated on the drawings. Flexible pipe sleeves shall be cast in the walls of the structure during the manufacturing process. Flexible pipe sleeves shall be NPC Kor-N-Seal Pipe-to-Manhole Connector as manufactured by Trelleborg Pipe Seals Milford, Inc., Milford, NH; Z-Lok as manufactured by A-Lok Products, Inc., Tullytown, PA; Tylox CIB Series Cast-In Boot Connector as manufactured by Hamilton Kent, Winchester, TN; or approved equal.

G. Bituminous Waterproofing: The exterior surfaces of precast structures shall be given two heavy coats of bituminous waterproofing material. The material shall be No. 35-J-10 Hi Building Bituminous Coating made by Mobil Chemical Company, Edison, NJ; Bitumastic Super Service Black made by Koppers Company, Inc., Pittsburgh, PA; Bitumastic 300M made by Caroline Company, St. Louis, MO; Sonoshield HLM 5000 as manufactured by BASF Corporation Building Systems, Shakopee, MN; or acceptable equivalent products. The waterproofing material shall be applied by brush or spray and in accordance with the instructions of the manufacturer. Time shall be allowed between coats to permit sufficient drying so that the application of the second coat has no effect on the first coat.

H. Storm Drainage Brick Masonry: Bricks shall be sound, hard, uniformly burned, regular, and uniform in shape and size. Underburned or salmon brick shall not be acceptable. Only whole brick shall be used.

1. Bricks for raising manhole and catch basin frames to finished grade shall conform to ASTM C32, Grade MS.

2. Mortar shall be in conformance with ASTM C270, Type M. The mortar shall be composed of one part Portland cement, 3-1/2 parts sand, and ¼ parts hydrated lime, by volume. Portland cement shall be ASTM C150, Type II; hydrated lime shall be Type S conforming to ASTM D207.
3. Sand shall be washed, cleaned, screened, well-graded with all particles passing a No. 4 sieve, and conform to ASTM C33.

2.2 MANHOLES AND CATCH BASINS

A. General: Provide precast reinforced concrete structures as indicated and complying with ASTM C 478.

B. Manhole Top: Precast concrete, of concentric cone, eccentric cone, or flat slab top type, as indicated in the Contract Drawings. Tops shall be designed to meet H20 loadings.

C. Base and Riser Sections: Precast concrete, with base riser section with integral floor. Diameter, base and riser thicknesses shall be as indicated on the Contract Drawings.

D. Cement: Type II.

E. Concrete strength: 4,000 psi minimum.

F. Precast concrete sections shall have tongue and groove joints.

G. Horizontal Joints: Joints between sections of concrete structures shall be sealed with a flexible, watertight joint, made with preformed butyl rubber joint sealant conforming to ASTM C990 or with a rubber gasket joint conforming to ASTM C443. Sealants and/or gaskets shall be installed in accordance with the manufacturer's written instructions.

H. Manhole Steps: Steps for manholes shall be non-skid raised edge-front steel reinforced polypropylene plastic type with at least 13 inches wide stepping surface. Steps shall meet the requirements of ASTM C-478 and AASHTO M-199. Steel shall be 1/2-inch grade 60 conforming to ASTM A615 encapsulated with molded copolymer polypropylene. The polypropylene shall conform to ASTM D-4101. Rungs shall protrude no more than 6 inches from the wall. The portion of the legs to be embedded in the precast section shall have fins and be tapered to ensure a secure bond. Steps shall start a foot above the shelf of the manhole floor and continued twelve inches on center spacing up through the completed height of the unit. The steps shall finish no lower than twenty-four (24)-inches below the rim elevation. Placement into precast walls shall be by a method recommended by the supplier of the precast manhole sections. Steps shall be installed per the manufacturer's specifications.

I. Pipe Connections: Drainage structures shall have plain beveled openings to accept the type of pipe specified. Pipe openings shall be minimum size required to receive the pipe and shall be accurately set to conform to the required line and grade. Drain pipe shall be joined to the wall of the concrete manhole or catch basin with non-shrink grout or flexible manhole sleeve as indicated on the drawings. Grout mixture shall follow instructions provided by manufacturer. Flexible manhole sleeves shall be cast in the walls of the manholes during the manufacturing process. Flexible manhole sleeves shall be NPC Kor-N-Seal Pipe-to-Manhole Connector as manufactured by Trelleborg Pipe Seals Milford, Inc., Milford, NH; Z-Lok as manufactured by A-Lok Products, Inc., Tullytown, PA; Tylox CIB Series Cast-In Boot Connector as manufactured by Hamilton Kent, Winchester, TN; or approved equal.

J. Drain manholes shall be constructed with drop connections when the proposed invert of the connection is at least 2.75 feet above the manhole invert. All drop manholes will be of the external type. The drop pipe shall be constructed of minimum SDR 35 PVC. The drop piping and horizontal cleanout sections will be sized the same as the drain main piping and shall enter the manhole at invert elevation. The drop portion of the piping shall be secured with anchor straps. The drop piping shall be encased with control density fill.

K. Storm Drainage Brick Masonry: Bricks shall be sound, hard, uniformly burned, regular, and uniform in shape and size. Underburned or salmon brick shall not be acceptable. Only whole brick shall be used.

1. Bricks for channels and shelves shall conform to ASTM C32, Grade SS except that the mean of five tests for absorptions shall not exceed 8 percent and no individual brick exceed 11 percent.
2. Bricks for raising manhole and catch basin frames to finished grade shall conform to ASTM C32, Grade MS.
3. Mortar shall be in conformance with ASTM C270, Type M. The mortar shall be composed of one part Portland cement, 3-1/2 parts sand, and ¼ parts hydrated lime, by volume. Portland cement shall be ASTM C150, Type II; hydrated lime shall be Type S conforming to ASTM D207.
4. Sand shall be washed, cleaned, screened, well-graded with all particles passing a No. 4 sieve, and conform to ASTM C33.

L. In drain manholes, the invert channel within the structure shall be an inverted arch with bricks laid as stretchers and on edge and so constructed as to conform in shape to the lower half of the pipe. The shelf in manholes shall consist of bricks laid flat and the top of the shelf shall be at the elevation of the top of the pipe, as indicated on the Contract Drawings, and shall be sloped to flow toward the channel.

M. Inverts in drain manholes shall conform accurately to size of the adjoining pipe. Side inverts and main inverts where the direction changes shall be laid out in smooth curves of the longest possible radius which is tangent, within the manhole, to the centerline of the adjoining pipelines.

N. For all manhole depths greater than 10 feet, the inside diameter of the manholes shall be at least 5’-0”.

O. Safety landings will be installed inside manholes greater than 16 feet in depth.

P. When installing manholes on existing lines and when flows cannot be diverted, drop-over manholes shall be used. Drop-over manholes shall be precast with opening cast in the sidewalls of sufficient size to fit over the existing line(s) to remain in service. Drop-over manholes shall be set on a precast or cast-in-place concrete base slab. Drop-over manholes shall be manufactured to the same requirements and dimensions as standard manholes.

2.3 CONCRETE BLOCK MANHOLES

A. Concrete block manholes shall only be utilized when it is not feasible to utilize a precast concrete manhole and then only with written approval from the Owner’s Representative.

B. Concrete block drain manholes shall be minimum 48 inches inside diameter and built of standard solid manhole barrel blocks set on a concrete or precast sectional plate base. The upper 2 feet of masonry shall be built using batter blocks. All joint spaces shall be completely filled, horizontal and vertical. All block to be thoroughly wet before jointing. A leveling course of two bricks at the top shall be used to meet proper grade. Cement concrete blocks shall be machine-made solid segments conforming to the requirements for Concrete Masonry Units for Construction of Catch Basin and Manholes, ASTM-C-139. Blocks shall be 6 inches in width with the inside and outside surfaces curved to the necessary radius and so designed that the interior surfaces of the structures shall be cylindrical. The top batter courses shall be designed to reduce uniformly the inside section of the structure to the top size and shape. The blocks used in the top courses shall be designed to produce a surface 8 inches in width upon which to seat the frame.

2.4 MANHOLE FRAMES AND COVERS

A. Manhole frames and covers shall be of cast iron conforming to the requirements of AASHTO M306 and shall be manufactured by East Jordan Iron Works, Inc. (EJIW), LebBron Foundry, or approved equal. Manhole frames and covers shall be equal to EJIW 1056Z frame and EJIW 1056A cover or LeBaron LC239/L23C-1. Manhole covers shall be supplied with a closed pick hole and shall show the working “Worcester, A Town June 14, 1722: A City February 29, 1848” cast into said cover. Frames and covers shall be designed to accept H20 loads. Frame height shall be 8 inches.

2.5 CATCH BASIN FRAMES AND GRATES

A. Catch basin frames and grates shall be of cast iron conforming to the requirements of AASHTO M306 and shall be manufactured by East Jordan Iron Works, Inc. (EJIW), LeBaron Foundry, or approved equal. Catch basin grates shall be EJIW 7288M or LeBaron L28SG1. Catch basin frames shall be EJIW 7288Z (4-flange), EJIW 7288Z1 (3-flange), or LeBaron LF288, Type E. Frames and grates shall be designed to accept H20 loads. Frame height shall be 8 inches.

2.6 CATCH BASIN HOODS

A. All catch basin hoods shall be City of Worcester standard 8-inch green traps as supplied by Tolman Manufacturing Company of Boston, MA, or approved equal. Outlet pipes from catch basin hoods shall be 8-inch DR18, Class 150 PVC pipe.

2.7 AREA DRAIN

A. Area drains required for this contract shall be manufactured from PVC pipe stock, utilizing a thermo-molding process to reform the pipe stock to the specified configuration. The drainage pipe connection stubs shall be manufactured from PVC pipe stock and formed to provide a watertight connection with the specified pipe system. This joint tightness shall conform to ASTM D3212 for joints for drain and sewer plastic pipe using flexible elastomeric seals conforming to ASTM F477. The pipe bell spigot shall be joined to the main body of the area drain. A PVC cap shall be installed at the bottom of the area drain sump. The raw material used to manufacture the pipe stock that is used to manufacture the main body and pipe stubs of the surface drainage inlets shall conform to ASTM D1784 cell class 12454. Area drains shall be manufactured by Nyloplast or approved equal.

B. Grates and frames furnished for all area drainage shall be ductile iron for sizes 8”, 10”, 12”, 15”, 18” and 24” and shall be made specifically for each basin so as to provide a round bottom flange that closely matches the diameter of the surface drainage inlet. Grates for area drains shall be capable of supporting H-20 wheel loading for vehicular traffic areas or H-10 loading for pedestrian traffic areas unless otherwise noted. 12” and 15” square grates shall be hinged to the frame using pins. Metal used in the manufacture of the castings shall conform to ASTM A536 grade 70-50-05 for ductile iron. Grates shall be provided painted black. Grates in walkways shall meet ADA requirements. Grates in planting beds shall be domed grates. The grates furnished for area drains bioretention areas shall be 24” in diameter. Area drain grates shall be manufactured by Nyloplast or approved equal.

2.8 INLINE DRAINS

A. The inline drain required for this contract shall be manufactured from PVC pipe stock, utilizing a thermos-molding process to reform the pipe stock to the furnished configuration. The drainage pipe connection stubs shall be manufactured from PVC pipe stock and formed to provide a watertight connection with the specified pipe system. This joint tightness shall conform to ASTM D3212 for joints for drain and sewer plastic pipe using flexible elastomeric seals. The flexible elastomeric seals shall conform to ASTM F477. The pipe bell spigot shall be joined to the inline drain body by use of a swage mechanical joint. The ram material used to manufacture the pipe stock that is used to manufacture the inline drain body and pipe stubs of the surface drainage inlets shall conform to ASTM D1784 cell class 12454.

B. The grates furnished for all surface drainage inlets shall be ductile iron grates for sizes 8”, 10”, 12”,15”, 18”, and 30” shall be made specifically for each fitting so as to provide a round bottom flange that closely matches the diameter of the surface drainage inlet. Grates for inline drains shall be capable of supporting H-20 wheel loading for traffic areas or H-10 loading for pedestrian areas. 12” and 15” square grates will be hinged to the frame using pins. Metal used in the manufacture of the castings shall conform to ASTM A536 grade 70-50-05 for ductile iron. Grates shall be provided painted black.

2.9 MANUFACTURED TRENCH DRAINS

A. Trench drains shall be a pre-engineered, manufactured system that conforms to the design loading requirements of AASHTO H-20 and HS-20 (minimum) with the following minimum requirements:

1. Channels shall be manufactured from polyester resin polymer concrete with an integrally cast-in ductile iron edge rail. Each edge rail shall be at least ¼” thick.
2. The polymer concrete shall be frost proof, dilute acid and alkali resistant, and salt proof (B117 Salt Spray Test Compliant) with the minimum properties as follows:
   a. Compressive Strength: 14,000 psi
   b. Flexural Strength: 4,000 psi
   c. Tensile Strength: 1,500 psi
   d. Water Absorption: 0.07%
3. The system shall have internal and overall widths per the plans and details and a built-in slope of 0.5%. Channel invert shall have a partial radius in the trench bottom. All channels shall be interlocking with a male/female joint.
4. Trench drain grates shall be slotted ductile iron conforming to ASTM 536-84, Grade 65-45-12. After removal of grates, there shall be uninterrupted access to the trench to aid maintenance.

5. Units shall have horizontal cast in anchoring keys on the outside wall to ensure maximum mechanical bond to the surrounding bedding material and pavement surface.
6. The trench drain shall have a locking device that directly connects the grate to the frame.
7. Channel shall be designed to withstand loading to Load Class F as outlined by EN 1433. Grate type shall be appropriate to meet the system load class specified.
8. Trench drain system shall be installed in strict accordance with manufacturer's installation instructions, recommendations, and shop drawings.

2.10 WATER QUALITY STRUCTURE

A. Water quality inlets and structures shall be Vortsentry HS, CDS, and/or Vortechs as manufactured by Contech Engineered Solutions, Hydroguard as manufactured by Hydroworks, Downstream Defender as manufactured by Hydro International, or equivalent. Water quality inlets shall be provided with a frame and grate. Water quality structures shall be provided with a frame and cover. Other acceptable equivalent manufactured devices may be used if following requirements are met. Prior to acceptance, the contractor shall receive written approval for use of said substitution from the City of Worcester and/or their authorized representatives.

B. The water quality structure shall have a proven laboratory test record of having the capability to remove a minimum of 80% of the sediment load from the low-flow storm conditions from the total catchment area of the drainage system. Laboratory testing methods shall conform to the “Technology Acceptance Reciprocity Partnership” (TARP) Tier II protocol or other acceptable equivalent method and shall have the capability of removing clay and silt-size particles.

C. The available water quality structure laboratory performance documentation shall achieve a grade of “2” or better as rated through the “Massachusetts Stormwater Evaluation Project” (MAStep).

D. The water quality structure shall be installed underground as part of the stormwater system.

E. The structure shall be constructed of precast concrete components.

F. Precast Concrete Sections: All precast concrete components shall be designed and manufactured to a minimum live load of AASHTO HS-20 truck loading.

G. Joints: The concrete joints shall be watertight and meet the design criteria according to ASTM C443.

H. Frame and Cover: The frame and cover shall clearly indicate with lettering the unit’s name cast into the cover to allow for easy identification in the field.

I. Concrete: Precast concrete components shall meet the requirements of ASTM C478.

J. Fiberglass: The fiberglass portion of the water treatment structure shall be constructed in accordance with ASTM D409, Contact Molded Glass Fiber Reinforced Chemical Resistant Tanks. The internal fiberglass insert shall be bolted and sealed watertight inside the reinforced concrete component.

K. The water quality structure shall be vertically oriented with easy access to facilitate maintenance.

L. The first 16 inches of oil storage should be lined with fiberglass or another coating acceptable to the Engineer to provide double-wall containment of any hydrocarbon-based material.

M. Water quality structure shall be equipped with high flow bypass that shall be physically separated from the separation area to prevent mixing.

N. The structure shall be maintainable from the surface via access points without requiring entry into the structure.

O. The structure shall be designed to prevent the formation of secondary eddy currents or scour conditions.

P. The structure shall be able to be installed to the invert elevations of the drainage system as detailed on the Contract Drawings.

Q. The water quality structure shall be capable of containing floatable substances such as oil and gasoline within the structure during normal operation as well as periods of service and repair. Floatables containment shall be achieved without the use of floatable additives.

R. The water quality structure shall not be compromised by backwater conditions i.e., trapped pollutants should not be resuspended and scoured from the interceptor during backwater conditions.

S. Calculations stamped by a Professional Engineer shall be supplied to demonstrate that the water quality structures will accept the design flow rates without causing a backwater condition.

T. Inspection: All precast concrete sections shall be inspected to ensure that dimensions, appearance, and quality of the product meet the requirements of ASTM C478.

2.11 DUCTILE IRON PIPE AND FITTINGS

A. General: Provide pipes of the following materials of class indicated. Provide pipe fittings and accessories of same materials and class as pipes with joining method, as indicated. The piping shall be manufactured by an established manufacturer of good reputation in the industry and in a permanent plant adapted to meet all the design requirements of the pipe.

1. Ductile iron pipe shall be that of a manufacturer who can demonstrate at least five years of successful experience in manufacturing ductile iron pipe. The pipe shall be equipped with push on type, restrained joint, or mechanical joints, as required.
2. All ductile iron drain pipe shall conform to American Water Works Association (AWWA) C150 and AWWA C151.
3. The ductile iron pipe shall be Class 52 and furnished in minimum nominal 18-foot lengths, with Push-on as manufactured by U.S. Pipe and Foundry Company, Atlantic States Cast Iron Pipe Co., Clow Corporation, or approved equal with gaskets conforming to AWWA C111 "Rubber Gasket Joints".
4. Ductile iron drain pipe shall be cement-mortar lined and the pipe exterior asphalt seal coated in accordance with AWWA C104.
5. The pipe shall be furnished along with necessary materials and equipment recommended by the manufacturer for use in joining pipe lengths and fittings.

6. Fittings shall be ASTM A-536 ductile iron with mechanical joint fittings. All fittings 3 inches through 48 inches in diameter shall meet or exceed the requirements of AWWA C110. Compact fittings shall be ductile iron meeting or exceeding the requirements of AWWA C153. Fittings shall have the same lining and coating as the pipe specified above. All fittings shall be marked with the weight and shall have distinctly cast upon them the pressure rating, the manufacturer's identification, nominal diameter of openings and the number of degrees or fraction of the circle on all bends. All fittings 4 through 24 inches shall be Class 350. All fittings greater than 24 inches shall be as specified above except they shall be Class 250. Compact fittings shall only be used in sizes 4 through 24 inches. Fittings shall conform to the weights, excluding accessories, and dimension shown in the latest edition of the Handbook of Ductile Iron Pipe and come complete with all joint accessories as required. All accessories (gland, gaskets, T-bolts, and nuts) shall be in accordance with AWWA C111. All mechanical joint bolts (T-bolts) shall be Cor-Ten or equal.
7. Contractor shall provide all adapters and fittings such as transition couplings, as determined in the field, necessary to complete all cross connections, whether or not specifically stated in the Contract Drawings and Specifications.
8. All pipes shall be marked with the class, thickness designation, and initials of the manufacturer.
9. If required the manufacturer shall supply the Engineer with certificates of compliance with these Specifications and certification that each piece of ductile iron pipe has been tested at the foundry with the Ball Impression Test, Ring Bending, or equal.
10. Pipe for use with sleeve-type couplings shall be as specified except that the ends shall be plain (without bells or beads). The ends shall be cast or machined at right angles to the axis.

B. INSPECTION, TESTS, AND ACCEPTANCE FOR DUCTILE IRON PIPE

1. All pipe delivered to the job site shall be accompanied by test reports certifying that the pipe and fittings conform to "AWWA Standard for Ductile Iron Pipe, for Water and Other Liquids" (AWWA H3) and (AWWA C151).
2. All tests shall be made in accordance with the methods prescribed by the above mentioned AWWA Standards, and the acceptance or rejection shall be based on the test results.
3. Pipe which does not conform to the requirements of this contract shall be immediately removed and replaced by the Contractor.
4. All ductile iron pipe to be installed under this Contract may be inspected at the foundry for compliance with these Specifications by an independent testing laboratory selected by the Owner. The Contractor shall require the manufacturer's cooperation in these inspections. The cost of foundry inspection of all pipe approved for this Contract, plus the cost of the inspection of a reasonable amount of disapproved pipe, will be borne by the Owner.

C. SLEEVE COUPLINGS FOR DUCTILE IRON PIPE

1. Sleeve couplings and accessories shall be pressure rated at least equal to that of the pipe. Couplings shall be cast iron and shall be Dresser Style 53 or 153, Rockwell Style 441, Baker Series 4245 or acceptable equivalent product. The couplings shall be provided with Cor-Ten bolts and nuts or approved equal.
2. After assembly, all exterior surfaces including the bolts and nuts shall be thoroughly coated with two coats of heavy-duty protective coating. The interior of the coupling shall be epoxy coated. Coating shall be a minimum of 10 mils. and a maximum of 20 mils. dry film thickness thermosetting epoxy.

2.12 HUB AND SPIGOT CAST IRON SOIL PIPE AND FITTINGS

A. Hub and Spigot Cast Iron pipe and fittings shall be manufactured from gray cast iron and shall conform to ASTM A74. Joints shall be made using a compression gasket manufactured from an elastomer meeting the requirements of ASTM C564. Installation shall comply with manufacturer's recommendations and applicable code requirements.

2.13 PVC DRAINAGE PIPE

A. General: Provide pipes of the following materials of class indicated. Provide pipe fittings and accessories of same materials and class as pipes with joining method, as indicated. The piping shall be manufactured by an established manufacturer of good reputation in the industry and in a permanent plant adapted to meet all the design requirements of the pipe.

B. PVC (Polyvinyl Chloride) Gravity Sewer Pipe and Fittings: ASTM D3034, SDR 35, for elastomeric gasket joints. Pipe 18 to 36 inches in diameter shall conform to ASTM F679, T-1 heavy wall. The pipe shall have an SDR ratio of 35 and a pipe stiffness of 46 psi.

C. PVC pipe for catch basin outlets shall be DR18, Class 150 PVC.

D. Joints: PVC pipe shall have an integral wall bell and spigot push-on joint with elastomeric gaskets secured in place in the bell of the pipe. The bell shall consist of an integral wall section with solid cross-section elastomeric gasket, factory assembled, securely locked in place to prevent displacement during assembly. Pipe joints shall conform to ASTM D3212 and elastomeric gaskets shall conform to ASTM F477.

E. Spigot pipe ends shall be supplied with bevels from the manufacturer to ensure proper insertion. Each spigot end shall have an "assembly stripe" imprinted thereon to which the bell end of the mated pipe will extend upon proper joining of the two pipes.

F. PVC gravity sewer fittings and accessories shall be as manufactured and furnished by the pipe supplier or approved equal and have bell and spigot configurations compatible with that of the pipe.

2.14 CORRUGATED POLYETHYLENE PIPE

A. General: Provide pipes of the following materials of class indicated. Provide pipe fittings and accessories of same materials and class as pipes with joining method, as indicated. The piping shall be manufactured by an established manufacturer of good reputation in the industry and in a permanent plant adapted to meet all the design requirements of the pipe.

1. Corrugated polyethylene pipe shall have an interior surface that is smooth and even, free from roughness, projections, indentations, offsets, or irregularities of any kind.
    a. Pipe shall conform to AASHTO M252, Type S for 4- through 10-inch diameter pipes.
    b. Pipe shall conform to AASHTO M294, Type S or ASTM F2306 for 12- through 60-inch diameter pipes.
    c. Fittings shall conform to AASHTO M252, AASHTO M294 or ASTM F2306. Bell and spigot connections shall utilize a spun-on or welded bell and valley or saddle gasket meeting the watertight joint performance requirements of AASHTO M252, AASHTO M294 or ASTM F2306.

2. Pipe and fittings shall be high-density polyethylene meeting the requirements of ASTM D3350.
3. Pipe units shall have a minimum laying length of 20-feet except as otherwise indicated or allowed by the Engineer.
4. Pipe shall be installed with a minimum 12-inch cover for AASHTO H-20 loading.

B. CORRUGATED POLYETHYLENE FLARED END SECTION

1. The pipe shall have an interior surface that is smooth and even, free from roughness, projections, indentations, offsets, or irregularities of any kind. Flared end section shall be high-density polyethylene meeting ASTM D3350 minimum cell classification 213320C. Metal threaded fastening rods shall be stainless steel.

C. JOINTS ON CORRUGATED POLYETHYLENE PIPE

1. The pipe and fitting joints shall be bell-and spigot with watertight gaskets in accordance with the requirements of ASTM D3212.
2. Gaskets shall meet the requirements of ASTM F477. Gaskets shall be installed by the pipe manufacturer and covered with a removable, protective wrap to ensure the gasket is free from debris. A joint lubricant available from the manufacturer shall be used on the gasket and bell during assembly.
3. Pipe entrances at catch basins shall be made with a mortar made with Type II cement. Mortar mixture shall follow instructions provided by cement manufacturer. Pipe connections at drain manholes and water quality structures shall be made with integral flexible rubber sleeves and Corrugated Pipe Adapters designed for use with the pipe and sleeves.

2.15 REINFORCED CONCRETE PIPE (CLASS IV; 12 THROUGH 48 INCHES)

A. General: Provide pipes of the following materials of class indicated. Provide pipe fittings and accessories of same materials and class as pipes with joining method, as indicated. The piping shall be manufactured by an established manufacturer of good reputation in the industry and in a permanent plant adapted to meet all the design requirements of the pipe.

1. The pipe shall have an interior surface, which is smooth and even, free from roughness, projections, indentations, offsets, or irregularities of any kind. Pipe shall conform to ASTM "Specifications for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe," Designation: C76 and shall be Wall B for the Class IV and V, as noted on the drawings, and with additions and exceptions as follows:
2. Type II cement shall be used unless otherwise approved by the Engineer. Admixtures shall not be used except with prior approval of the Engineer.
3. Elliptical reinforcement will not be permitted. Longitudinal reinforcement shall be continuous. Reinforcement shall have a minimum cover of ¾ inch. Pipe shall have no lifting holes.
4. Absorption shall be as specified under "Tests of Materials and Pipe Units."
5. Pipes manufactured by the centrifugal process or in vertical forms shall be cast of wet mix concrete. Concrete cast in vertical forms shall be consolidated by internal or external mechanical vibration or both. The vibrating equipment shall be operated at high speed (more than 5,000 rpm) and have a low amplitude. Pipes manufactured by the modified packer process shall have a supplementary concrete densification operation that shall assure the attainment of full bond between reinforcement and concrete and also eliminate any displacement of the reinforcement. Additional passes with the

revolving packerhead or the use of additional vibrators attached to the platform or exterior forms will not be acceptable.

6. Pipe units shall have a minimum laying length of 8-feet except as otherwise indicated or allowed by the Engineer.
7. Pipe may be rejected for any of the following reasons:
   a. Exposure of any wires, positioning spacers or chairs used to hold the reinforcement cage in position, or steel reinforcement in any surface of the pipe, except as permitted by Section 8.2 of ASTM C76.
   b. Transverse reinforcing steel found to be in excess of 1/4-inch out of specified position after the pipe is molded.
   c. Any shattering or flaking of concrete as a crack.
   d. Voids, with the exception of a few minor bugholes, on the interior and exterior surfaces of the pipe exceeding 1/4-inch in depth, unless properly and soundly pointed with mortar or other approved material.
   e. A hollow spot (identified by tapping the internal surface of the pipe) which is greater than 30-inches in length or wider than 3 times the specified wall thickness.
   f. Defects that indicate imperfect molding of concrete; or any surface defect indicating honeycomb or open texture (rock pockets) greater in size than area equal to a square with a side dimension of 2½ times the wall thickness or deeper than two times the maximum graded aggregate size; or local deficiency of cement resulting in loosely bonded concrete.
   g. Any of the following:
      1) A crack having a width of 0.005 to 0.01-inches throughout a continuous length of 36-inches or more.
      2) A crack having a width of 0.0 to 0.03-inches or more throughout a continuous length of 1-foot or more.
      3) Any crack greater than 0.005-inches extending through the wall of the pipe and having a length in excess of the wall thickness.
      4) Any crack showing two visible lines of separation for a continuous length 2-feet or more, or an interrupted length of 3-feet or more anywhere in evidence, both inside and outside.
      5) Cracks anywhere greater than 0.03-inches in width.
   h. Application of any wash coat of cement or grout to the pipe will not be permitted without approval of the Engineer. Any pipe dressing procedures shall be subject to the approval of the Engineer.

B. Joints on Reinforced Concrete Pipe:

1. Pipe joints for all reinforced concrete pipe shall be of the rubber gasket type in which the gaskets are in compression and which will permit both longitudinal and angular movement. Each unit of pipe shall be provided with proper ends made of concrete formed true to size and formed on machined rings to ensure accurate joint surfaces.
2. Joints and gaskets for pipe shall be the O-ring gasket type and shall conform to the requirements of ASTM C443 and the additional requirements specified.
3. Joints shall be of such design that when tested under an average internal hydrostatic pressure of 13 pounds per square inch for a period of 10 minutes, no visible leakage will result. The diameters of the joint surfaces which compress the gasket shall not vary from the true diameters by more than 1/16-in or the amount permitted by the appropriate above-mentioned ASTM Standard Specifications, whichever is less.

4. Gaskets shall be of a composition and texture which is resistant to common ingredients of sewage, industrial wastes, and groundwater, and which will endure permanently under the conditions likely to be imposed by this service. Gaskets shall be the product of a manufacturer regularly engaged in the manufacture of rubber gaskets for pipe joints.

C. Flared End Sections: Reinforced Concrete Pipe flared end sections shall conform to requirements of AASHTO M170, minimum Class IV.

2.16 SUBSURFACE INFILTRATION CHAMBERS

A. Subsurface detention chambers shall be HDPE chamber system as manufactured by StormTech, Cultec, or similar. The chambers will be handled, stored, and installed according to manufacturer's specifications and details. The chambers will be placed on a drainage course bed with a minimum of depth of six inches. The chambers shall not be placed with backfill depths greater than 96" to surface as per manufacturer's details.

B. The nominal storage volume of stormwater chambers shall be 74.9 cubic feet per chamber, including the volume of drainage course bedding.

C. The galley shall have both of its ends open to allow for unimpeded hydraulic flows and for visual inspection and maintenance of the row's entire length. The galley shall have a circular, indented, flat surface on the top for an inspection port or clean-out.

D. The galley shall be analyzed and designed using AASHTO methods for thermoplastic culverts contained in the LRFD Bridge Design Specifications, 2nd Edition, including Interim Specifications through 2001. Design live load shall be the AASHTO HS20 vehicle. Design shall consider earth and live loads as appropriate for the specified depth of fill.

E. The end cap shall be designed to fit into any corrugation of a galley, which allows capping a galley that has its length trimmed and segmenting rows into storage basins of various lengths.

F. The end cap shall have saw guides to allow easy cutting for various diameters of pipe that may be used to inlet the system. The end cap shall have excess structural adequacies to allow cutting an orifice of the required size at any invert elevation.

G. The primary face of an end cap shall be curved outward to resist horizontal loads generated near the edges of beds.

2.17 FILTER FABRIC

A. Filter Fabric used, as a drainage medium shall consist of a non-woven fabric made from polypropylene or polyethylene filaments or yarns. The fabric shall be inert to organic chemicals commonly encountered in the soil. Edges of filter fabric shall overlap a minimum of one foot. The fabric shall conform to the following recommended property tests:

Property	Unit	Test Method	Minimum Value
Weight	oz/sy	ASTM D-5261-92	4.8
Grab Strength	lbs	ASTM D-4632-91	120
Grab Elongation	percent	ASTM D-4632-91	50
Trapezoid Tear Strength	lbs	ASTM D-4533-91	50
Mullen Burst Strength	psi	ASTM D-3786-87	225
Puncture Strength	lbs	ASTM D-4833-00	65
Apparent Opening Size (AOS)	U.S. std. Size Sieve	ASTM D-4751-99A	70

2.18 CRUSHED STONE

A. Crushed stone shall consist of durable crushed rock or durable crushed gravel stone, free of ice and snow, sand, clay, loam, or other deleterious or organic material. The crushed stone shall be uniformly blended and shall conform to the following requirements.

Percent Passing by Weight		
Sieve Size	**3/4-inch Stone**	**1/2-inch Stone**
1-inch	100	---
3/4-inch	90-100	---
5/8-inch	---	100
1/2-inch	10-50	85-100
3/8-inch	0-20	15-45
No. 4	0-5	0-15
No. 8	---	0-5

2.19 DRAIN COUPLINGS

A. Drain Couplings shall be pressure rated at least equal to that of the pipe. The coupling sleeve shall be 1/4-inch minimum thickness elastomeric polyvinyl chloride with a minimum tensile strength of 1500 psi. The sleeve shall fit snugly onto the pipe to be joined and be resistant to common chemicals present in stormwater. Adjustable pipe clamps shall consist of a slotted band that mate with the worm gear screw and a screw housing all manufactured of stainless steel, and suitable for underground service.

2.20 CLEANOUTS

A. General: Provide cast-iron ferrule and countersunk brass cleanout plug, with round cast-iron access frame and heavy-duty, secured, scoriated cast-iron cover.

B. The drain cleanouts shall be minimum 6-inch diameter or sized to match the service pipe, whichever is greater. The cleanout shall be complete with a flush mount over. The cleanout cover shall be clearly marked “DRAIN” and shall be minimum eight inches in diameter or two inches greater than the cleanout size, whichever is greater. Cleanouts shall include a watertight cap.

2.21 IDENTIFICATION

A. Detectable Underground Warning Tapes: Acid and alkali-resistant polyethylene plastic film warning tape, 6-inches wide by 4-mils minimum thickness, with continuously printed caption in black letters "CAUTION - xxxxx LINE BURIED BELOW." The text and color of the tape shall be as shown in the table below. The tape shall have a metallic core encased in a protective jacket for corrosion protection and be detectable by a metal detector when the tape is buried up to 2.5-feet deep.

Color	Utility
Safety Red	Electric
High Visibility Safety Yellow	Gas, Oil, Steam
Safety Alert Orange	Telephone, Communications, Cable Television
Safety Precaution Blue	Water System, Irrigation
Safety Green	Sanitary Sewer, Storm Sewer
White	Proposed Excavation

PART 3 – EXECUTION

3.1 GENERAL INSTALLATION

A. General: General Locations and Arrangements: Contract Drawings indicate the general location and arrangement of the underground storm drainage system piping. Location and arrangement of piping layout take into account many design considerations. Install the piping as indicated, to the extent practical. Any modifications to the layout of the storm drainage system shall be submitted to the Engineer for review and approval at least five days prior to the start of the affected work.

B. Install piping beginning at low point of systems, true to grades and alignment indicated with unbroken continuity of invert. Place bell ends of piping facing upstream. Install gaskets, seals, sleeves, and couplings in accordance with manufacturer's recommendations, accepted practices, and utility owner's requirements. Maintain swab or drag in line and pull past each joint as it is completed.

C. All pipe shall be laid in the dry. Adequate measures shall be taken to prevent floatation of pipe in the trench.

D. Whenever encountered within the trench, existing abandoned water, sewer, and/or drain lines shall be removed within the trench limits, unless otherwise noted. The remaining portion of the abandoned lines shall be plugged at all open ends.

E. When bell and spigot pipes are used, bell holes shall be dug in the bedding to accommodate the bells. They shall be deep enough to ensure that the bell does not bear on the bottom of the hole but shall be excessively wide in the longitudinal direction of the installation.

F. Use manholes for changes in direction, except where a fitting is indicated. Use fittings for branch connections, except where direct tap into an existing storm drain is indicated.

G. Use proper size increasers, reducers, and couplings, where different size or material of pipes and fittings are connected. Reduction of the size of piping in the direction of flow is prohibited without the written approval of the Engineer.

H. Install piping pitched down in direction of flow as indicated on the Contract Drawings.

I. Extend storm drainage system piping to connect to building drain services, of sizes and in locations indicated on the Contract Drawings.

J. Install piping in accordance with governing authorities having jurisdiction, except where more stringent requirements are indicated.

K. Acceptance of Pipe: Acceptance will be on the basis of tests specified herein before. The quality of all materials used in the pipe, the process of manufacture, and the finished pipe shall be subject to review by the Engineer. Inspection may be made at the place of manufacture, or on the work site after delivery or at both places and the pipe shall be subject to rejection at any time on account of failure to meet any of the specification requirements, even though sample pipe units may have been accepted as satisfactory at the place of manufacture. All pipe which is rejected shall be immediately removed from the project site by the Contractor.

L. Pipe Storage: Pipe sections shall not be stored on areas over the newly laid pipe or other pipelines which might be damaged by the superimposed load, and storage sections shall be restricted to approved areas.

M. Handling Pipe: Each pipe unit shall be handled into its position in the trench only in such manner and by such means, as the Engineer accepts as satisfactory. The Contractor will be required to furnish suitable devices to permit satisfactory support of all parts of the pipe unit when it is lifted.

N. Laying Pipe: Except where a concrete cradle or envelope is required, the pipe shall be laid in a crushed stone cradle. In trenches, no blocking or supporting of the piping by concrete, stones, bricks, wooden wedges, or method other than bedding the pipe on crushed stone will be permitted. Each length of pipe shall be shoved home against the pipe previously laid and

held securely in position. Joints shall not be "pulled" or "cramped" without approval of the Engineer.

O. Jointing Pipe: After the pipe are aligned in the trench and are ready to be jointed, all joint surfaces shall be cleaned.

P. Alignment and Placement: All pipe shall be laid with extreme care as to grade and alignment. Each pipe shall be so laid as to form a close joint with the next adjoining pipe and bring the inverts continuously to the required grade.

1. Stakeout of drain work and setting of line and grade is the responsibility of the Contractor.
2. The Contractor shall establish centerline and offset stakes at each manhole, plus one intermediate centerline and offset stake as a checkpoint between manholes. Laser aligning shall not be used to establish a continuous line in excess of 400-feet.

Q. Cleaning: Care shall be taken to prevent earth, water, and other materials from entering the pipeline. As soon as possible after the pipe and manholes are completed, the Contractor shall clean out the pipeline and manholes being careful to prevent soil, water, and debris from entering any existing drainage system.

1. Place plugs in end of uncompleted conduit at end of day or whenever work stops.
2. Flush lines between manholes to remove collected debris.

R. Review of Completed Storm Drain System: The completed drain system shall be visually inspected by the Owner's Representative. If the visual observation of the completed drain or any part thereof shows any pipe, manhole, or joint to be of defective work or material, the defect shall be replaced or repaired as directed by the Engineer or the Owner's Representative. The Contractor shall coordinate and provide site access for inspection.

3.2 PLACEMENT OF DUCTILE IRON PIPE AND FITTINGS

A. Care shall be taken in loading, transportation, and unloading to prevent injury to the pipe or coatings. Pipe or fittings shall not be dropped. All pipe and fittings shall be examined before placement, and no piece shall be installed which is found to be defective. Any damage to the pipe coatings shall be repaired as directed by the Engineer.

B. If any defective pipe is discovered after it has been placed, it shall be removed and replaced with a sound pipe in a satisfactory manner by the Contractor, at his own expense. All pipe and fittings shall be kept clean until they are used in the work, be thoroughly cleaned before placement, and when placed, shall conform to the lines and grades required. Ductile iron pipe and fittings shall be installed in accordance with requirements of AWWA Standard Specification C600 except as otherwise provided herein. A firm even bearing throughout the length of the pipe shall be constructed by compacting gravel borrow around the pipe and up to the spring line.

1. Blocking will not be permitted.

C. All pipes shall be sound and clean before placement. When pipe laying is not in progress, including lunchtime, the open ends of the pipe shall be temporarily closed by watertight plug or other acceptable means. Alignment shall be maintained during placement. The deflection at joints shall not exceed sixty percent of that recommended by the manufacturer. Fittings, in addition to those shown on the plans, shall be provided, if required, in crossing utilities, which

may be encountered upon opening the trench. Solid sleeves shall be used only where allowed by the Engineer.

D. When cutting pipe is required, the cutting shall be done by machine, leaving a smooth cut at right angles to the axis of the pipe. Cut ends of pipe to be used with a push-on type bell shall be beveled to conform to the manufactured spigot end.

E. The Contractor shall take care not to damage pipe by impact, bending, compression, or abrasion during handling, and installation. Joint ends of pipe especially shall be kept clean.

F. Pipe shall be stored above ground at a height no greater than 5 feet and with even support for the pipe barrel.

G. Only nylon protected slings shall be used for handling the pipe. No hooks, chains or bare cables will be permitted.

H. Gaskets shall be shipped in cartons and stored in a clean area, away from grease, oil, heat, direct sunlight and ozone-producing electric motors.

I. Jointing of ductile iron push on pipe and fittings shall be done in accordance with the printed recommendations of the manufacturer and as specified. The last 8 inches of the outside of the spigot end of pipe and the inside of the bell end of pipe shall be thoroughly cleaned. The joint surfaces and the gasket shall be painted with a lubricant just prior to making up the joint. The spigot end shall then be gently pushed home into the bell. The position of the gasket shall be checked to ensure that the joint has been properly made and is watertight. Care shall be taken not to exceed the manufacturer's recommended maximum deflection allowed for each joint.

1. Jointing Ductile Iron Pipe (Push-On Type): Push-on joints shall be made in strict accordance with the manufacturer's instructions. Pipe shall be laid with bell ends looking ahead. A rubber gasket shall be inserted in the groove of the bell end of the pipe, and the joint surfaces cleaned and lubricated. The plain end of the pipe to be entered shall then be inserted in alignment with the bell of the pipe to which it is to be joined, and pushed home with a jack or by other means. After joining the pipe, a metal feeler shall be used to make certain that the rubber gasket is correctly located.
2. Jointing Mechanical Joint Fittings: Mechanical joints at fittings and where designated shall be installed in accordance with the "Notes on Method of Installation" under ANSI Specification A 21.11 and the instructions of the manufacturer. To assemble the joints in the field, the Contractor shall thoroughly clean the joint surfaces and rubber gasket with soapy water before tightening the bolts. Bolts shall be tight to the specified torque. Under no condition shall extension wrenches or pipes over handles or ordinary ratchet wrenches be used to secure greater leverage.

J. Installation and jointing of ductile iron pipe shall be in accordance with AWWA C600, Sections 9b and 9c, latest revision, as applicable.

K. Ductile iron pipe installed within 5-feet of gas lines shall be fully encased with polyethylene material. Polyethylene shall be 8 millimeters thick and comply with AWWA C 105.

3.3 PVC PIPE

A. General: Install piping in accordance with governing authorities having jurisdiction, except where more stringent requirements are indicated.

B. PIPE HANDLING

1. All pipe and fittings shall be carefully handled from the truck onto the ground and into the trench or excavation so as to prevent damage to the pipe. Pipes shall be kept free of dirt and foreign material, especially on the inside. Joint ends of pipe shall especially be kept clean.
2. Pipe stored on site shall be protected from heat and direct sunlight and shall be suitably ventilated.
3. Pipe or fittings shall not be dropped. All pipe or fittings shall be examined before laying, and no piece shall be installed which is found to be defective.

C. ALIGNMENT AND PLACEMENT OF PVC PIPE

1. Bedding material for the pipe must be installed with care in the area around the pipe. Bedding material must be placed to provide uniform and adequate support under pipe. Do not use blocking to bring pipe up to grade.
2. Provide bell holes at each joint to permit joint to be assembled properly while maintaining uniform pipe support.
3. Place and consolidate the bedding material under the pipe haunch to provide adequate side support while avoiding both vertical and lateral displacement of pipe.
4. Initial backfill must be completed to a point at least 12-inches over the top of the pipe and be hand placed. Use little or no tamping of initial backfill directly over the top of pipe. Compaction methods may be utilized during final backfilling.
5. No length of pipe shall be laid until the proceeding lengths of pipe have been thoroughly embedded in place, to prevent movement or disturbance of the pipe alignment.
6. Full lengths of pipe shall be used in the installation except that partial lengths may be used at the entrance to structures, and to accommodate the required locations of service connection fittings.
7. Pipe entrances to structures shall be cut flush with the inside face of the structure, and cut ends of the pipe surface within the structure shall be properly rounded and finished so that there will be no protrusion, ragged edges or imperfections that will impede or affect the hydraulic characteristics of the sewage flow. The method of cutting and finishing shall be subject to the approval of the Engineer.
8. The Contractor shall protect the installation at all times during construction. The movement of construction equipment, vehicles and loads over and adjacent to any pipe shall be performed at the Contractor’s own risk.
9. Drain pipes shall be laid to the required grades by use of a laser and target system, unless otherwise specifically approved by the Engineer.
10. Jointing of PVC drain pipe and fittings shall be done in accordance with the printed recommendations of the manufacturer and as specified. The bell end of the pipe shall be thoroughly cleaned. The joint surfaces and the gasket shall be lubricated prior to making up the joint. The position of the gasket shall be checked to ensure the joint has been properly made and is watertight. Care shall be taken not to exceed the manufacturer's recommended maximum deflection allowed for each joint.
11. PVC pipe shall be pushed home by hand or with the use of bar and block. The use of power equipment, such as a backhoe bucket, is not acceptable.
12. Field-cut pipe ends shall be cut square and the pipe surface beveled to the size and shape of a factory-finished beveled end. All sharp edges shall be rounded off.

3.4 INSTALLATION OF REINFORCED CONCRETE PIPE AND PIPE FITTINGS

A. General: Install piping in accordance with ASTM D2321, the governing authorities having jurisdiction over the utility, and the manufacturer's instructions, except where more stringent requirements are required by the Contract Documents.

B. Acceptance of Pipe: Acceptance will be on the basis of tests specified hereinbefore. The quality of all materials used in the pipe, the process of manufacture, and the finished pipe shall be subject to review by the Engineer. Inspection may be made at the place of manufacture, or on the work site after delivery or at both places and the pipe shall be subject to rejection at any time on account of failure to meet any of the specification requirements, even though sample pipe units may have been accepted as satisfactory at the place of manufacture. All pipe which is rejected shall be immediately removed from the project site by the Contractor at no cost to the Owner.

C. Pipe Storage: Pipe sections shall not be stored on areas over the newly laid pipe or other pipelines which might be damaged by the superimposed load, and storage sections shall be restricted to approved areas.

D. Laying Pipe: Except where a concrete cradle or envelope is required, the pipe shall be laid in a crushed stone cradle. In trenches, no blocking or supporting of the piping by concrete, stones, bricks, wooden wedges, or method other than bedding the pipe on crushed stone will be permitted. Each length of pipe shall be shoved home against the pipe previously laid and held securely in position. Joints shall not be "pulled" or "cramped" without approval of the Engineer.

E. Jointing Pipe: After the pipes are aligned in the trench and are ready to be jointed, all joint surfaces shall be cleaned.

F. Alignment and Placement: All pipes shall be laid with extreme care as to grade and alignment. Each pipe shall be so laid as to form a close joint with the next adjoining pipe and bring the inverts continuously to the required grade.

1. Stakeout of drain work and setting of line and grade is the responsibility of the Contractor.
2. The Contractor shall establish centerline and offset stakes at each manhole, plus intermediate centerline and offset stakes as needed to ensure proper alignment and grade. Laser aligning shall not be used to establish a continuous line in excess of 400-feet.

G. Cleaning: Care shall be taken to prevent earth, water, and other materials from entering the pipeline. As soon as possible after the pipe and manholes are completed, the Contractor shall clean out the pipeline and manholes being careful to prevent soil, water, and debris from entering any existing Drain.

1. Place plugs in end of uncompleted conduit at end of day, or whenever work stops.
2. Flush lines between manholes to remove collected debris.

H. Review of Completed Reinforced Concrete Pipe System: If the visual observation of the completed drain or any part thereof shows any pipe, manhole, or joint to be of defective work or material the defect shall be replaced or repaired as directed at no cost to the Owner. The visual observation shall be conducted by the Engineer and any defects shall be as identified by such. The Contractor shall coordinate and provide site access for the Owner.

3.5 INSTALLATION OF CORRUGATED POLYETHYLENE PIPE AND PIPE FITTINGS

A. General: Install Corrugated Polyethylene Pipe in accordance with ASTM D2321 and governing authorities having jurisdiction, except where more stringent requirements are indicated.

B. Acceptance of Pipe: Acceptance will be on the basis of tests specified herein before. The quality of all materials used in the pipe, the process of manufacture, and the finished pipe shall be subject to review by the Engineer. Inspection may be made at the place of manufacture, or on the work site after delivery or at both places and the pipe shall be subject to rejection at any time on account of failure to meet any of the specification requirements, even though sample pipe units may have been accepted as satisfactory at the place of manufacture. All pipe which is rejected shall be immediately removed from the project site by the Contractor.

C. Pipe Storage: Pipe sections shall not be stored on areas over the newly placed pipe or other pipelines which might be damaged by the superimposed load, and storage sections shall be restricted to approved areas.

D. Handling Pipe: Each pipe unit shall be handled into its position in the trench only in such manner and by such means, as the Engineer accepts as satisfactory. The Contractor will be required to furnish suitable devices to permit satisfactory support of all parts of the pipe unit when it is lifted.

E. Alignment and Placement: All pipe shall be placed with extreme care as to grade and alignment. Each pipe shall be so placed as to form a close joint with the next adjoining pipe and bring the inverts continuously to the required grade.

1. Stakeout of drain work and setting of line and grade is the responsibility of the Contractor.
2. The Contractor shall establish centerline and offset stakes at each manhole, plus intermediate centerline and offset stake as needed to ensure proper alignment and grade between manholes. Laser aligning shall not be used to establish a continuous line in excess of 400-feet.
3. Bedding material for the pipe must be installed with care in the area around the pipe. Bedding material must be placed to provide uniform and adequate support under pipe. Do not use blocking to bring pipe up to grade. Bedding shall be crushed stone.
4. Provide bell holes at each joint to permit joint to be assembled properly while maintaining uniform pipe support.
5. Place and consolidate the bedding material under the pipe haunch to provide adequate side support while avoiding both vertical and lateral displacement of pipe.
6. Initial backfill must be completed to a point at least 12-inches over the top of the pipe and be hand placed. Use little or no tamping of initial backfill directly over the top of pipe. Compaction methods may be utilized during final backfilling.
7. No length of pipe shall be laid until the proceeding lengths of pipe have been thoroughly embedded in place, to prevent movement or disturbance of the pipe alignment.
8. Full lengths of pipe shall be used in the installation except that partial lengths may be used at the entrance to structures, and to accommodate the required locations of service connection fittings.

9. Pipe entrances to structures shall be cut flush with the inside face of the structure, and cut ends of the pipe surface within the structure shall be properly finished so that there will be no protrusion, ragged edges or imperfections that will impede or affect the hydraulic characteristics of the stormwater flow. The method of cutting and finishing shall be subject to the approval of the Engineer.
10. The Contractor shall protect the installation at all times during construction. The movement of construction equipment, vehicles and loads over and adjacent to any pipe shall be performed at the Contractor's own risk.
11. Jointing of pipe and fittings shall be done in accordance with the printed recommendations of the manufacturer and as specified. The bell end of the pipe shall be thoroughly cleaned. The joint surfaces and the gasket shall be lubricated prior to making up the joint. The position of the gasket shall be checked to ensure the joint has been properly made and is watertight. Care shall be taken not to exceed the manufacturer's recommended maximum deflection allowed for each joint.
12. Each length of pipe shall be pushed home by hand or with the use of bar and block. The use of power equipment, such as a backhoe bucket, is not acceptable.
13. Field-cut pipe ends shall be cut square.

3.6 INSTALLATION OF DRAIN MANHOLES AND CATCH BASINS

A. The bases shall be supported on a compacted level foundation of gravel borrow a minimum of 12 inches thick. Crushed stone may be substituted for gravel borrow if field conditions at the bottom of the excavation are wet.

1. The Contractor shall install the manholes and catch basins as soon as the pipe laying reaches the location of the structures.
2. The Contractor shall accurately locate each manhole and catch basin and set accurate templates to conform to the required line and grade. Any manhole or catch basin which is not installed in the correct location or oriented improperly shall be removed and rebuilt in its proper location, alignment, and orientation at no additional cost to the Owner.
3. Manhole risers and tops shall be installed using approved butyl rubber sealant or rubber gasket for sealing joints of manhole risers and tops; jointing shall be performed in accordance with the manufacturer's recommendations. Manhole risers and tops shall be installed level and plumb. Water shall not be permitted to rise over newly made joints, nor until after inspection as to their acceptability. All jointing shall be done in a manner to ensure watertight joints.
4. Openings shall be provided in the precast concrete manhole sections to receive entering pipes and these openings shall be made at the place of manufacture. Pipe entrances at catch basins shall have plain beveled openings to accept 8-inch DR18 PVC with an 8-inch green trap 2-piece lock joint set in mortar. Grout mixture shall follow instructions provided by manufacturer. Pipe connections at drain manholes shall be made as indicated on the Drawings with either non-shrink grout or integral flexible rubber sleeves and Corrugated Pipe Adapters designed for use with the pipe and sleeves. For grouted joints, surface between pipe and wall shall be completely filled with non-shrink grout and trowelled to provide a smooth surface conforming to both the outside and inside structure wall.
5. Care shall be taken to ensure that the openings are made to permit setting of the entering pipe at its correct elevation as indicated or directed. Manhole risers and tops shall be installed so that the manhole steps shall be in alignment.
6. All holes used for handling shall be thoroughly plugged with non-shrink grout.
7. Cutting or tampering in the field, for purpose of creating new sidewall openings or altering existing openings, will not be permitted except at the discretion of the Engineer or if necessary concrete block manhole(s) shall be used.

8. All interior manhole joints where the sealing material is not flush with the inside wall shall be grouted with non-shrink mortar and finished by hand/wet-brush.
9. A cast-in-place concrete invert shelf and channel shall be poured and shaped to the lower half of the pipes.
10. Clean all debris, mortar, and soil from the bottom of all structures prior to final acceptance of the project.

3.7 SETTING MANHOLE FRAMES AND COVERS AND CATCH BASIN FRAMES AND GRATES

A. Manhole and catch basin frames shall be set with tops conforming accurately to the grade of the pavement or finished ground surface or as indicated on the Contract Drawings or as directed.

B. Brick shall be used to bring the frames to the required elevation.

1. Frames shall be set centered with the opening in the top of the precast structure on a minimum 12 inches of brick in a full bed of mortar. A thick ring of mortar extending to the outer edge of brick or concrete shall be placed all around the bottom flange of the cast iron frame. The mortar shall be smoothly finished to a height of 5 inches above the flange for 8-inch frames and sloped to shed water away from the frame.
2. Completed brick installation shall be coated with mortar at least a ¾ inch thick on the outside to provide a fully sealed and watertight collar between the top manhole section and the cover frame.
3. Only clean bricks shall be used in brickwork to adjust frame elevations. The brick shall be moistened by suitable means.

C. Manhole covers shall be left in place in the frame until completion of other work at the manholes.

D. Where directed, the castings shall be temporarily set at such grades as to provide drainage during construction. The castings of structures located within the pavement area shall not be completely set to the established grade until the bottom course of pavement has been laid. The final set of all other castings shall be performed at the proper stage of construction.

3.8 CHANGE IN TYPE

A. When an existing catch basin is to be converted to a manhole, the frame and grate shall be carefully removed and a new frame and cover installed to finish grade. If in the opinion of the Engineer the existing casting is reusable, it may be reused in the work, otherwise, it shall be disposed of off-site.

1. The sump of the catch basin shall be thoroughly cleaned of debris and silt and the interior surfaces brushed to remove contaminants.
2. The sump shall be thoroughly filled with compacted gravel to a level no greater than 6 inches below the pipe invert. A cast-in-place concrete invert shelf and channel shall be poured and shaped to the lower half of the pipes.
3. New openings in existing structures shall be carefully cut with power saws of the proper size and elevation to accept the new connection. Damage to the structure caused by the Contractor’s construction methods shall be repaired at no additional cost.

3.9 STRUCTURE REBUILT

A. When in the opinion of the Engineer existing masonry structure walls show deterioration, the structure shall be rebuilt. The casting and deteriorated masonry shall be removed in a careful and neat manner until only a sound condition remains. Concrete blocks shall be used to rebuild the structure. The new masonry construction, replacing of the casting, and other incidental work shall be performed as specified above.

1. The Contractor's base bid shall include rebuilding 10 vertical linear feet of existing manhole or catch basin structures.

3.10 INSTALLATION OF WATER QUALITY STRUCTURES

A. Contractor shall take appropriate action to protect all structure components throughout the installation and construction process. Care shall be taken in loading, transporting, and unloading to prevent damage to materials during storage and handling.

B. Install water quality structures per manufacturer's specifications.

C. The installation of a precast concrete structure should conform to ASTM C 891 for the construction of manholes.

D. The precast concrete structure shall be installed in sections in the following sequence:

1. Aggregate Base: Structure shall be supported on a compacted level foundation of gravel borrow or crushed stone a minimum of 12 inches thick.
2. Base Slab
3. Treatment chamber section(s)
4. Transition slab (if required)
5. Bypass Section
6. Connect inlet and outlet pipes
7. Riser section and/or transition slab (if required)
8. Maintenance rider section(s) (if required)
9. Frame and access cover

E. The precast base shall be placed level at the specified grade. The entire base should be in contact with the underlying compacted granular material. Subsequent sections, complete with joint seals, shall be installed in accordance with the precast concrete manufacturer's installation requirements.

F. Adjustment of the stormwater quality treatment structure can be performed by lifting the upper sections free of the excavated area, re-leveling the base, and re-installing the sections. Damaged sections and gaskets shall be repaired or replaced as necessary. Once the stormwater quality treatment structure has been constructed, any lift holes shall be plugged watertight with mortar or non-shrink grout.

G. Internal components requiring field installation shall be installed by the Contractor in accordance with the manufacturer's specifications and installation requirements.

H. Inlet and outlet pipes should be securely set into the structure using approved pipe seals (flexible boot connections) so that the structure is watertight.

I. Grade rings shall be installed to set the frame and cover at the required elevation. The grade rings shall be laid in a full bed of mortar with successive units being joined using sealant recommended by the manufacturer. Frames for the cover shall be set in a full bed of mortar at the elevation specified.

J. If precast tank sections are to be field assembled, adequate waterproofing shall be used at the joint to resist the waterhead at that joint.

3.11 INSTALLATION OF PRECAST CONCRETE TANKS AND VAULTS

A. The bases shall be supported on a compacted level foundation of gravel borrow a minimum of 12 inches thick. Crushed stone may be substituted for gravel borrow if field conditions at the bottom of the excavation are wet.

B. The precast base shall be placed level at the specified grade. The entire base should be in contact with the underlying compacted granular material. Subsequent sections, complete with joint seals, shall be installed in accordance with the precast concrete manufacturer's recommendations. Structure sections shall be installed level and plumb. Water shall not be permitted to rise over newly made joints, nor until after inspection as to their acceptability. All jointing shall be done in a manner to ensure watertight joints.

C. Adjustment of the structure can be performed by lifting the upper sections free of the excavated area, re-leveling the base, and re-installing the sections. Damaged sections and gaskets shall be repaired or replaced as necessary. Once the structure has been constructed, any lift holes shall be plugged watertight with mortar or non-shrink grout. Any precast structure which is not installed in the correct location or oriented improperly shall be removed and rebuilt in its proper location, alignment, and orientation at no additional cost to the Owner.

D. Inlet and outlet pipes should be securely set into the structure using approved pipe seals (flexible boot connections, where applicable) so that the structure is watertight. Care shall be taken to ensure that the openings are made to permit setting of the entering pipe at its correct elevation as indicated or directed. Cutting or tampering in the field, for purpose of creating new sidewall openings or altering existing openings, will not be permitted.

E. Grade rings shall be installed to set the frame and cover at the required elevation. The grade rings shall be laid in a full bed of mortar with successive units being joined using sealant recommended by the manufacturer. Frames for the cover shall be set in a full bed of mortar at the elevation specified.

F. Clean all debris, mortar, and soil from the bottom of all structures prior to final acceptance of the project.

3.12 AREA DRAINS

A. Install area drains per manufacturer specifications.

B. The specified PVC surface drainage inlet shall be installed using conventional flexible pipe backfill materials and procedures. The backfill material shall be crushed stone or other granular material meeting the requirements of class 2 material as defined in ASTM D2321. Bedding and backfill for surface drainage inlets shall be placed and compacted uniformly in accordance with ASTM D2321. The drain basin body will be cut at the time of the final grade. No brick, stone or concrete block will be required to set the grate to the final grade height.

C. For H-20 load rated installations, a concrete ring shall be poured under and around the grate and frame as indicated on the Drawings.

3.13 INLINE DRAINS

A. The specified PVC surface drainage inlet shall be installed using conventional flexible pipe backfill materials and procedures. The backfill material shall be crushed stone or other granular material meeting the requirements of class 1 or class 2 material as defined in ASTM D2321. Bedding and backfill for surface drainage inlets shall be well placed and compacted uniformly in accordance with ASTM D2321. The drain basin body will be cut at the time of the final grade. No brick stone or concrete block will be required to set the grate to the final grade height. For H-20 load rated installations, a concrete ring will be poured under and around the grate and frame. The concrete slab must be designed taking into consideration local soil conditions, traffic loading, and other applicable design factors. For other installation considerations such as migration of fines, groundwater, and soft foundations refer to ASTM D2321 guidelines.

3.14 TRENCH DRAINS

A. Install trench drain structures per manufacturer specifications.

3.15 DRAIN COUPLINGS

A. Couplings which are factory manufactured shall be installed at all connections from existing pipe to proposed pipe unless the existing pipe is the same material as the proposed pipe and the bell and spigot end of the pipes to be connected are compatible and free from defects. All drain couplings shall be installed in accordance with the manufacturer's recommendations for the types of pipe to be connected.

3.16 SUBSURFACE INFILTRATION CHAMBERS

A. Install chambers, bedding, and inspection ports per manufacturer specifications.

3.17 CLEANOUTS

A. Install cleanouts and extensions from drain pipe to cleanout at grade as indicated on the Contract Drawings. Set cleanout frame and cover in concrete 18 by 18 by 6-inches deep, except where location is in bituminous or concrete paving. Set top of cleanout 1-inch above surrounding earth grade or flush with grade when installed in paving.

3.18 TAP CONNECTIONS

A. Make connections to existing underground drainage structures, so that finished work will conform as nearly as practicable to requirements specified for new work. The contractor shall verify the location, size, invert, and type of existing pipes at all points of connection prior to making the connections.

B. Make branch connections from side into existing piping by installing a wye or T-wyes, and couplings manufactured for use with the same type of pipe as indicated on the Contract Drawings. The Contractor shall install a 45-degree wye branch or 90-degree tee fittings in the drain pipe at all locations where storm service pipe connections are shown on the Drawings. Connections of the storm service pipes shall be made into the wye branches or tees by means of 45-degree bends. The connections shall be made thoroughly watertight

and concrete shall be placed under each connection to bear on undisturbed earth and firmly support the connection.

C. Protect existing piping and structures to prevent concrete or debris from entering while making tap connections. Remove debris, concrete, or other extraneous material that may accumulate.

D. Connections into existing drainage facilities shall be performed in accordance with the requirements of the City of Worcester. The Contractor shall comply with all such requirements, including securing of all required permits and paying the costs thereof.

3.19 BACKFILLING

A. General: Conduct excavation and backfill operations for structure and pipe installations in accordance with Section 312000 – EARTH MOVING, local requirements, and the contract documents.

B. Initial backfill shall be placed evenly on both sides of the pipe to distribute the load and not to cause movement or deflection of the pipe.

3.20 INSTALLATION OF IDENTIFICATION

A. Install continuous plastic underground warning tape during back-filling of trench for underground storm drainage system piping. Locate tape two-feet below finished grade, directly over piping.

3.21 FIELD TESTING OF CORRUGATED POLYETHYLENE PIPING

A. The pipe shall be cleaned and visually inspected for offsets and obstructions prior to testing.

B. The total length of each pipe installed on the project shall be tested or inspected for deflection. Conveyance pipes connecting at both ends to concrete drainage structures (catch basins, manholes, outlet control structures, water quality structures, etc.) shall be mandrel tested. Deflection of pipes used for stormwater detention/retention/infiltration systems, and pipes connecting to wye connections, building connections, trench drains, and other connections that do not allow mandrel testing shall be verified by visual inspection by the Owner's Representative during installation.

C. Mandrel tests shall be performed by the Contractor and observed by the Owner's Representative not sooner than 20 days after completion of installation and compaction of backfill. Testing for pipes greater than 24-inch in diameter shall be tested prior to the installation of drainage structure cone and frame.

D. Installed pipe shall be tested to ensure that the maximum deflection of the pipe does not exceed 7.5 percent of its base inside diameter. The base inside diameter is defined as the specified nominal diameter minus the allowable inside diameter tolerance of 1.5% but not more than 1/2 inch.

E. A mandrel shall be pulled through the pipe by hand to ensure that maximum allowable deflections have not been exceeded. The mandrel diameter shall be verified and approved by the Owner's Representative prior to use. Use of an unapproved mandrel will invalidate the test. If the mandrel fails to pass through the pipe, the pipe will be deemed to be over-deflected.

F. The mandrel shall be a rigid device, with an odd number of legs (9 legs minimum) having an effective length not less than its nominal diameter. The mandrel shall be fabricated of steel with pulling rings at each end.

G. The minimum diameters at any point along the full length are as follows:

Nominal Size	Minimum Mandrel Diameter
6”	5.3”
8”	7.0”
10”	8.8”
12”	10.6”
15”	13.2”
18”	15.8”
24”	21.1”
30”	26.4”
36”	31.7”
42”	37.0”
48”	42.2”
54”	47.5”
60”	52.8”

3.22 FIELD QUALITY CONTROL

A. Testing: Perform testing of completed piping in accordance with local authorities having jurisdiction.

B. Video Inspections: Seven days after the completion of the backfilling of each section of new pipe, as defined as a length of pipe between two manholes, the Contractor will provide a televised inspection of the pipe to be submitted to the Designer. The Owner’s Representative shall be present during the recording. The recording shall be in DVD color format with audio and will show a clear picture of the inside of the new pipe. If the Designer determines that the DVD is unacceptable for review the contractor shall re-televise the line until an acceptable DVD has been submitted. In the event that the pipe is not acceptable for any reason relating to the proper construction of the pipe according to these specifications, the Contractor will be responsible to re-excavate and repair the defects to the satisfaction of the Designer at no additional cost.

C. Cleaning: Clear interior of piping and structures of dirt and other superfluous material as work progresses. Maintain swab or drag in piping and pull past each joint as it is completed.

1. In large, accessible piping, brushes and brooms may be used for cleaning.
2. Place watertight plugs in ends of uncompleted pipe at end of day or whenever work stops. If water is in the trench when work is resumed, the plug shall not be removed until the trench has been dewatered and all danger of water entering the pipe eliminated.
3. Flush piping between manholes to remove collected debris.

D. Interior Inspection: If deemed necessary by the Owner’s Representative, inspect piping to determine whether line displacement or other damage has occurred.

1. Make inspections after pipe between manholes has been installed and approximately 2 feet of backfill is in place, and again at completion of project.

2. If inspection indicates poor alignment, debris, displaced pipe, infiltration or other defects, the Contractor shall correct such defects and reinspect.

E. Prior to acceptance of the storm drainage system, the Contractor shall submit the following to the Architect and to the local authority:

1. System As-Built Plan stamped by a Professional Land Surveyor or Engineer Registered in the Commonwealth of Massachusetts.
2. Video inspection DVDs and report: The report shall document the observations of the video inspections.
3. Deflection test report: The report shall fully describe the test procedures and list the test results. The report shall be signed by the Contractor's superintendent.

3.23 FINAL INSPECTION

A. Final inspection and acceptance of the storm drainage system shall be made by the Owner's Representative and the utility owner having jurisdiction over the particular system.

B. Prior to placing the systems in service, all components shall be inspected, with the Owner's Representative present, to ensure that no debris or other contaminants are present. If necessary, the Contractor shall clean the structures and flush piping.

C. The Contractor is responsible for coordinating and scheduling the inspection of the work by local jurisdictional authorities. No additional payment will be made for inspections and permits required in the performance of the work.

End of Section