CleaverBrooks®

Model 4WG

Packaged Boiler

100 to 800 HP Steam and Hot Water
Fuel: Light Oil, Gas or Combination

Operation, Service, and Parts Manual

750-212
12/2013

⚠WARNING

If the information in this manual is not followed exactly, a fire or explosion may result causing property damage, personal injury or loss of life.

— Do not store or use gasoline or other flammable vapors and liquids in the vicinity of this or any other appliance.

— WHAT TO DO IF YOU SMELL GAS

- Do not try to light any appliance.
- Do not touch any electrical switch; do not use any phone in your building.
- Immediately call your gas supplier from a neighbor's phone. Follow the gas supplier's instructions.
- If you cannot reach your gas supplier, call the fire department.

— Installation and service must be performed by a qualified Cleaver-Brooks, service agency or the gas supplier.

⚠WARNING

To minimize the possibility of serious personal injury, fire or damage to the equipment, never violate the following safety rules.

— Always keep the area around the boiler free of combustible materials, gasoline, and other flammable liquids and vapors

— Never cover the boiler, lean anything against it, stand on it, or in any way block the flow of fresh air to the boiler.

Notice

Where required by the authority having jurisdiction, the installation must conform to the Standard for Controls and Safety Devices for Automatically Fired Boilers, ANSI/ASME CSD-1.

⚠WARNING

Improper installation, adjustment, service, or maintenance can cause equipment damage, personal injury, or death. Refer to the Operation and Maintenance manual provided with the boiler. Installation and service must be performed by a qualified Cleaver-Brooks service provid-

⚠WARNING

Be sure the fuel supply which the boiler was designed to operate on is the same type as specified on the boiler name plate.

⚠WARNING

Should overheating occur or the gas supply valve fail to shut off, **do not** turn off or disconnect the electrical supply to the boiler. Instead turn off the gas supply at a location external to the boiler.

⚠WARNING

Do not use this boiler if any part has been under water. Immediately call your Cleaver-Brooks service representative to inspect the boiler and to replace any part of the control system and any gas control which has been under water.

Notice

This manual must be maintained in legible condition and kept adjacent to the boiler or in a safe place for future reference. Contact your local Cleaver-Brooks representative if additional manuals are required.

⚠ WARNING

The boiler and its individual shutoff valve must be disconnected from the gas supply piping system during any pressure testing of that system at test pressures in excess of 1/2 psi (3.5 kPa).

⚠ WARNING

The installation must conform to the requirements of the authority having jurisdiction or, in the absence of such requirements, to UL 795 Commercial-Industrial Gas Heating Equipment and/or the National Fuel Gas Code, ANSI Z223.1

TO: Owners, Operators and/or Maintenance Personnel

This operating manual presents information that will help to properly operate and care for the equipment. Study its contents carefully. The unit will provide good service and continued operation if proper operating and maintenance instructions are followed. No attempt should be made to operate the unit until the principles of operation and all of the components are thoroughly understood. Failure to follow all applicable instructions and warnings may result in severe personal injury or death.

It is the responsibility of the owner to train and advise not only his or her personnel, but the contractors' personnel who are servicing, repairing or operating the equipment, in all safety aspects.

Cleaver-Brooks equipment is designed and engineered to give long life and excellent service on the job. The electrical and mechanical devices supplied as part of the unit were chosen because of their known ability to perform; however, proper operating techniques and maintenance procedures must be followed at all times. Although these components afford a high degree of protection and safety, operation of equipment is not to be considered free from all dangers and hazards inherent in handling and firing of fuel.

Any "automatic" features included in the design do not relieve the attendant of any responsibility. Such features merely free him of certain repetitive chores and give him more time to devote to the proper upkeep of equipment.

It is solely the operator's responsibility to properly operate and maintain the equipment. No amount of written instructions can replace intelligent thinking and reasoning and this manual is not intended to relieve the operating personnel of the responsibility for proper operation. On the other hand, a thorough understanding of this manual is required before attempting to operate, maintain, service, or repair this equipment.

Because of state, local, or other applicable codes, there are a variety of electric controls and safety devices which vary considerably from one boiler to another. This manual contains information designed to show how a basic burner operates.

Operating controls will normally function for long periods of time and we have found that some operators become lax in their daily or monthly testing, assuming that normal operation will continue indefinitely. Malfunctions of controls lead to uneconomical operation and damage and, in most cases, these conditions can be traced directly to carelessness and deficiencies in testing and maintenance.

It is recommended that a boiler room log or record be maintained. Recording of daily, weekly, monthly and yearly maintenance activities and recording of any unusual operation will serve as a valuable guide to any necessary investigation. Most instances of major boiler damage are the result of operation with low water. We cannot emphasize too strongly the need for the operator to periodically check his low water controls and to follow good maintenance and testing practices. Cross-connecting piping to low water devices must be internally inspected periodically to guard against any stoppages which could obstruct the free flow of water to the low water devices. Float bowls of these controls must be inspected frequently to check for the presence of foreign substances that would impede float ball movement.

The waterside condition of the pressure vessel is of extreme importance. Waterside surfaces should be inspected frequently to check for the presence of any mud, sludge, scale or corrosion.

It is essential to obtain the services of a qualified water treating company or a water consultant to recommend the proper boiler water treating practices.

The operation of this equipment by the owner and his or her operating personnel must comply with all requirements or regulations of his insurance company and/or other authority having jurisdiction. In the event of any conflict or inconsistency between such requirements and the warnings or instructions contained herein, please contact Cleaver-Brooks before proceeding.

CONTENTS

CHAPTER 1

Basics of Firetube Operation

1.1 — Introduction

Firetube boilers are available for low or high pressure steam, or for hot water applications. Firetube boilers are typically used for applications ranging from 15 to 1500 horsepower. A firetube boiler is a cylindrical vessel with horizontal tubes passing through and connected to the front and rear tube sheets. The 4WG boiler utilizes a Water-Back design with a rear access way for cleaning and maintenance of the furnace and second pass tubes. The vessel contains the water and absorbs the energy generated from the flame. The front door and rear door provide the seal to contain the hot combustion gasses. Baffles designed into the doors serve to redirect the combustion gasses through the various firetube passages. The flame originates in the furnace. As the combustion gasses travel down the furnace and through the various firetube channels, heat from the flame and combustion gasses is transferred to the water.

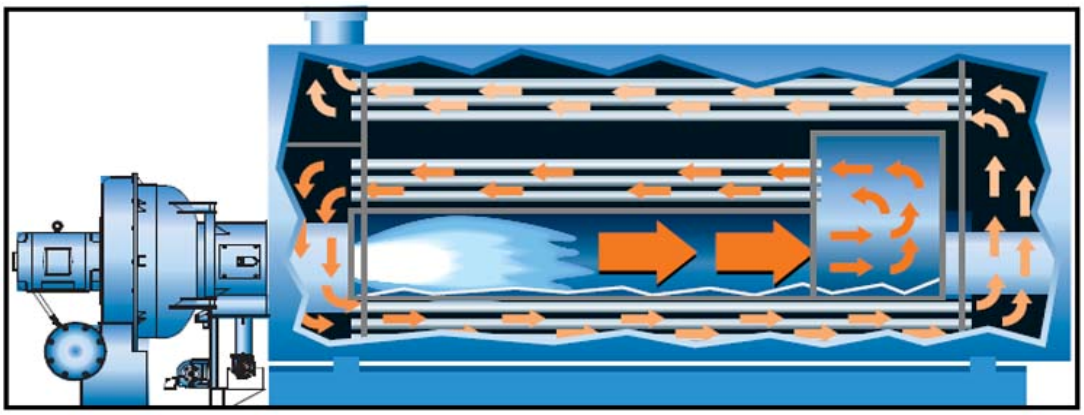


FIGURE 1-1. Firetube Passages

Transferred energy develops into the required steam or hot water. The primary purpose of the boiler is to supply energy to the facility's operations — for heat, manufacturing processes, laundry, kitchen, etc. The nature of the facility's operation will dictate whether a steam or hot water boiler should be used.

The general information in this manual applies to the Cleaver-Brooks 4WG line of boilers in sizes ranging from 100 through 800 boiler horsepower for the following fuels:

Series 100	Light Oil (No. 2)
Series 200	Light Oil (No. 2) or Gas
Series 700	Gas Only

Rated Capacity	100 through 800 HP
Operating Pressure	Steam: 15 - 270 psig Hot Water: 30 - 125 psig
Fuel	Light Oil or Gas or Combination
Ignition	Automatic
Firing 100 - 800 hp	Full Modulation
Burner (Gas)	Non-premix, Orificed Type
Air Shutter	Rotary Damper (Electrically Modulated)
Steam Trim	ASME Code
Water Trim	ASME Code

Always order genuine Cleaver-Brooks parts from your local Cleaver-Brooks authorized representative.

The boiler and related equipment installation are to be in compliance with the standards of the National Board of Fire Underwriters. Installation should also conform to state and local codes governing such equipment. Prior to installation, the proper authorities having jurisdiction are to be consulted, permits obtained, etc. All boilers in the 4WG series comply, when equipped with optional equipment, to Industrial Risk Insurers (IRI), Factory Mutual (FM), or other insuring underwriters' requirements.

1.2 — The Boiler

The 4WG boiler is a packaged firetube boiler of welded steel construction and consists of a pressure vessel, burner, burner controls, burner accessories, refractory, and appropriate boiler trim.

The horsepower rating of the boiler is indicated by the numbers following the fuel series. Thus, 4WG 700-250 indicates a gas-fired 250 HP boiler.

The firetube construction provides some characteristics that differentiate it from other boiler types. Because of its vessel size, the firetube contains a large amount of water, allowing it to respond to load changes with minimum variation in steam pressure.

Firetube boilers are rated in boiler horsepower (BHP), which should not be confused with other horsepower measurements.

Hot water is commonly used in heating application with the boiler supplying water to the system at 180º F to 220º F. The operating pressure for hot water heating system usually is 30 psig to 125 psig. The various tube sets and baffles allow the gas to travel through the boiler, thereby transferring the energy into the waterside to generate steam or hot water.

FIGURE 1-2. 4WG Boiler (configurations may vary)

Steam boilers are designed for low pressure or high pressure applications. Low pressure boilers are limited to 15 psig design, and are typically used for heating applications. High pressure boilers are typically used for process loads and can have a design pressure of 75 to 300 psig.

Steam and hot water boilers are defined according to design pressure and operating pressure. Design pressure is the maximum pressure used in the design of the boiler for the purpose of calculating the minimum permissible thickness or physical characteristics of the pressure vessel parts of the boiler. Typically, the safety valves are set at or below design pressure. Operating pressure is the pressure of the boiler at which it normally operates. The operating pressure usually is maintained at a suitable level below the setting of the pressure relieving valve(s) to prevent their frequent opening during normal operation.

The type of service that your boiler is required to provide has an important bearing on the amount of waterside care it will require.

⚠ Caution

Waterside care is of prime importance. For specific information or assistance with your water treatment requirements, contact your Cleaver-Brooks service and parts representative or your local water treatment professional. Failure to follow these instructions could result in equipment damage.

Feedwater equipment should be checked and ready for use. Be sure that all valves, piping, boiler feed pumps, and receivers are installed in accordance with prevailing codes and practices.

Water requirements for both steam and hot water boilers are essential to boiler life and length of service. Constant attention to water requirements will pay dividends in the form of longer life, less downtime, and prevention of costly repairs. Care taken in placing the pressure vessel into initial service is vital. The waterside of new boilers and new or remodeled steam or hot water systems may contain oil, grease or other foreign matter. A method of boiling out the vessel to remove accumulations is described in Chapter 2.

The operator should be familiar with Chapter 2 before attempting to place the unit into operation.

1.3 — Construction

Steam boilers designed for operating at 15 psig and hot water boilers designed for 250º F at 125 psi or less are constructed in accordance with Section VI, Heating Boilers, of ASME Code.

FIGURE 1-3. Boiler Construction

Steam boilers designed for operating pressures exceeding 15 psig are constructed in accordance with Section I, Power Boilers, of the ASME Code. Hot water boilers designed for operating temperatures above 250º F or 125 psi are likewise built to Section I of the ASME Code.

1.4 — Steam Controls (All Fuels)

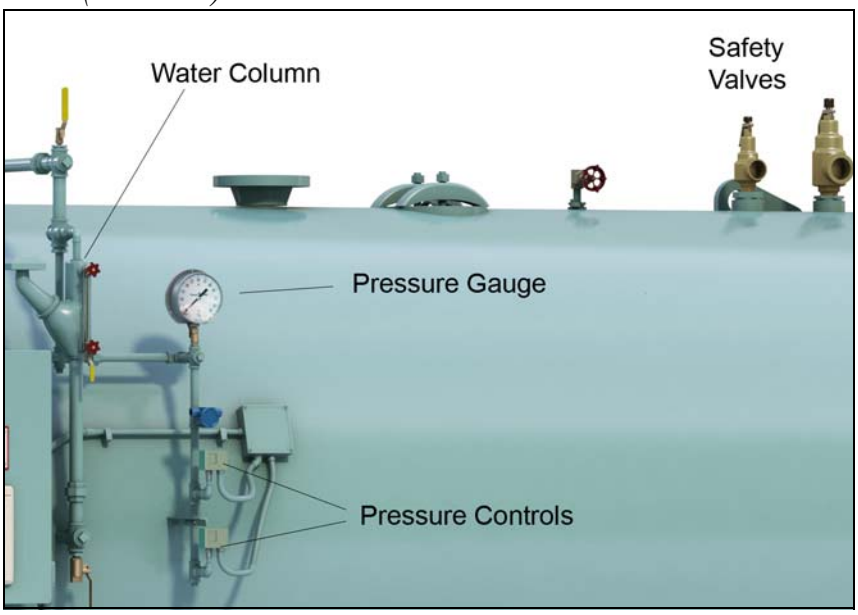


FIGURE 1-4. Boiler Controls (configurations may vary)

Control	Description
Operating Limit Pressure Control	Breaks a circuit to stop burner operation on a rise of boiler pressure at a selected setting. It is adjusted to stop or start the burner at a preselected pressure setting.
High Limit Pressure Control	Breaks a circuit to stop burner operation on a rise of pressure above a selected setting. It is adjusted to stop the burner at a preselected pressure above the operating limit control setting. The high limit pressure control is normally equipped with a manual reset.
Modulating Pressure Control	Senses changing boiler pressures and transmits the information to the modulating motor to change the burner firing rate when the manual-automatic switch is set on "automatic." On boilers with a Cleaver-Brooks Hawk control system, firing rate modulation is accomplished in the PLC.
Low Water Cutoff and Pump Control	Float operated control responds to the water level in the boiler. It performs two distinct functions: A. Stops firing of the burner if water level lowers below the safe operating point. Energizes the low-water light in the control panel. It also causes the low-water alarm bell (optional equipment) to ring. Code requirements of some models require a manual reset type of low water cutoff. B. Starts and stops the feedwater pump (if used) to maintain water at the proper operating level.
Water Column Assembly	Houses the low water cutoff and pump control and includes the gauge glass and gauge glass shutoff cocks.

Control	Description
Water Column Drain Valve	Provided so that the water column and its piping can be flushed regularly to assist in maintaining cross-connecting piping and in keeping the float bowl clean and free of sediment. A similar drain valve is furnished with auxiliary low-water cutoff for the same purpose.
Gauge Glass Drain Valve	Provided to flush the gauge glass.
Vent Valve	Allows the boiler to be vented during filling, and facilitates routine boiler inspection as required by ASME Code.
Auxiliary Low Water Cutoff	Breaks the circuit to stop burner operation in the event boiler water drops below the primary low-water cutoff point. Manual reset type requires manual resetting in order to start the burner after a low-water condition.
Safety Valve(s)	Prevent pressure buildup over the design pressure of the pressure vessel. The size, rating, and number of valves on a boiler is determined by the ASME Boiler Code. The safety valves and the discharge piping are to be installed to conform to the ASME code requirements. The installation of a valve is of primary importance to its service life. A valve must be mounted in a vertical position so that discharge piping and code required drains can be properly piped to prevent buildup of back pressure and accumulation of foreign material around the valve seat area. Apply only a moderate amount of pipe compound to male threads and avoid overtightening, which can distort the seats. Use only flat-jawed wrenches on the flats provided. When installing a flange-connected valve, use a new gasket and draw the mounting bolts down evenly.

⚠ Caution

Determine that the main and auxiliary low water cutoffs and pump control are level after installation and throughout the equipment's operating life. Failure to follow these instructions could result in equipment damage.

⚠ Warning

Only properly certified personnel such as the safety valve manufacturer's certified representative can adjust or repair the boiler safety valves. Failure to follow these instructions could result in serious injury or death.

FIGURE 1-5. Safety Valve

1.5 — Hot Water Controls (All Fuels)

Control	Description
Water Temperature Gauge	Indicates the boiler internal water pressure.
Operating Limit Temperature Control	Breaks a circuit to stop burner operation on a rise of boiler temperature at a selected setting. It is adjusted to strop or start the burner at a preselected operating temperature.
High Limit Temperature Control	Breaks a circuit to stop burner operation on a rise of temperature at a selected setting. It is adjusted to stop the burner at a preselected temperature above the operating control setting. The high limit temperature control normally is equipped with a manual reset.
Low Water Cutoff (optional probe type)	Breaks the circuit to stop burner operation if the water level in the boiler drops below the primary low-water cutoff point.
Safety Valve(s)	Relieves the boiler of pressure higher than the design pressure or a lower pressure, if designated. Relief valves and their discharge piping are to be installed to conform to ASME Code requirements.

⚠ Warning

Only properly certified personnel such as the safety valve manufacturer's certified representative can adjust or repair the boiler relief valves. Failure to follow these instructions could result in serious injury or death.

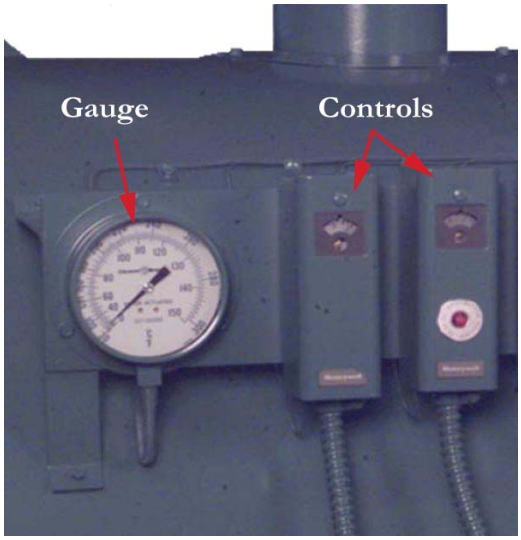


FIGURE 1-6. Hot Water Termperature Gauge and Controls

CHAPTER 2 Waterside Care

2.1 — Overview

The operator should be familiar with this entire manual and related equipment operation and service manuals before attempting to place the unit into operation.

Although it is of prime importance, the subject of water supply and treatment cannot adequately be covered in this manual. For specific information or assistance with your water treatment requirements, contact your Cleaver-Brooks service and parts representative.

Feedwater equipment should be checked and ready for use. Be sure that all valves, piping, boiler feed pumps, and receivers are installed in accordance with prevailing codes and practices.

Water requirements for both steam and hot water boilers are essential to boiler life and length of service. It is vital that care be taken in placing the pressure vessel into initial service. The waterside of new boilers and new or remodeled steam or hot water systems may contain oil, grease, or other foreign matter. A method of boiling out the vessel to remove the accumulations is described later in this chapter.

Boilers, as a part of a hot water system, require proper water circulation. The system must be operated as intended by its designer in order to avoid thermal shock or severe, possibly damaging, stresses from occurring to the pressure vessel.

NOTE: "Hot Water Boilers" in this manual refers only to boilers using water. Glycol solutions have different operating requirements, circulation rates and temperatures, etc.

2.2 — Water Requirements

2.2.1 — Hot Water Boiler

Air Removal

The hot water outlet includes a dip tube which extends 2 to 3 inches into the boiler. The dip tube reduces the possibility of air, which may be trapped at the top of the shell, from entering into the system. Oxygen or air released in the boiler will collect or be trapped at the top of the boiler shell.

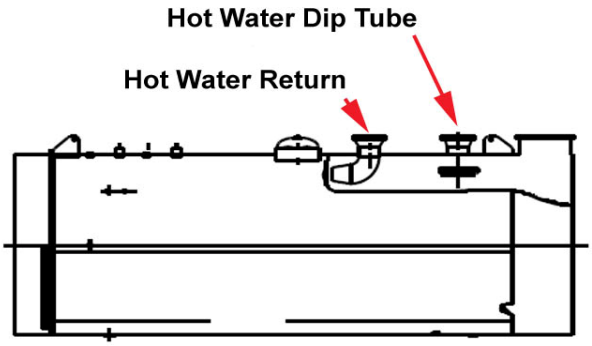


FIGURE 2-1. Dip Tube

The air vent tapping on the top center line of the boiler should be piped into the expansion or compression tank. Air trapped at the top of the boiler will find its way out of the boiler through the tapping.

Minimum Water Temperature

The minimum recommended boiler water temperature is 170º F. When water temperatures lower than 170º F are used, the combustion gasses are reduced in temperature to a point where water vapor condenses, causing corrosion in the boiler and possible breeching.

Condensation is more severe on a unit that operates intermittently and which is greatly oversized for the actual load. Condensation can be minimized by maintaining boiler water temperatures above 170º F.

Rapid Replacement of Boiler Water

The system layout and controls should be arranged to prevent the possibility of pumping large quantities of cold water into a hot boiler, which will cause shock or thermal stresses. Water temperature in a boiler of 200º F or 240º F cannot be completely replaced with 80º F water in a few minutes time without causing thermal stress. The same fact applies to periods of normal operation, as well as during initial startup.

NOTE: The circulating pumps should be interlocked with the burner so that the burner cannot operate unless the circulating pump is running in order to avoid damage to the equipment.

When individual zone circulating pumps are used, it is recommended that they be kept running, even though the heat users do not require hot water. The relief device or bypass valve will thus allow continuous circulation through the boiler and can help prevent rapid replacement of boiler water with cold zone water.

Continuous Flow Through the Boiler

The system should be piped and the controls arranged to allow water circulation through the boiler under all operating conditions. The operation of three-way valves and system controls should be checked to be sure that the boiler will not be bypassed. Constant circulation through the boiler eliminates the possibility of stratification within the unit and results in more even water temperatures to the system.

A rule of thumb is 3/4 to 1 gpm per boiler horsepower can be used to determine the minimum continuous flow rate through the boiler under all operating conditions. The operator should determine that a flow of water exists through the boiler before initial firing or refiring after the boiler has been drained.

Water Circulation

Multiple Boiler Installations: When multiple boilers are used, care must be taken to ensure adequate or proportional flow through the boilers. Proportional flow can best be accomplished by use of balancing valves and gauges in the supply line from each boiler. If balancing valves or orifice plates are used, a significant pressure drop (for example, 3 - 5 psi) must be taken across the balancing device to accomplish the purpose.

If care is not taken to ensure adequate or proportional flow through the boilers, wide variations in firing rates between boilers can result.

In extreme cases, one boiler may be in the high-fire position while the other boiler or boilers may be at low-fire. The net result would be that the common header water temperature to the system would not be up to the desired point.

Boiler Size (BHP)	Boiler Output (1000) BTU/HR	System Temperature Drop – Degress °F									
		10	20	30	40	50	60	70	80	90	100
		Maximum Circulating Rate – GPM									
100	3,347	670	335	224	168	134	112	96	84	75	67
125	4,185	836	418	279	209	168	140	120	105	93	84
150	5,025	1,005	503	335	251	201	168	144	126	112	100
200	6,695	1,340	670	447	335	268	224	192	168	149	134
250	8,370	1,675	838	558	419	335	280	240	210	186	167
300	10,045	2,010	1,005	670	503	402	335	287	251	223	201
350	11,720	2,350	1,175	784	587	470	392	336	294	261	235
400	13,400	2,680	1,340	895	670	535	447	383	335	298	268
500	16,740	3,350	1,675	1,120	838	670	558	479	419	372	335
600	20,080	4,020	2,010	1,340	1,005	805	670	575	502	448	402
700	23,430	4,690	2,345	1,565	1,175	940	785	670	585	520	470
800	26,780	5,360	2,680	1,785	1,340	1,075	895	765	670	595	535

FIGURE 2-2. Hot Water Boiler Maximum Circulation Rate in Gallons Per Hour

Pump Location: It is recommended that the system circulating pumps take suction form the outlet connection on the boiler, and that they discharge to the system load, in order to put the boiler and the expansion tank on the suction side of the pump. The suction side is preferred because it decreases air entry into the system and does not impose the system head on the boiler.

It is common practice to install a standby system circulating pump. The main circulating pumps are usually located adjacent to the boilers in the boiler room.

Pump Operation: Pumps are normally started and stopped by manual switches. It is also desirable to interlock the pump with the burner so that the burner cannot operate unless the circulating pump is running.

Pressure

The design of the system and usage requirements often dictate the pressure exerted upon the boiler. Some systems are pressurized with air, or with an inert gas such as nitrogen. Caution must be exercised to ensure that the proper relationship of pressure-to-temperature exists within the boiler so that all of the boiler's internal surfaces are fully wetted at all times. For this reason, the internal boiler pressure, as indicated on the water pressure gauge, must be held to the level shown on the water level gauge glass.

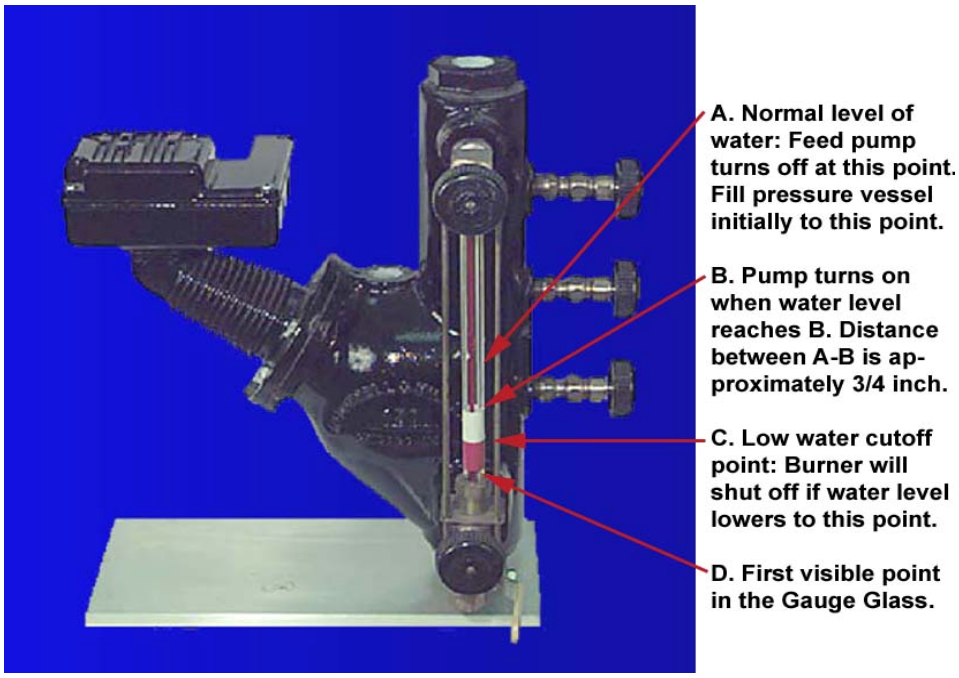


FIGURE 2-3. Water Level Gauge Glass

When initially firing a newly installed boiler, or when cutting an existing boiler into an operating system, the boiler of boilers to be cut into operation MUST be pressurized equal to the system and/or other boilers prior to opening the header valves.

It is advisable to have a thermometer installed in the return line to indicate return water temperature. Knowing the supply water temperature, the boiler system differential can be established. With knowledge of the pumping rate, the operator can easily detect any excessive load condition and take appropriate corrective action.

Special caution must be taken to guard against any condition, or combination of conditions, that might lead to the transfer of cold water to a hot boiler or hot water to a cold boiler. It cannot be overemphasized that rapid changes in temperature within the boiler can, and sometimes do, cause damage.

2.2.2 — Steam Boiler

Feed Pump Operation

To prevent possible damage to the feed pump mechanism, be certain that all valves in the water feed line are open BEFORE turning on the pump motor. After opening the valves, momentarily energize the feed pump motor to establish correct pump rotation. With the correct rotation established, close the boiler feed pump entrance switch. The pump should shut down when the water level reaches the proper level.

Feedwater pumps must have adequate capacity to maintain required water level under all operating conditions. Check the feedwater pumps periodically and maintain as necessary to prevent unexpected breakdowns.

NOTE: Prior to operating the pump, carefully check the alignment of the flexible coupling, if one is used. A properly aligned coupling will last a long time and provide trouble free mechanical operation.

Water Feeder Operation (Optional)

Water feeder operation is usually applicable to boilers operating at 15 psi steam or less. It is only necessary to open the water supply line valve and the water feeder discharge valve.

NOTE: In the event that water column isolation valves are provided or installed, it must be established that the valves are open and seated or locked in the open position. If the valves are installed, it is illegal to operate the boiler with closed or unsealed open valves.

2.3 — Water Treatment

Properly treated boiler feed water, coupled with good engineering and operating practices, leads to maximum effectiveness and long trouble free life of pressure vessel, at the lowest operating cost. Contact your local Cleaver-Brooks authorized representative for information on how to prevent the presence of unwanted solids and corrosive gasses.

Water treatment objectives include:

- Prevent hard scale deposits or soft sludge deposits, which reduce heat transfer and can lead to overheated metal and costly downtime and repairs.
- Eliminate corrosive gasses in the supply or boiler water.
- Prevent intercrystalline cracking or caustic embrittlement of boiler metal.
- Prevent carryover and foaming.

Accomplishment of the above objectives generally requires proper feedwater treatment before and after introduction of the water into the boiler. The selection of pre-treatment processes depends upon the water source, its chemical characteristics, amount of make-up water needed, plant operating practices, etc. Treating methods include filtering, softening, de-mineralizing, deaerating, and preheating. After-treatment involves chemical treatment of the boiler water. Because of the variables involved, no single boiler compound can be considered a “cure-all” nor is it advisable to experiment with homemade treating methods. Sound recommendations and their employment should be augmented by a periodic analysis of the feedwater, boiler water, and condensate.

The internal or waterside surfaces of the pressure vessel should be inspected with enough frequency to determine the presence of any contamination, accumulations of foreign matter, or corrosion, and/or pitting. If any of these conditions are detected, contact your local Cleaver-Brooks authorized representative for advice on corrective action.

A properly sized water meter should be installed in the raw water makeup line in order to accurately determine the amount of raw water admitted to the boiler (steam or hot water) and to aid in maintaining proper waterside conditions.

2.4 — Cleaning

2.4.1 — Hot water and Steam Piping

Steam and water piping systems connected to the boiler may contain oil, grease, or foreign matter. The impurities must be removed in order to prevent damage to pressure vessel heating surfaces. On a steam system, the condensate should be wasted until tests show the elimination of undesirable impurities. During the period that condensate is wasted, attention must be given to the treatment of the raw water used as make-up so that an accumulation of unwanted materials or corrosion does not occur. For more information, contact your local Cleaver-Brooks authorized representative.

On a hot water system, chemical cleaning is generally necessary and the entire system should be drained after treatment. Consult your local Cleaver-Brooks authorized representative for recommendations, cleaning compounds, and application procedures.

2.4.2 — Pressure Vessel

The waterside of the pressure vessel must be kept clean from grease, sludge, and foreign material. Such deposits, if present, will shorten the life of the pressure vessel, will interfere with efficient operation and functioning of safety devices control, and quite possibly cause unnecessary and expensive rework, repairs, and downtime.

The installation and operating conditions that the boiler will be subjected to should be considered and cleaning of the waterside of the pressure vessel should be provided during the course of initial startup.

The pressure vessel and the steam and return lines or hot water piping represent, in effect, a closed system. Although the steam and return (condensate) lines or the hot water piping system may have been previously cleaned, it is possible that:

- Cleaning has been inadequate.
- Partial or total old system is involved.
- Conditions may prevent adequate cleaning of piping.

The pressure vessel waterside should be inspected on a periodic basis. An inspection will reveal true internal conditions and serve as a check against conditions indicated by chemical analysis of the boiler water. Inspection should be made three months after initial starting and at regular 6-, 9-, or 12-month intervals thereafter. The frequency of further periodic inspections will depend upon the internal conditions found.

If any unwanted conditions are observed, contact your local Cleaver-Brooks authorized representative for recommendations.

Any sludge, mud, or sediment found will need to be flushed out. If excessive mud or sludge is noticed during the blowdown, the scheduling or frequency of blowdown may need to be revised. The need for periodic draining or washout will also be indicated.

Any oil or grease present on the heating surfaces should be removed promptly by a boil-out with an alkaline detergent solution.

NOTE: Temperature of initial fill of water for hydrostatic tests, boil-out, or for normal operation should be as stated in the ASME Boiler Code: Boil-Out of New Unit.

The internal surfaces of a newly installed boiler may have oil, grease, or other protective coatings used in manufacturing. Such coatings must be removed because they lower the heat transfer rate and could cause over-heating of a tube. Before boiling out procedures may begin, the burner should be ready for firing. The operator must be familiar with the procedure outlined under burner operation.

Your local Cleaver-Brooks authorized representative will be able to recommend a cleaning or boil-out procedure. In the event such service is unavailable or is yet unscheduled, the following information may be of assistance.

There are several chemicals suitable for boil-out. One combination often used is soda ash (sodium carbonate) and caustic soda (sodium hydroxide) at the rate of 3 to 5 pounds each per 1,000 pounds of water, along with a small amount of laundry detergent added as a wetting agent.

Suggested boiler cleaning procedure:

1. Assemble sufficient cleaning material to complete the job.
2. When dissolving chemicals:
   a. Warm water should be put into a suitable container.
   b. Slowly introduce the dry chemical into the water, stirring it at all times until the chemical is completely dissolved.
   c. Add the chemical slowly and in small amounts to prevent excessive heat and turbulence.
3. An overflow pipe should be attached to one of the top boiler openings and routed to a safe point of discharge. A relief or safety valve tapping is usually used.
4. Water relief valves and steam safety valves must be removed before adding the boil-out solution so that neither it nor the grease which it may carry will contaminate the valves. Use care in removing and reinstalling the valves.
5. All valves in the piping leading to or from the system must be closed to prevent the cleaning solution from getting into the system.
6. Fill the pressure vessel with clean water until the top of the tubes are covered. Add the cleaning solution and then fill to the top. The temperature of the water used in the initial fill should be at ambient temperature.
7. The boiler should then be fired intermittently at a low rate sufficient to hold solution just at the boiling point. Boil the water for at least five hours. don not produce steam pressure.
8. Allow a small amount of fresh water to enter the boiler to create a slight overflow that will carry off surface impurities.

9. Continue the boil and overflow process until the water clears. Shut the burner down.
10. Let the boiler cool to 120º F or less.
11. Remove handhole plates and wash the waterside surfaces thoroughly using a high pressure water stream.
12. Inspect the surfaces. If they are not clean, repeat the boil-out.
13. After closing the handholes and reinstalling the safety or relief valves, fill the boiler and fire it until the water is heated to at least 180º F to drive off any dissolved gasses, which might otherwise corrode the metal.

⚠ Warning

Be sure to drain the hot water to a safe point of discharge to avoid scalding. Failure to follow these instructions could result in serious injury or death.

The above procedure may be omitted in the case of a unit previously used or known to be internally clean. However, consideration must be given to the possibility of contaminating materials entering the boiler from the system.

2.5 — Washing Out

2.5.1 — Hot Water Boiler

In theory, a hot water system and boiler that has been initially cleaned, filled with raw water (and water treated), and with no make-up water added, will require no further cleaning or treatment. However, since the system (new or old) can allow entrance of air and unnoticed or undetected leakage of water, introductions of raw water make-up or air may lead to pitting, corrosion, and formation of sludge, sediment, scale, etc., on the pressure vessel waterside.

If the operator is absolutely certain that the system is tight, then an annual waterside inspection may be sufficient. However, if there is any doubt, the pressure vessel waterside should be inspected no later than three months after initially placing the boiler into operation, and periodically thereafter as indicated by conditions observed during inspections.

2.5.2 — Steam Boiler

No later than three months after initially placing the boiler into operation and starting service, and thereafter as conditions warrant, the pressure vessel should be drained after being properly cooled to near ambient temperature. Handhole covers should be removed and waterside surfaces should be inspected for corrosion, pitting, or formation of deposits.

2.5.3 — Flushing of Pressure Vessel Interior

Upon completion of the inspection, the pressure vessel interior should be flushed out, as required, with a high pressure hose. If deposits are not fully removed by flushing, a consultation may be required with your local Cleaver-Brooks authorized representative. In extreme cases, it may be necessary to resort to acid cleaning. Professional advice is recommended if acid cleaning is required.

The inspections will indicate the effectiveness of the feedwater treatment. The effectiveness of treatment, the water conditions, and the amount of fresh water make-up required are all factors to be considered in establishing fre-

quency of future pressure vessel washouts. Contact your local Cleaver-Brooks authorized representative for more information.

2.7 — Blowdown: Steam Boiler

Boiler water blowdown is the removal of some of the concentrated water from the pressure vessel and its replacement with feedwater so that the lowering of the concentration of solids in the boiler water occurs. Solids are brought in by the feedwater even though the water is treated prior to use through external processes that are designed to remove unwanted substances which contribute to scale and deposit formations. However, none of the processes can remove all substances. Regardless of their high efficiency, some solids will be present in the boiler feedwater.

Solids become less soluble in the high temperature of the boiler water and tend to accumulate on heating surfaces. Therefore blowdown and internal chemical treatment are required to prevent the solids from forming harmful scale and sludge.

Scale has a low heat transfer value and acts as an insulation barrier. Scale retards heat transfer, which not only results in lower operating efficiency, and consequently higher fuel consumption, but more importantly, can cause overheating of boiler metal. Over heating of boiler metal can result in tube failures or other pressure vessel metal damage and lead to boiler downtime and costly repairs.

Scale is caused primarily by calcium and magnesium salts, silica, and oil. Any calcium and magnesium salts in the boiler water are generally precipitated by the use of sodium phosphate, along with organic materials, to maintain the precipitates or "sludge" in a fluid form. The solids such as sodium salts and suspended dirt do not readily form scale. But as the boiler water boils off as relatively pure steam, the remaining water is thickened with the solids. If the concentration is permitted to accumulate, foaming and priming will occur and the sludge can cause harmful deposits that bring about overheating of the metal.

The lowering or removal of the concentration requires the use of boiler water blowdown.

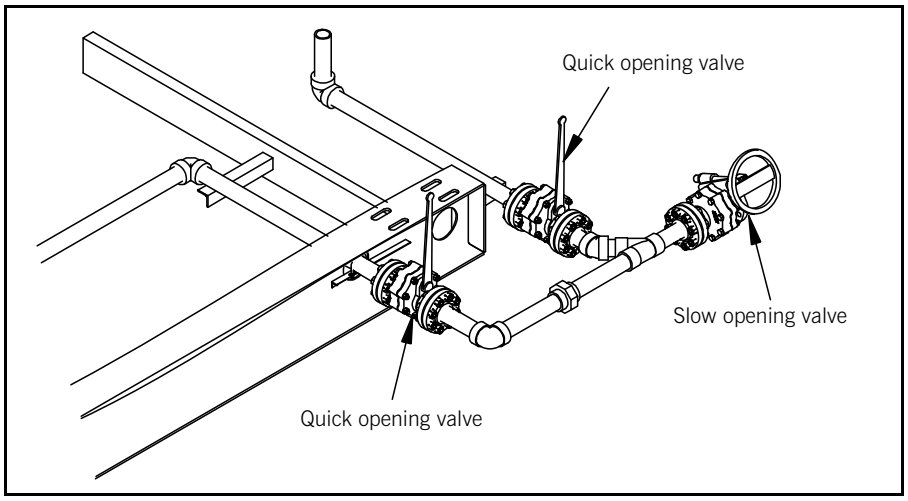


FIGURE 2-4. Bottom Blowdown Layout

2.7.1 — Types of Blowdowns

The two principle types of blowdown are: 1) intermittent manual blowdown; 2) continuous blowdown.

Intermittent Manual Blowdown

Manual or sludge blowdown is necessary for the operation of the boiler regardless of whether or not continuous blowdown is employed.

The blowdown tappings are located at the bottom or lowest part of the boiler in order to lower the dissolved solids in the pressure vessel water, and to remove a portion of the sludge that accumulates in the lower part of the vessel.

Equipment generally consists of a quick opening valve and a shutoff valve. The valves and necessary piping are not normally furnished with the boiler, but supplied by others. All piping must be to a safe point of discharge. Piping must be properly supported and free to expand.

Continuous Blowdown

Continuous blowdown is used in conjunction with a surface blow-off tapping and is the continuous removal of concentrated water.

The surface blow-off opening, when furnished, is on the top center line of the pressure vessel. It is provided with an internal collecting pipe terminating slightly below the working water level for the purpose of skimming surface sediment, oil, or other impurities from the surface of the pressure vessel water.

A controlled-orifice valve is used to allow a continual, yet controlled flow of concentrated water.

Periodic adjustments are made to the valve setting to increase or decrease the amount of blowdown in accordance with the test analysis.

The flow control valve and piping are generally provided by others. All piping must be to a safe point of discharge.

2.7.2 — Frequency of Manual Blowdown

When continuous blowdown is utilized, manual blowdown is primarily used to remove suspended solids or sludge. The continuous blowdown removes sediment and oil from the surface of the water along with a prescribed amount of dissolved solids.

When surface or continuous blowdown is not utilized, manual blowdown is used to control the dissolved or suspended solids in addition to the sludge.

In practice, the valve(s) of the bottom blowdown are opened periodically in accordance with an operating schedule and/or chemical control tests. From the standpoint of control, economy, and results, frequent short blows are preferred to infrequent lengthy blows. The length and frequency of the blowdown is particularly important when the suspended solids content of the water is high. With the use of frequent short blows, a more uniform concentration of the pressure vessel water is maintained.

In cases where the feedwater is exceptionally pure, or where there is a high percentage of return condensate, blowdown may be employed less frequently since less sludge accumulates in the pressure vessel. When dissolved and/or

suspended solids approach or exceed predetermined limits, manual blowdown to lower the concentrations is required.

It is generally recommended that a steam boiler be blown down at least once in every eight-hour period, but frequency may vary depending upon water and operating conditions. The blowdown amounts and schedule should be recommended by your local Cleaver-Brooks representative.

A hot water boiler does not normally include openings for surface blowdown and bottom blowdown since blowdowns are seldom practiced. The need remains to be alert to system water losses and corresponding amount of raw water make-up. A water meter is recommended for water make-up lines.

2.7.3 — Manual Blowdown Considerations

Blowdown is most effective at a point when the generation of steam is at the lowest rate and feedwater input is also low, thus providing a minimum dilution of the boiler water with low concentration feedwater.

Be sure the blow-off piping and tank, if used, are in proper operating condition. Discharge vents should be clear of obstruction, and the waste should be piped to a point of safe discharge.

Most blow-off lines are provided with two valves, generally a quick opening valve nearest the boiler and a slow opening globe type valve downstream. Valves will vary depending upon pressure involved and make or manufacturer. If seatless valves are installed, follow the manufacturer's recommendations.

If a quick opening valve and globe type of slow opening valve are in combination, the former is normally opened first and closed last with blowdown accomplished with the globe or slow opening valve.

When opening the second or downstream valve, crack it slightly to allow the lines to warm, then continue opening slowly.

⚠ Caution

Do not pump the lever action valve open and closed, as water hammer is apt to break the valve bodies or pipe fittings. Failure to follow these instructions could cause damage to the equipment.

The length of each blow should be determined by actual water analysis. Lowering the water in the gauge glass approximately 1/2" is often acceptable as a guide to adequate blow. However, lowering the water 1/2" should not be interpreted as a rule since water analysis procedures should prevail. If the glass cannot be viewed by the party operating the valve, another operator should watch the glass and direct the valve operator.

Close the downstream (slow opening) valve first and as fast as possible. Then close the valve next to the boiler. Slightly crack the downstream valve and then close it tightly. Under no circumstances should a blow-off valve be left open and the operator should never leave until the blowdown operation is completed and the valves are closed.

2.8 — Periodic Inspection

Insurance regulations or local laws will require a periodic inspection of the pressure vessel by an authorized inspector. Sufficient notice is generally given to permit removal of the boiler from service and preparation for inspection.

⚠ Warning

To avoid the hazard of electrical shock, we recommend the use of a low voltage flashlight during an internal inspection. Preferably, inspectors should work in pairs. Failure to follow these instructions could result in serious injury or death.

When shutting down the boiler, the load should be reduced gradually and the pressure vessel cooled at a rate that avoids damaging temperature differential that can cause harmful stresses. Vessels should not normally be drained until all pressure is relieved — again, to prevent uneven contraction and temperature differentials that can cause expanded tubes to leak. Draining the unit too quickly may cause the baking of deposits that may be present on the heating surfaces. Some heat, however, may be desirable to dry out the interior of the boiler.

If the internal inspection is being made at the request of an authorized inspector, it is well to ask the inspector to observe the conditions prior to cleaning or flushing of waterside surfaces.

Be certain that a supply of manhole and handhole gaskets is available, along with any other gaskets or items needed to place the unit back into operation after inspection.

Have available information on the boiler design, dimensions, generating capacity, operating pressure or temperature, time in service, defects found previously, and any repairs or modifications. Also have available for reference records of previous inspections.

Be prepared to perform any testing required by the inspector including a hydrostatic test.

After proper cooling and draining of the vessel, flush out the waterside with a high pressure water hose. Remove any scale or deposits from the waterside surfaces and check for internal or external corrosion and leakage.

The fireside surface should also be thoroughly cleaned so that metal surfaces, welds, joints, tube ends, fittings, and any previous repairs can be readily checked.

Be sure that steam valves, and valves to expansion tank (hot water), feedwater valves, blow-off valves, all fuel valves, valves to expansion tank, and electrical switches are shut off prior to opening handholes, manhole, and front or rear doors. Adequately vent the pressure vessel prior to entry.

Clean out the low-water cutoff piping, the water level controls, and cross-connecting pipes. Replace the water gauge glass and clean out the water cocks. Also check and clean the drain and the blowdown valves and piping.

Check all water and steam piping and valves for leaks, wear, corrosion, and other damage. Replace or repair as required.

2.9 — Preparation for Extended Lay-Up

Many boilers used for heating or seasonal loads or for standby service may have extended periods of non-use. special attention must be given to idle boilers so that neither waterside nor fireside surfaces are allowed to deteriorate from corrosion.

Too many conditions exist to lay down definite rules. There are two methods of storage: wet and dry. Your local Cleaver-Brooks authorized representative can recommend the better method depending upon circumstances in the particular installation.

Whichever method is used, common sense dictates a periodic recheck of fireside and waterside conditions during lay-up to allow variations from the above methods for special area or jobsite conditions.

Swing open the boiler head at the stack end of the unit to prevent flow of warm, moist air through the boiler tubes.

Although pollution control regulations may continue to limit the permissible sulphur content of fuel oils, care must be taken to avoid corrosion problems that sulphur can cause, especially in a boiler that is seasonally shutdown. Dormant periods, and even frequent shutdowns, expose the fireside surfaces to condensation below the dew point during cooling. Moisture and any sulphur residue can form an acid solution. Under certain conditions, and especially in ares with high humidity, the corrosive effect of the acid will be serious enough to eat through or severely damage boiler tubes or other metal heating surfaces during the time that a boiler is out of service.

The condition does not generally occur during normal firing operation, because the high temperature of operation vaporizes any condensation. However, proper boiler operation must be maintained, especially with a hot water boiler, to prevent the flue gasses from falling below the dew point.

At the start of lay-up, thoroughly clean the fireside by removing any soot or other products of combustion from the tubes, tube sheets, and other fireside surfaces. Brushing will generally suffice. Sweep away or vacuum any accumulation. The fireside surfaces may be flushed with water. However, all moisture must be eliminated after flushing and the surface dried by blowing air or applying some form of heat. It is good practice to protect the cleaned surfaces by coating them with an anti-corrosive material to prevent rust.

To prevent condensation from forming in the control cabinet, keep the control circuit energized. For extended lay-up periods, especially where high humidity or large swings in ambient temperature occur, the program relay should be removed and stored in a dry atmosphere.

Dry storage is generally employed when the boiler will be out of service for a significant period of time, or where freezing temperatures may exist. In the dry storage method the boiler must be thoroughly dried because any moisture would cause corrosion. Both fireside and waterside surfaces must be cleaned of all scale, deposits, soot, etc. Steps must be taken to eliminate moisture by placing moisture absorbing materials such as quick lime (at 2 pounds for 3 cubic feet of volume) or silica gel (at 5 pounds for 30 cubic feet of volume) on trays inside the vessel. Fireside surfaces may be coated with an anticorrosive material, or grease or tar paint. Refractories should be brushed clean and wash-coated. All openings to the pressure vessel, such as manhole and handholes, should be shut tightly. Feedwater and steam valves should be closed. Damper and vents should be closed to prevent air from reaching fireside surfaces. Periodic inspection should be made and absorption materials renewed.

Wet storage is generally used for a boiler held in standby condition or in cases where dry storage is not practical. The possibility of freezing temperatures must be considered. Care must again be taken to protect metal surfaces. Variables preclude definite recommendations. However, it is suggested that the pressure vessel be drained, thoroughly cleaned internally, and re-filled to overflowing with treated water. If deaerated water is not available, the unit should be fired to boil the water for a short period of time. Additional chemicals may be suggested by your local Cleaver-Brooks authorized representative to minimize corrosion. Internal water pressure should be maintained at greater than atmospheric pressure. Nitrogen is often used to pressurize the vessel. Fireside surfaces must be thoroughly cleaned and the refractory should be wash-coated.

2.10 — Opening and Closing Doors

2.10.1 — Opening Front or Rear Door

Before opening the doors, tighten the nut on the Davit arm to create slight tension. This will prevent sagging and facilitate opening of the door. After opening either door, check the gaskets and seating surfaces. Replace the door gaskets if they are hard or brittle. Clean the sealing surfaces of the door and tube sheet.

FIGURE 2-5. Tighten Davit Nut

2.10.2 — Rear Access Plug

Access to the first to second gas pass turn around area is accomplished through the removal of the rear plug.

FIGURE 2-6. Removing Rear Access Plug

The access plug weighs approximately 120 pounds. Two people make the handling of the access plug easier. When resealing the access plug area, be sure the sealing area is clean and free of old gasket material and rust. Secure 2" blanket insulation to the inside of the plug with a 2" overlap around the circumference of the plug refractory.

Attach one wrap of 1" rope to the inner access sealing area and two wraps of 1/2" rope to the outside area. Insert the plug and tighten evenly.

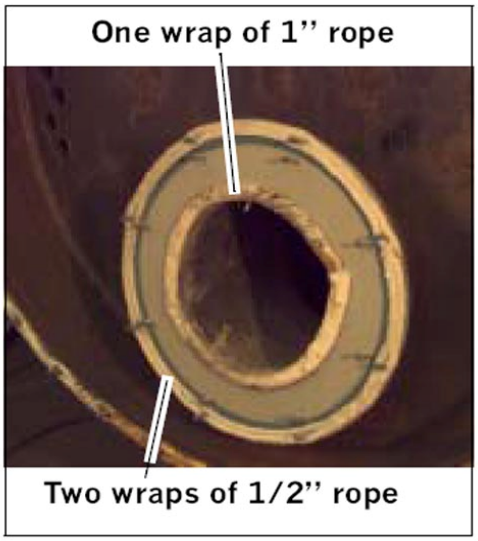


FIGURE 2-7. Sealing Wraps

⚠ Caution

The rear access plug is made up of cast in place refractory. When removing, two boiler technicians should be on hand to assist with removal.

2.10.3 — Closing and Sealing Doors

Swing the door to the closed position and run all retaining bolts in until snug. Tighten the bolts uniformly, starting at the top center and alternating between the top and bottom bolts until both are tight. Do not over-tighten. Tighten alternate bolts until all are secure and the door is gas tight.

NOTE: When closing the rear door, inspect the threads on all studs and where necessary use the correct sized die to clean the threads. Damaged stud threads can strip the brass nuts.

After closing the door, loosen the nut on the Davit arm stud to release tension on the Davit arm. Failure to do so may result in damage to the boiler due to thermal stresses during boiler operation.

After the boiler is back in operation, re-tighten the door bolts to compensate for compression of the gasket or movement of the door.

CHAPTER 3 Sequence of Operation

3.1 — Overview

Chapter 3 outlines the electrical sequencing of various controls through the pre-purge, ignition, run, and shutdown cycles of the burner.

The program relay establishes the sequence of operation and directs the operation of all other controls and components to provide an overall operating sequence.

> **NOTE:** The make or model of the program relay provided will vary depending upon job specifications. The following sequence applies regardless of the make or model. Please refer to the Wiring Diagram (WD) prepared by Cleaver-Brooks for your specific installation.

The burner and control system are in starting condition when the following conditions exist:

- Boiler water is up to the correct level, closing the low water cutoff switch.
- The low-water light (panel) is off.
- The operating limit pressure control (steam boiler) or the operating limit temperature control (hot water boiler) and high limit pressure or temperature control are below their cutoff setting.
- All applicable limits are correct for burner operation.
- The load demand light glows (fuel pressure, temperature).
- Reset manual reset (water, fuel pressure, operating limits).

All entrance switches are closed and power is present at the line terminals of:

- Blower motor starter
- air compressor motor starter (if provided)
- Oil pump motor starter (if provided)

The sequences do not attempt to correlate the action of the fuel supply system or feedwater system except for the interlock controls that directly relate to the action of the program relay. Chapters 4 and 5 contain setup and operat-

ing instructions for the "F" Series ProFire burner. Chapters 6 and 7 contain setup and operation instructions for the "D" Series ProFire burner.

3.2 — Circuit and Interlock Controls

The burner control circuit is a two-wire system designed for 115 VAC, 60 Hz, single-phase power.

The electrical portion of the boiler is made up of individual circuits with controls that are wired in a manner designed to provide a safe workable system. The program relay provides connection points for the interconnection of the various circuits.

The controls used vary depending upon the fuel oil or gas and the specific requirements of applicable regulatory bodies. Refer to the boiler wiring diagram to determine the actual controls provided. The circuits and controls normally used in the circuits are displayed in the table below and are referred to in the sequence of operation information.

Circuit	**Components**
Limit Circuit	• Burner Switch (BS) • Operating Limit Control (OLC) - pressure or temperature • High Limit Control (HLC) - pressure or temperature • Low Water Cutoff (LWCO) • Gas-Oil Selector Switch (GOS) - combination burner only • Low Gas Pressure Switch (LGPS) • High Gas Pressure Switch (HGPS)
Fuel Valve Over-Travel Interlock Circuit	• Main Gas Valve Auxiliary Switch (MGVAS)
Blower Motor Starter Circuit	• Blower Motor Starter (BMS) • Air Compressor Motor Starter (ACMS) - if provided
Running Interlock Circuit	• Blower Motor Starter Interlock (BMSI) • Combustion Air Proving Switch (CAPS) • Atomizing Air Proving Switch (AAPS) - if provided
Low Fire Proving Circuit	• Low Fire Switch (LFS)
Pilot Ignition Circuit	• Gas Pilot Valve (GPV) • Ignition Transformer (IT) • Gas Pilot Vent Valve (GPVV) - if provided
Flame Detector Circuit	• Flame Detector (FD)
Main Fuel Valve Circuit	• Main Gas Valve (MGV) • Main Gas Vent Valve (MGVV), if provided • Oil Valve (OV) • Main Fuel Valve Light (FVL)

Circuit	Components
Firing Rate Circuit	• Modulating Damper Motor (MDM) • Manual-Automatic Switch (MAS) • Manual Flame Control (MFC) • Modulating Control (MC)
High Fire Proving Circuit	• High Fire Switch (HFS)
Running Interlock and Limit Circuit	• Low Oil Pressure Switch (LOPS) • High Oil Pressure Switch (HOPS) • Auxiliary Low Water Cutoff (ALWCO)
To comply with requirements of insurance underwriters such as Factory Mutual (FM), Industrial Risk Insurers (I.R.I.), or others, additional interlock devices may be used in addition to those identified in this table.	

3.3 — Sequence of Operation: Oil or Gas

On a combination fuel unit, the gas/oil switch must be set for the proper fuel.

The following sequence occurs with power present at the program relay (PR) input terminals and with all other operating conditions satisfied.

3.3.1 — Pre-Purge Cycle

When the burner switch (BS) is turned "on," and controls wired in the "limit" and "fuel valve interlock" circuits are closed and no flame signal is present, the "blower motor start circuit" is powered energizing the blower motor starter (BMS). The load demand light (LDL) turns on. When firing oil, the air compressor motor starter (ACMS - if provided) is also powered.

At the same time, the program relay signals the modulating damper motor (MDM) to open the air damper. The damper begins to open and drives to its full open or high fire position. Opening the damper motor allows a flow of purging air through the boiler prior to the ignition cycle.

On all boilers the circuitry will include a high fire switch (HFS). The purpose of the switch is to prove that the modulating damper motor (MDM) has driven the damper to the open position during the pre-purge cycle.

The controls wired into the "running interlock circuit" must be closed within 10 seconds after the start sequence. In the event any of the controls are not closed at this time, or if they subsequently open, the program relay will go into a safety shutdown.

At the completion of the high fire purge period, the program relay signals the modulating damper motor (MDM) to drive the air damper to its low fire position.

To assure that the system is in low fire position prior to ignition, the low fire switch (LFS) must be closed to complete the "low fire proving circuit." The sequence will stop and hold until the modulating damper motor (MDM) has returned to the low fire position and the contacts of the low fire switch (LFS) are closed. Once the low fire switch is closed, the sequence is allowed to continue.

NOTE: The ignition trial cannot be started if flame or a flame simulating condition is sensed during the pre-purge period. A safety shutdown will occur if flame is sensed at this time.

3.3.2 — Ignition Cycle

The ignition transformer (IT) and gas pilot valve (GPV) are energized from the appropriate pilot ignition terminal.

The pilot flame must be established and proven by the flame detector (FD) within a 10 second period in order for the ignition cycle to continue. If for any reason this does not happen, the system will shut down and safety lockout will occur.

With a proven pilot, the main fuel valve(s) (OV or MGV) is energized and the main fuel valve light (FVL) in the panel is lighted. The main flame is ignited and the trial period for proving the main flame begins. It lasts 10 seconds for light oil and/or natural gas. At the end of the proving period, if the flame detector still detects main flame, the ignition transformer and pilot valve are de-energized and the pilot flame is extinguished.

NOTE: If the main flame does not light, or stay lit, the fuel valve will close. The safety switch will trip to lock out the control. Refer to Flame Loss Sequence (Section 3.4) for description of action.

⚠ Warning

The cause for loss of flame or any other unusual condition should be investigated and corrected before attempting to restart. Failure to follow these instructions could result in serious injury or death.

3.3.3 — Run Cycle

With main flame established, the program relay releases the modulating damper motor (MDM) from its low fire position to control by either the manual flame control (MFC) or the modulating control (MC), depending upon the position of the manual-automatic switch (MAS). This allows operation in ranges above low fire.

With the manual-automatic switch (MAS) set at automatic, subsequent modulated firing will be at the command of the modulating control (MC), which governs the position of the modulating damper motor (MDM). The air damper and fuel valves are actuated by the motor through a linkage.

NOTE: Normal operation of the burner should be with the switch in the automatic position and under the direction of the modulating control. The manual position is provided for initial adjustment of the burner over the entire firing range. When a shutdown occurs while operating in the manual position at other than low fire, the damper will not be in a closed position, thus allowing more air than desired to flow through the boiler. Excess air flow subjects the pressure vessel metal and refractory to undesirable conditions.

The burner starting cycle is now complete. The (LDL and FVL) lights on the panel remain lit. Demand firing continues as required by load conditions.

3.3.4 — Burner Shutdown: Post-Purge

The burner will fire until steam pressure or water temperature in excess of demand is generated. With modulated firing, the modulating damper motor (MDM) should return to the low fire position before the operating limit control (OLC) opens. When the limit control circuit is opened, the following sequence occurs:

1. The main fuel valve circuit is de-energized, causing the main fuel valve (MGV or OV) to close. The flame is extinguished. The control panel lights (LDL and FVL) are turned off. The blower motor continues to urn to force air through the boiler for the post-purge period.
2. The blower motor start circuit is de-energized at the end of the post-purge cycle and the shutdown cycle is complete.
3. The program relay is now ready for subsequent recycling, and when steam pressure or water temperature drops to close the contacts of the operating control, the burner again goes through its normal starting and operating cycle.

3.4 — Flame Loss Sequence

The program relay will recycle automatically each time the operating control closes, or after a power failure. It will lockout following a safety shutdown caused by failure to ignite the pilot, or the main flame, or by loss of flame. Lockout will also occur if flame or flame simulating condition occurs during the pre-purge period or any time the burner switch is open.

The control will prevent startup or ignition if limit circuit controls or fuel valve interlocks are open. The control will lockout upon any abnormal condition affecting air supervisory controls wired in the running interlock circuit.

⚠ Caution

The lockout switch must be manually reset following a safety shutdown. The cause for loss of flame or any unusual condition should be investigated and corrected before attempting to restart. Failure to follow these instructions could cause damage to the equipment.

3.4.1 — No Pilot Flame

The pilot flame must be ignited and proven within a 10-second period after the ignition cycle begins. If not proven within this period, the main fuel valve circuit will not be powered and the fuel valve(s) will not be energized. The ignition circuit is immediately de-energized and the pilot valve closes, the reset switch lights and lockout occurs immediately.

The blower motor will continue to operate. The flame failure light and the alarm bell (optional) are energized 10 seconds later.

The blower motor will be de-energized. The lockout switch must be manually reset before operation can be resumed. (Refer to previous caution notice.)

3.4.2 — Pilot But No Main Flame

When the pilot flame is proven, the main fuel valve circuit is energized. The pilot flame will be extinguished 10 seconds later. The flame detecting circuit will respond to de-energize the main fuel valve circuit within 2 to 4 seconds to stop the flow of fuel. The reset switch lights and lockout occurs immediately. The blower motor will continue to operate.

The flame failure light and alarm bell (optional) are energized 10 seconds later.

The blower motor will be de-energized. The lockout switch must be manually reset before operation can be resumed. (Refer to previous caution notice.)

3.4.3 — Loss of Flame

If a flame outage occurs during normal operation and/or the flame is no longer sensed by the detector, the flame relay will trip within 2 to 4 seconds to de-energize the fuel valve circuit and shut off the fuel flow. The reset switch lights and lockout occurs immediately. The blower motor continues operation. The flame failure light and alarm bell (optional) are energized 10 seconds later.

The blower motor will be de-energized. The lockout switch must be manually reset before operation can be resumed. (Refer to previous caution notice.)

If the burner will not start, or upon a safety lockout, the Troubleshooting section in Chapter 8 and the technical bulletin should be reviewed for assistance in pinpointing problems that may not be readily apparent.

The program relay has the capability to self-diagnose and to display a code or message that indicates the failure condition. Refer to the control bulletin for specifics and suggested remedies. Familiarity with the program relay and other controls in the system can be obtained by studying the contents of the manual and the bulletin.

Knowledge of the system and its controls will make troubleshooting much easier. Costly down time or delays can be prevented by systematic checks of the actual operation against the normal sequence to determine the stage at which performance deviates from normal. Following a routine may possibly eliminate overlooking an obvious condition, often one that is relatively simple to correct.

Remember, a safety device, for the most part, is doing its job when it shuts down or refuses to operate. Never attempt to circumvent any of the safety features.

Preventive maintenance and scheduled inspection of all components should be followed. Periodic checking of the relay is recommended to see that a safety lockout will occur under conditions of failure to ignite either pilot or main flame, or from loss of flame.

CHAPTER 4

Profire Burner

The Model 4WG uses a Cleaver-Brooks Profire FP, D, or LND Series burner, depending on boiler HP and emissions level.

BOILER / BURNER CHART 4WG			
Boiler Diameter	Boiler HP	Burner Model	
		Standard Emissions	30 PPM
60”	100	Profire FP	Profire LND
	125	Profire FP	Profire LND
67”	150	Profire FP	Profire LND
	200	Profire FP	Profire LND
78”	250	Profire FP	Profire LND
	300	Profire FP	Profire LND
85”	350	Profire D	Profire LND
	400	Profire D	Profire LND
96”	500	Profire D	Profire LND
	600	Profire D	Profire LND
106”	700	Profire D	Profire LND
	800	Profire D	Profire LND

4.1 - Profire FP

Operating Controls

The control panel contains a flame safeguard programming control, motor relays (starters), and terminal strips mounted internally on a panel subbase. Lights, switches, and a control circuit breaker are mounted externally on the panel as indicated below:

Component	Description
1. On-Off Burner Switch	On-Off selector switch.
2. Fuel Selector Switch	• Gas Position: Selects gas as the firing fuel. • Off Position: Burner off. • Oil Position: Selects oil as the firing fuel.
3. Control Circuit Breaker	Supplementary low overcurrent protection only. No larger than 15 amps.
4. Auto-Manual Modulation Selector Switch	• Auto Position: Selects boiler modulation control. In this position, the burner will operate automatically in response to load demand. • Manual Position: Selects 135 ohm potentiometer for manual modulating control.
5. Manual Modulating Control	135 ohm (for full modulation burners only) increases or decreases the burner firing rate manually.
6. Signal Lamps	• Power On (white): Illuminates when the control circuit is energized (powered). • Ignition (amber): Illuminates when the ignition transformer is powered, and pilot valve is energized (opened). • Main Fuel (green): Illuminates when the main fuel valve or valves are energized (open). • Flame Failure (red): Illuminates when the flame safeguard system fails to detect pilot or main flame.
7. Modulating Motor	Operates the air damper and fuel rate valves through a linkage system to adjust air-fuel ratios under all load conditions.
8. Ignition Transformer	Provides high voltage spark for ignition of gas pilot or main flame direct spark models.

Flame Safeguard Control

The flame safeguard controls the operating sequence of the combustion system (pre-purge, pilot, firing, and shutdown). The flame safeguard programmer incorporates a flame sensing cell (scanner) to shut down the burner in the event of pilot flame or main flame failure. Other safety controls shut down the burner based on sequence of operation as shown in the manufacturer's flame safeguard manual.

Combustion Air Handling System

Air from the impeller flows through the blast tube and baffle to mix with fuel in the ignition zone. Combustion air flow rate is determined by the position of the air regulating blades at the inlet of the impeller. Linking the air flow with fuel flow provides efficient combustion at all firing rates.

Component	Description
1.Motor and Blower	The impeller is directly driven by the motor at 3450 rpm. Combustion air is supplied by a heavy duty balanced backward curved impeller. The impeller remains free from dirt accumulation.
2. Air Volume Regulator	The air damper is located in the air inlet housing. Low-High-Off, Low-High-Low, or Full Modulation burners have the damper directly driven by the modulating motor.
3. Combustion Air Proving Switch	A pressure sensitive switch actuated by air pressure created by the blower fan. Contacts close to prove combustion air flow.

Oil System

Combination and light oil-only burners are high pressure atomizing burners using fuel pressure for atomization. Atomized fuel is discharged from the nozzle as a fine conical spray.

Component	Description
1. Fuel Unit	Direct driven from the blower motor with a flexible coupling at 3450 rpm, and set for 300 psi operation, the fuel unit is two-stage (two sets of gears) and must be installed for a two pipe installation, one suction and one return line. Separately driven oil pumps are available as an option to the standard arrangement.
2. Nozzle	The nozzle meters oil flow delivering a specified amount at a specific pressure. Fuel pressure (mechanical) atomizes oil in a fine conical spray pattern from the nozzle orifice. The burner is supplied with nozzle(s) to fire to its maximum rate unless a different firing rate was specified. Return flow nozzle(s) are used on the full modulation burners.
3. Nozzle Adaptor	The nozzle adaptor provides the the means for connecting fuel lines with the nozzle.
4. Oil Solenoid Valves	Two normally closed (N.C.) valves and one normally open (N.O.) solenoid valves are part of the oil system on Low-High-Off and Low-High-Low burners. The two N.C. valves provide positive shutoff of fuel oil while the one N.O. valve cycles the burner to high fire when closed.
5. Oil Metering Valve	The firing rate is controlled by an adjustable metering valve in the return line. At low fire, the metering valve is open, and is closed at high fire.
6. Oil Filter	Prevents foreign matter from entering the burner oil system. This item is provided as an option and shipped loose with the burner.

Fuel is delivered to the fuel unit, either by gravity, fuel unit suction, or by a circulating pump, through a fuel oil filter. Pressurized fuel returns to the storage tank until the two solenoid valves open. On direct spark ignited burners, ignition occurs when the oil valves open. Where gas pilots are provided, the oil valves open after the pilot is proven. Oil input rate is controlled by the oil metering valve, which varies the flow to meet load demands. The low fire positions bypass oil back to the storage tank. At high fire, the metering valve is in the closed position. The modulating motor positions the metering valve and the air damper simultaneously.

Gas Handling System

Depending upon the requirements of the regulating authority, the gas control system and gas train may consist of some, or all, of the following items:

Main Gas Train Component	Description
1. Gas Volume Valve	The butterfly type valve is positioned by linkage from the modulating motor and controls the rate of flow of gas.
2. Main Gas Valves	Electrically operated safety shutoff valve(s) that open to admit gas to the burner. Standard U.L. burners include: • Models 13-25: one gas diaphragm valve and one safety solenoid valve • Models 30-42: one motorized gas valve w/proof of closure • Models 54-145: one motorized gas valve w/proof of closure and one safety solenoid valve
3. Main Gas Regulator	Regulates gas train pressure to specified pressure required at the burner manifold. Input is set by main gas pressure regulator adjustment.
4. Main Gas Cocks	Used for manual shutoff of the gas supply upstream of the pressure regulator. A second shutoff cock downstream of the main gas valve(s) provides a means of testing for leakage through the gas valve(s).
5. High Gas Pressure Switch (Models 25-145)	A pressure actuated switch that remains closed when gas pressure is below a selected setting. Should the pressure rise above the setting, the switch contacts will open causing main gas valve(s) to close. This switch requires manual reset after being tripped.
6. Low Gas Pressure Switch (Models 25-145)	A pressure actuated switch that remains closed when gas pressure is above a selected setting. Should the pressure drop below this setting, the switch contacts will open, causing main gas valve(s) to close. This switch requires manual reset after being tripped.

Metered gas flows through the main gas shutoff cock, through the pressure regulator to the automatic gas valves and butterfly valve to the gas manifold. The butterfly gas valve modulates flow to burner input demand. The butterfly valve is positioned through mechanical linkage by the modulating motor. The air control damper is positioned simultaneously by the modulating motor. The automatic gas valve(s) cannot be energized unless the combustion air proving switch is closed. The low and high gas pressure switches must be closed to prove proper gas pressure.

A normally open vent valve, if required, is located between the two automatic gas valves. This valve is shut when the automatic gas valves are open. When the automatic valves are closed, the vent valve is open for venting gas to the outside, should any be present.

NOTE: Gas train components upstream of the butterfly valve are shipped loose to be mounted by the installer.

NOTE: The pilot gas supply connection must be upstream of the main gas pressure regulator.

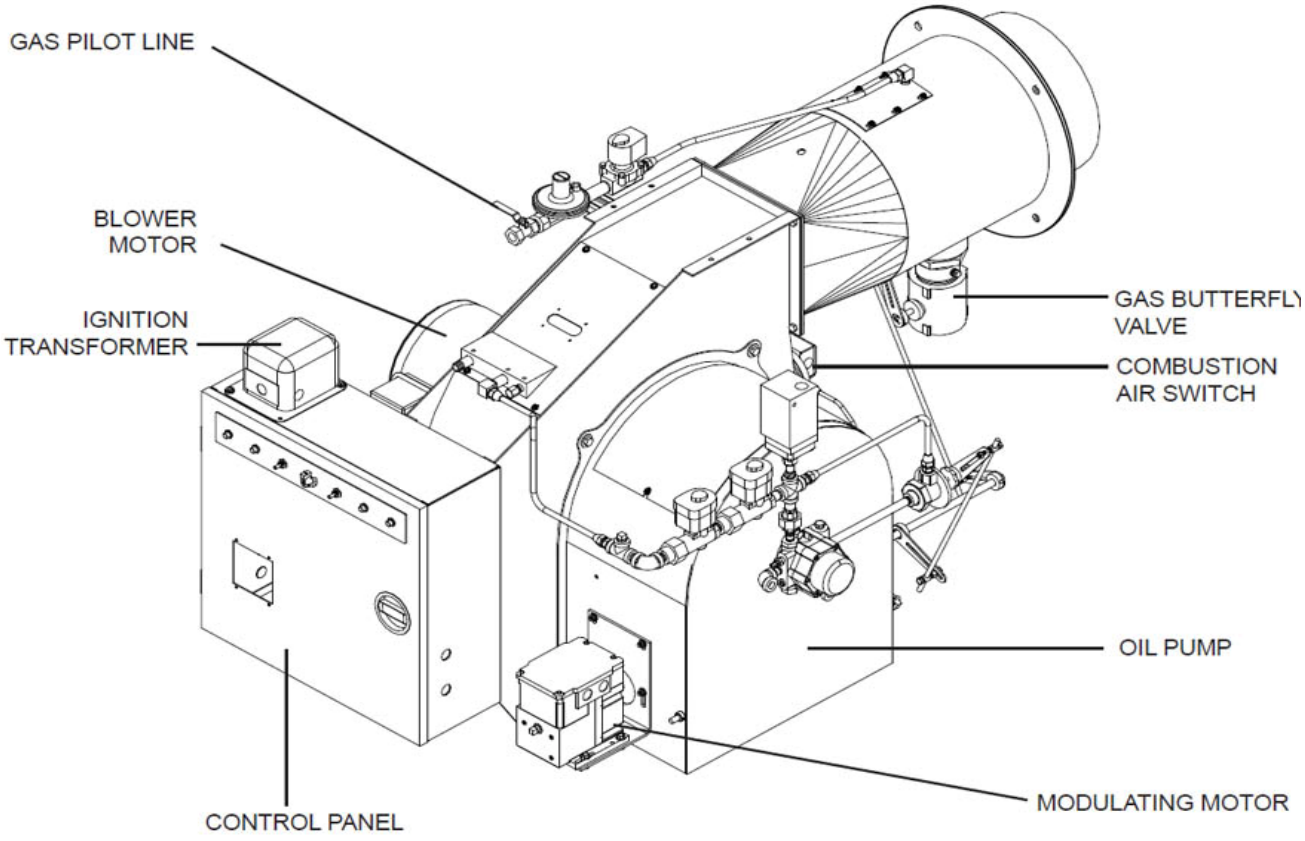


FIGURE 4-1. Burner Unit

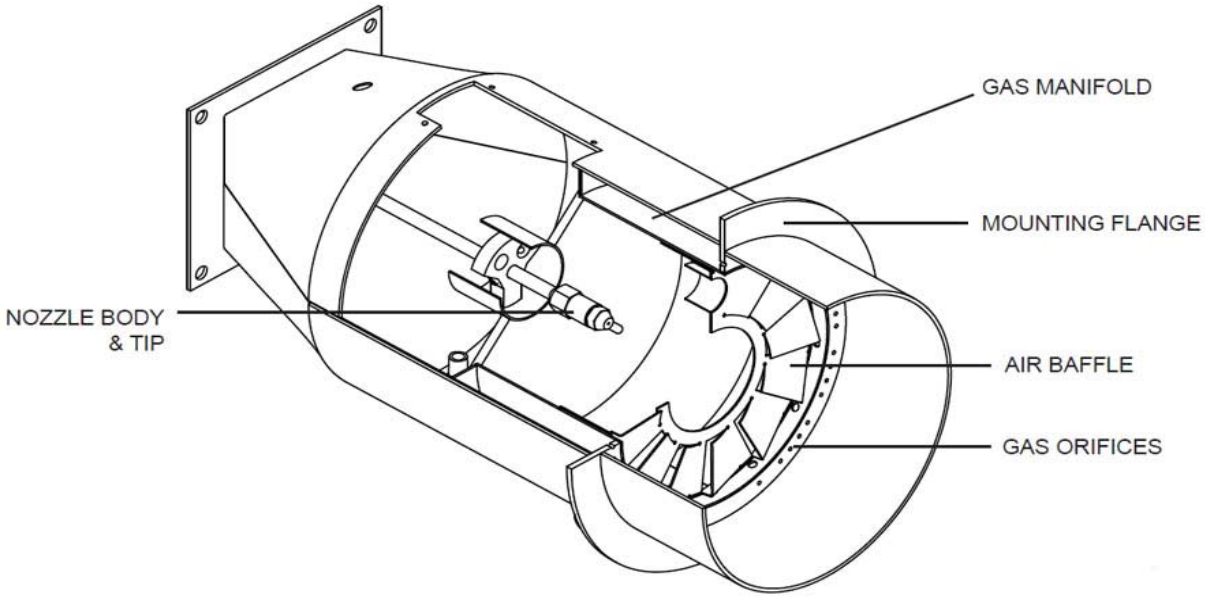


FIGURE 4-2. Burner Internal Components

4.1.1 - Preparation for Initial Startup

When the installation is complete and all electrical, fuel, water, and vent stack connections are made, make certain these connections are tight. The operator should become familiar with the burner, boiler controls, and components. Adjustment procedures given in Chapter 4 should be reviewed prior to firing. The wiring diagram should also be studied along with the operating sequence of the burner programmer. Check the electrical power supply for accordance with the nameplate specifications for all motors and controls.

Read and understand starting instructions before attempting to operate the burner. The following checks must be made:

Component	Inspect
Boiler	Check boiler water level. Be sure all boiler valves are installed correctly and positioned properly. Set the high limit control slightly above the operating control. Set the operating control at the desired temperature or pressure.
Burner	For protection in shipment, the flame safeguard control chassis is shipped unmounted. Check all screw connections before attaching the flame safeguard chassis to the base. The screw must be secure to assure low resistance connections. The relay chassis is mounted on the subbase with a screw which, when tightened, completes the connection between the sub-base and chassis contacts. Press the manual reset button to be sure safety switch contacts are closed. Check fuses in the main panel and in the burner control cabinet. Check wiring to the burner control cabinet for compliance with the wiring diagram and local codes. The control cabinet components are 120 volt. If a control transformer is supplied, ensure that the supply voltage matches its primary voltage. Check motor rotation by momentarily closing the starter or relay. Blower rotation is clockwise when viewed from the drive end. Check the pilot electrode setting. Refer to Chapter 4. Check control linkage for proper movement of the air volume damper and fuel metering components. This can be done by loosening the linkage at the actuator lever and manipulating by hand. Check the air shutter and adjust the low fire setting. Refer to Chapter 4.

Check to make certain that all plugs, connections, linkages, etc. are tight. Prior to initial firing, oil flow and pressure should be verified.

Gas Burners

A representative of the gas utility should turn on the gas. Determine by a test gauge upstream of the burner regulator that sufficient pressure exists at the entrance to the gas train. The gas pressure regulator must be adjusted to the pressure required and the pressure setting recorded.

On combination fuel models, set the selector switch to gas. On initial startup it is recommended that the main gas shutoff cock remain closed until the programmer has cycled through pre-purge and pilot sequences to determine that the main gas valve opens. Turn the burner switch "OFF" and let the programmer complete its cycle. Check to see that the gas valve closes tightly.

On burners equipped with high and low gas pressure switches, set the switch pressure actuating levels and record the settings for future service reference.

See the burner specification nameplate inside the control panel door for minimum and maximum input rate and required manifold pressure.

When the conditions covered above and in Chapter 2 are assured, the burner is ready for firing. Refer to Section 3.5 for starting and operating information.

Oil Burners

Prior to initial firing, oil flow and pressure should be verified. If the burner is a dual fuel model, make certain that the main gas shutoff cock is closed and the fuel selector switch is set to "OIL."

Oil Flow

If the oil supply tank is below the level of the oil fuel unit, it is recommended that the suction line be primed with oil prior to starting the pump to avoid the possibility of damage to the pump through operation without lubrication.

To check for proper pump rotation, momentarily energize the starter. With rotation verified, operate the pump to determine that oil circulation is present. Observe the oil burner pressure gauge. If no pressure shows after a few moments, stop the oil pump and re-prime. If the supply tank is lower than the pump, it is possible that the initial priming of the suction line, followed by operation of the pump, will not establish oil flow. This might be caused by an obstruction in the suction line, excessive lift, inadequate priming, suction line leaks, etc. Until oil flow is established, avoid prolonged operation of the pump. If oil flow is not established after a second priming, investigation is required.

A vacuum (or compound pressure-vacuum) gauge should be installed at the suction port of the pump. It is advisable that the reading be less than 15" Hg vacuum. Vacuum in excess of this may cause unstable firing.

Oil Pressure and Vacuum

If the vacuum gauge reads higher than calculated, look for restriction in the suction line, a closed valve, kinked copper tubing, plugged filter, sticking check valve, frozen oil line, undersized oil line, or excessive lift.

When there is a positive head of oil at the fuel unit, either from a gravity or by pump circulation, the pressure must not exceed 3 psi at the fuel unit suction inlet. Special pressure regulating valves are available for suction pressure above 3 psi. The fuel unit discharge pressure should be set at 300 psi.

Burner Settings

To ensure reliable and safe burner performance, the location and gap setting of the electrode for direct-spark igniters, and the relative positions of the burner nozzle, diffuser, and air baffle components must be correctly set. The air damper blades must be adjusted, relative to the established flow rates, to provide the correct amount of air for complete efficient combustion.

These items are preset at the factory, but must be checked prior to placing the burner into initial service, or after conducting any service work that may have altered their positions. Refer to Chapter 4.

Combustion Settings

Fuel and air flow rates are individually adjusted at low fire and at high fire to achieve rated heat input, firing rate turndown, optimum efficiency, safe operation, and the ability to cope with environmental changes (including air temperature, humidity, barometric pressure) and fuel property changes. Refer to the nameplate inside the control panel for minimum and maximum fuel input ratings. Also refer to Chapter 4.

Test Equipment

The following test equipment should be on site:

- Combustion analyzer with O_2 or CO_2 indication
- U-Tube manometer, or pressure gauge, to measure gas pressures (main and pilot), pressure and vacuum gauge for the oil burners
- Inclined manometer to measure draft pressures
- Smoke spot tester for oil burners and CO analyzer for gas fired units
- Voltmeter/Ammeter
- Stack thermometer and thermocouples

⚠ Warning

Read the flame safeguard manual and fully understand its content before attempting to operate this equipment. Failure to follow this instruction may result in serious personal injury or death.

⚠ Warning

Should a starting failure occur for any reason, combustible fumes may fill the combustion chamber. Never attempt to re-light the burner under these conditions. Before re-lighting the combustion chamber must be purged.

Sequence of Operation

The programming control sequences the operation of all controls and components through the starting, ignition, firing, and shutdown cycle. The burner and control system are in starting condition when:

a. the operating and high limit control (temperature and pressure) are below their cutoff setting
b. all power supply switches are closed
c. power is present at the control panel

Refer to the manufacturer's literature on programming controls and burner wiring diagrams for detailed information.

Electrical Interference Test

Prior to putting the burner into service, conduct the following test to ascertain that ignition spark will not cause the flame relay to pull in.

Gas Fired

1. Close the pilot and main line manual gas valves.
2. Start the burner and at the time of the pilot trial with just the electrical ignition system energized. The flame relay should not pull in (should not be energized).
3. Upon completion of a successful test, proceed with startup procedures.

Oil Fired

1. Disconnect the electrical power to the burner.
2. Disconnect the electric oil safety shutoff valve.
3. Reconnect electric power.
4. Close the pilot line manual gas valve, if used, with just the electrical ignition system energized. The flame relay should not pull in.
5. Upon completion of a successful test, disconnect the power supply.
6. Reconnect the oil safety shutoff valve and turn on the manual pilot gas valve.
7. Reconnect the power supply and proceed with startup procedures.

4.1.2 - Startup and Operating

Gas Burners

A gas valve leak test must be performed on the automatic safety shutoff valves located in the main gas train prior to any initial commissioning or subsequent maintenance of the burner and gas train systems - where automatic valve proving systems interlocked with the main burner safety control are not provided. This test should be performed periodically to ensure no leakage of valves in their closed or de-energized position.

Refer to the diagram below when following this procedure. The unit should be taken out of service if the unit fails any of the following tests. Any defective part must be replaced prior to putting the equipment back into service.

⚠ Warning

Failure to follow this procedure may result in explosion, fire, property damage, and serious personal injury or death. This procedure must be performed by authorized and qualified personnel only.

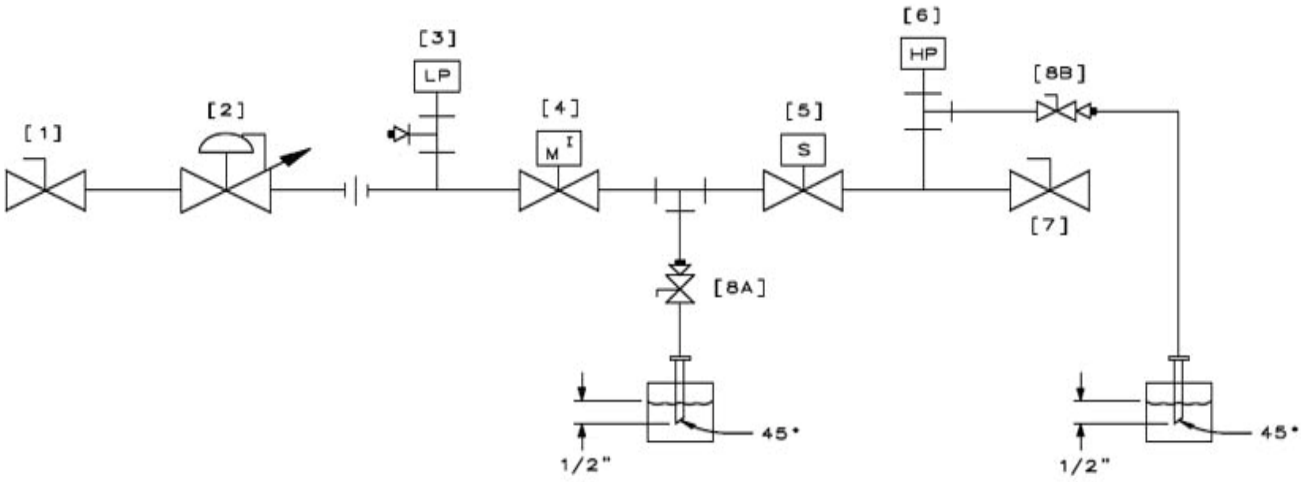


FIGURE 4-3. **Bubble Test Diagram**

1. Close (or shut off) the manual valve [7] downstream of the automatic safety shutoff valves, trapping gas pressure between the safety shutoff valves and the manual valve and causing a flame failure. This should close the auxiliary safety shutoff valve [4] and the main gas safety shutoff valve [5]. If both or either valve fails to close, do not proceed until the problem has been corrected.
2. Release gas pressure at the leak test cock [8B] between the manual valve [7] and the main gas safety shutoff valve [5], then conduct a bubble test for a leak through the blocking valve [5]. If there is no leak, close the test cock.
3. Release gas pressure at the test cock [8A] and bubble test for a leak through the auxiliary safety shutoff valve [4]. If no leak is observed, close the test cock and go to the next step. If either valve leaks, correct the problem and retest 10 times before proceeding.
4. When there are no valve leaks, open the manual valve [7] and re-light the burners. Then close the manual valve [1]. The safety shutoff and blocking valve should close due to low gas pressure.
5. Re-light the burners. Reduce the high gas pressure switch [6] setpoint setting until it reaches the operating gas pressure, which should cause the auxiliary and main gas safety shutoff valves to close from high gas pressure. Return the setpoint to its original position before proceeding.
6. Shut off the combustion air blower. This should cause a failure due to low air pressure and cause the safety valves to close.
7. Reset all manual valves to their normal setting for operation. Make sure all electric valves are operating normally. Make sure all test cocks are closed before resuming normal operation.

Initial Startup

1. Close the downstream main and pilot gas cocks. Make sure the "ON-OFF" switch is in the "OFF" position. Actuate the manual reset button of the flame safeguard control to close the safety switch contacts.

2. For Low-High-Off or Low-High-Low and Full Modulation models, set the "MANUAL-AUTO" switch to the "MANUAL" position.
3. Set the manual potentiometer to the low fire position.
4. Open the gas pilot cock and check the pressure. A normal setting is 3" to 6" WC when the pilot is burning.
5. Set the "ON-OFF" switch to "ON." The burner will start and pre-purge. After pre-purge, the ignition transformer and the gas pilot solenoid are energized.
6. On initial startup it is recommended that the main gas shutoff cock remain closed until the programmer has cycled through pre-purge and pilot sequences. Determine that the main gas valve opens. When this is confirmed, turn the burner switch to "OFF" and allow the programmer to finish its cycle.
7. Check to see that the gas valve has closed tightly. If ignition does not occur, turn the burner switch "OFF" and allow the programmer to recycle for a new ignition trial.
8. Turn the burner "ON" and after pilot ignition, when the flame relay pulls in, the slow opening, motorized, main gas valve is energized. Slowly open the downstream manual shutoff gas cock. Main flame should ignite at this time. The gas Valve and air damper continue advancing until high fire is reached.

Setting Combustion

Do not repeat unsuccessful light off attempts without rechecking the burner and pilot adjustment. Vent fuel vapors from the combustion chamber after each unsuccessful light off attempt. Set the gas low fire rate by adjusting the butterfly valve and air linkage. Referring to the Chapter 4 and using a combustion analyzer, adjust the low fire ratio (typical combustion analysis for low fire is 4% to 5% O_2 on standard turndown systems). Verify the minimum input rate by measuring the gas meter.

When low fire is adjusted, shut down the burner. Restart several times to be sure the low fire setting is suitable. Readjust if necessary. Never start the burner with fuel vapor in the furnace. In case of emergency, open the main power switches and close all fuel valves. After combustion adjustments are satisfactorily set, allow the heating vessel to slowly reach normal operating pressure or temperature.

After the boiler has reached operating temperature or pressure, turn the potentiometer switch in small increments to the high fire position. Check high fire at this point using combustion instruments. High fire combustion analysis typically is 2.0% to 3.5% O_2. Verify maximum input rate by measuring the gas meter.

Do not disturb established low fire adjustment. Allow the burner to return to low fire position before adjusting high or intermediate settings. CO levels should be less than 50 ppm as the target value.

Oil Burners

1. Set the fuel selector switch to "OIL" and the "ON-OFF" switch to the "OFF" position.
2. Actuate the manual reset button of the flame safeguard control to close the safety switch contacts.
3. Set the "ON-OFF" switch to "ON." The burner will start and pre-purge. After pre-purge, the ignition transformer will direct spark. If the flame detector proves the presence of a satisfactory pilot, the programmer will proceed to main flame ignition.

4. Make initial air shutter settings for smooth ignition. Return line oil pressure should be set according to the information in Chapter 4. Do not repeat unsuccessful light off attempts without rechecking burner and pilot adjustment. Vent fuel vapors from the combustion chamber after each unsuccessful light off attempt.
5. Set the oil low fire rate by adjusting the oil return pressure and air linkage. Refer to Chapter 4.
6. Using the combustion analysis instrument, adjust the low fire. Typical combustion analysis for low fire is 4.0% to 6.5% O_2.
7. When low fire is adjusted, shut down the burner. Restart several times to be sure the low fire setting is suitable. Readjust if necessary. Never start the burner with fuel vapor in the furnace. In case of emergency, open the main power switches and close all fuel valves. After combustion adjustments are satisfactorily set, allow the heating vessel to slowly reach normal operating pressure or temperature.
8. After the boiler has reached operating temperature or pressure, turn the potentiometer switch in small increments to the high fire position. This will cause the metering valve to close, resulting in an increase in the oil pressure feeding the burner nozzle. In high fire the oil metering valve should be in the fully closed position and the fuel oil pressure should be about 300 psi. Check high fire at this point using combustion instruments. High fire combustion analysis is typically 3.0% to 4.0% O_2. Verify maximum input rate by measuring the oil meter if available or by weighing the oil.

The burner should be set up and maintained to yield smoke spot levels less than a #1 spot (ASTM D2156 Shell-Bacharach Scale) to minimize soot buildup in the boiler.

Do not disturb established low fire adjustment. Allow the burner to return to low fire position before adjusting high or intermediate settings.

Combination Gas-Oil Burners

In general, the combination fueled system is to be started first using oil, because, as a fuel, oil has a greater combustion air requirement than natural gas.

Refer to the information in Chapter 4 for gas or oil burner adjustment procedures.

Once the adjustments are set for oil, shut down the burner and restart and adjust the natural gas fuel. Do not readjust the air shutters. The adjustment is made by balancing the fuel input rate against the existing flow of combustion air.

When conditions covered above are assured, refer to Sections 3.7 and 3.8.

NOTE: Sizes 1 and 2 combination gas/oil units use a direct coupling from the blower motor to the oil pump. When firing gas for an extended period of time, the coupling should be manually removed and replaced only when firing oil. If the coupling is left connected to the blower motor, ensure that there is proper oil circulation at all times to avoid damage and seizure of the pump.

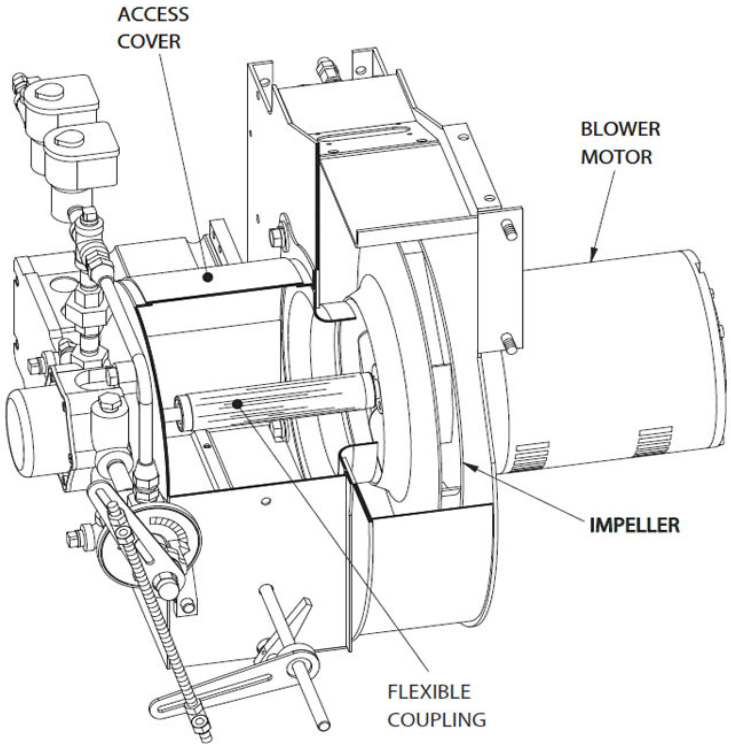


FIGURE 4-4. Flexible Coupling Location

4.1.3 - Normal Operation

Normal operation must be with the "MANUAL-AUTO" switch selector on "AUTO."

In automatic operation, the operating cycle always proceeds sequentially through pre-purge, pilot ignition, main flame ignition, run, and post-purge. The length of purge and ignition trial vary according to the type of programmer used.

During the run cycle, burner input is regulated to the load demand by the modulating pressure or temperature control on the boiler. The burner will continue to modulate until the operating pressure or temperature is reached.

Programmer control operation should be tested when the burner is initially placed into service, when the burner is initially placed into service, when a control is replaced, and at scheduled intervals in the maintenance program.

4.1.4 - Shutdown

When the operating limit control setting is reached or the burner switch is turned "OFF," the following sequence occurs:

1. The fuel valve(s) de-energize and the flame extinguishes. The blower motor continues running during post-purge (if so equipped with the post-purge feature).
2. At the end of the post-purge the blower motor is de-energized. The programmer returns to its starting position and stops. The unit is ready to restart.

Abnormal shutdown might result from motor overload, flame outage, low water, current or fuel supply interruption, combustion or atomizing air pressure below minimum level, tripped circuit breakers, blown fuses, or other interlock devices. Check for the cause and correct it before restarting the burner.

Safety shutdown caused by ignition or flame failure will actuate a red indicator light and energize an audible alarm (if so equipped). If the programmer has a non-recycling interlock circuit, any interruption in this circuit during the pre-purge or firing cycle will cause a safety shutdown. This type of shutdown requires manual reset of the programming control and must be corrected before operation can be resumed.

4.1.5 - Adjustments

While each burner is tested at the factory for correct operation before shipment, variable conditions such as burning characteristics of the fuel used and operating load conditions may require further adjustment after installation to assure maximum operating efficiency.

Prior to placing the boiler into initial service, a complete inspection should be made of all controls, connecting piping, wiring, and all fastenings such as nuts, bolts, and setscrews to be sure that no damage or mis-adjustments occurred during shipment and installation.

A combustion efficiency analysis made during the initial startup will help to determine what additional adjustments are required in a particular installation.

Combustion Adjustment on Oil and Gas

Efficient combustion cannot be properly judged by flame appearance, although it may help in making preliminary settings.

The proper settings of air-fuel ratios must be determined by flue gas analysis. Combustion gas analysis indicates the air to fuel ratio and the degree of complete combustion. Instruments are available to measure carbon dioxide (CO2), oxygen (O2), and carbon monoxide (CO). At no time should CO2 measurements alone be used to indicate proper excess air levels. Only O2 measurement can definitively show whether sufficient air has been provided for combustion.

Stack Temperature

Net stack temperature is obtained by subtracting the ambient temperature from the flue gas temperature. A high net stack temperature indicates wasted heat. Decreasing either the temperature or the volume of the flue gas, or both can reduce stack heat loss. Flue gas temperature is reduced by improving heat transfer or by reducing excess combustion air. A certain amount of excess air is necessary to complete combustion. More efficient burners require minimum excess air.

Smoke Measurement

Smoke measurements can be made using a variety of different methods. The standards will vary somewhat according to the equipment used, and instructions accompanying the instrument should be followed.

Smoky combustion can result from:

- improper air delivery
- insufficient draft
- improper fuel viscosity
- improper air-fuel ratio
- excessive air leaks in the combustion chamber
- improper fuel oil temperature

Test Equipment

The following test equipment should be used to setup and adjust the burner correctly:

- Combustion analyzer with O2 or CO2 indication
- U-Tube manometer, or pressure gauge, to measure gas pressures (main and pilot), vacuum and pressure gauges for oil
- Inclined manometer to measure draft pressures
- Smoke spot tester for oil burners and CO analyzer for gas fired units
- Voltmeter/Ammeter
- Stack thermometer and thermocouples

Air Flow Adjustments

The FP Series burners have a unique air shutter design that enables precise, independent air flow rate adjustments for both the high fire and low fire operating points. This design incorporates a variable main air shutter (mounted on a shaft and direct-coupled to the modulating motor), plus two adjustable, but non-modulating, air shutters.

The modulating main air shutter regulates the flow of inlet air through the fan at flow rates between high fire and low fire conditions according to the modulating motor position. One non-modulating air shutter, for high fire combustion air control, is adjusted to provide the correct amount of air while the system is operating at high fire fuel input rate with the main air shutter fully open. The other non-modulating shutter, for low fire combustion air control, is adjusted to provide the correct amount of air with the system operating at low fire input rate with the main shutter completely closed.

The three air shutters are mounted inside the air box assembly. The high fire and low fire shutters are mounted on independent shafts. A pointer, mounted on each shaft, indicates the set position of each non-modulating shutter. Adjustment of these shutters is accomplished by loosening a setscrew that holds the shutter shaft within a stationary collar mounted on the air box.

Combustion Settings

Fuel and air flow rates are individually adjusted at low fire and at high fire to achieve rated input, firing rate turndown, optimum efficiency, safe operation, and the ability to cope with environmental changes (including air temperature, humidity, barometric pressure), and fuel property changes.

Turndown capability for oil is less than that for gas due to the excess air requirement of oil for clean combustion. Therefore, on combination fueled burners, gas turndown performance may be restricted (or determined) by the excess air levels set initially for oil combustion.

Two key components residing in flue gas are used to optimize combustion efficiency: excess air and unburned fuel. The system should be adjusted to the minimum excess air quantity that provides low levels of unburned fuel with sufficient remaining oxygen to cope with normal atmospheric and fuel related changes. Unburned fuel is measured as carbon monoxide (CO) when burning natural gas, and smoke spots when burning oil.

Gas Adjustments

Low fire combustion analysis is typically 7% to 9% CO2 and less than .04% CO (400 ppm). A high fire reading is typically 9% to 10.5% O2 and less than .04% CO. The FP Series burners are capable of operating at low excess air and less than 50 ppm CO levels at all firing rates.

Fuel Oil Adjustments

Adjust for a "clean fire." typically for No. 2 oil, CO2 is 8% to 11% at low fire, and 10% to 13% at high fire.

The burner should be set up and maintained to yield smoke spot levels less than a #1 spot (ASTM D2156 Shell-Bacharach Scale) to minimize soot buildup in the boiler.

Gas Pilot Flame Adjustment

The gas pilot flame is regulated by adjusting the pressure setting of the pilot regulator. A normal setting is 3" to 6" WC when the pilot is burning. The flame must be sufficient to be proven by the flame detector and ignite the main flame. Although it is possible to visibly adjust the size of the pilot flame, obtain a proper DC volt or microamp reading of the flame signal.

The flame safeguard amplifier has a meter jack for this purpose. At initial startup and during planned maintenance, test the pilot flame signal, pilot turndown, and safety switch lockout. Refer to the flame safeguard instruction manual.

⚠ Warning

An ultra-violet flame sensor electrical spark interference test must be performed after final adjustment.

Check the pilot electrode setting. The pilot is accessible by loosening the four screws on the side of the blast tube and disconnecting the gas line.

Burner Settings

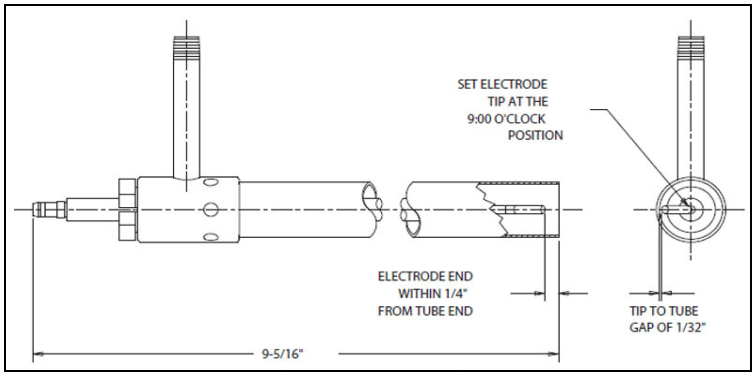
To ensure reliable and safe burner performance, the location and gap setting of the electrodes, and the relative positions of the burner nozzle, diffuser, and air baffle components must be set correctly. These items are preset at the factory, but must be checked prior to placing the burner into initial service, or after conducting any service work that may have altered their position.

The nozzle/diffuser assembly must be removed from inside the burner to enable measurement and adjustment. To remove:

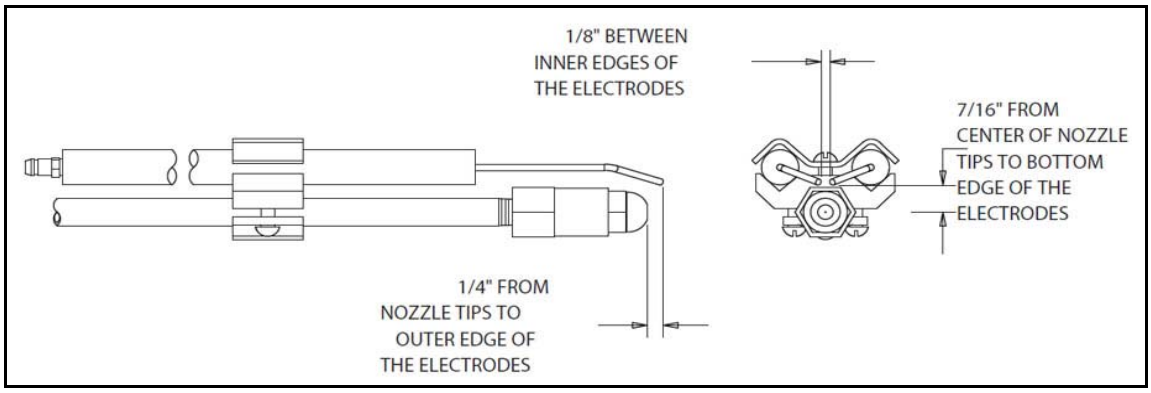
1. Lock out and tag the electrical power supply to the burner to prevent inadvertent operation during checkout or maintenance activities.
2. Disconnect the high voltage power supply from the oil-spark-ignition electrodes (if installed).
3. Disconnect the flame scanner and oil piping from the end of the blast tube.
4. Remove the fasteners that secure the drawer to the side of the fan housing, and remove the complete assembly.

For burners with a gas pilot:

1. Disconnect the pilot line and loosen the locking screws on the pilot access cover located on the side of the blast tube.
2. Disconnect the high voltage ignition cable by pulling it straight back, away from the pilot assembly. The pilot assembly will slide back and away from the diffuser.
3. Turn the assembly and retract it through the access hole.
4. Check the electrode position as illustrated.
5. Reassemble in reverse order.



Measure the position and gap of the pilot electrodes and compare them to the dimensions shown:



Adjust as follows:

1. Loosen the locking screws on the spark ignition clamp assembly.
2. Rotate and slide each electrode in the clamp, as necessary, to achieve the correct position relative to the burner tip.
3. Tighten the locking screws securely to lock the electrode in position. Apply a lock-tight type compound to the screws before tightening.

Measure the position of the tip of the nozzle to the diffuser and compare to the following drawer assembly drawings. To adjust:

1. Loosen the locking screws on the diffuser clamp.
2. Slide the diffuser clamp along the length of the burner pipe until the correct dimension is achieved.
3. Tighten the diffuser clamp securely to the burner pipe. Apply a lock-tight type compound to the screws before tightening.
4. Carefully install the drawer assembly into the burner. Reconnect the oil line, scanner, and high voltage power cable to the assembly.

Measure the position of the diffuser to the air baffle and compare it to the following drawer assembly drawings. To adjust:

1. Measure the distance between the leading edge of the diffuser and the front face of the inner ring on the air baffle assembly.
2. If adjustment is required, loosen the burner pipe locking setscrew located on the rear cap at the top of the fan housing, and slide the burner pipe until the correct dimension is achieved.
3. Tighten the burner pipe locking setscrew securely.

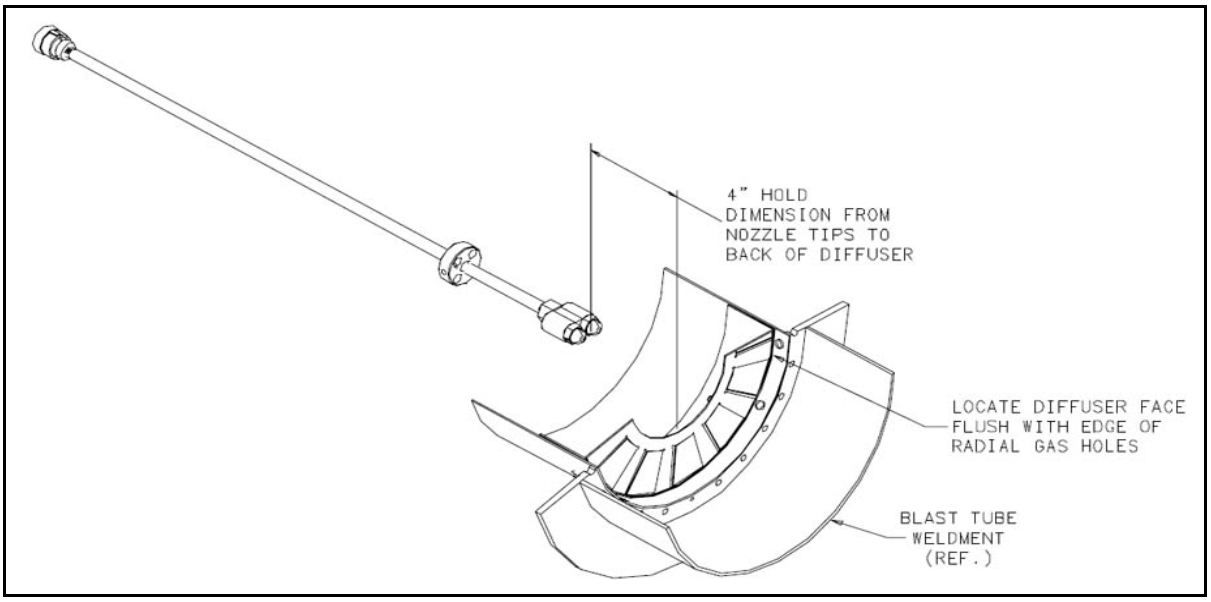


FIGURE 4-5. FP-3, 4200-6300

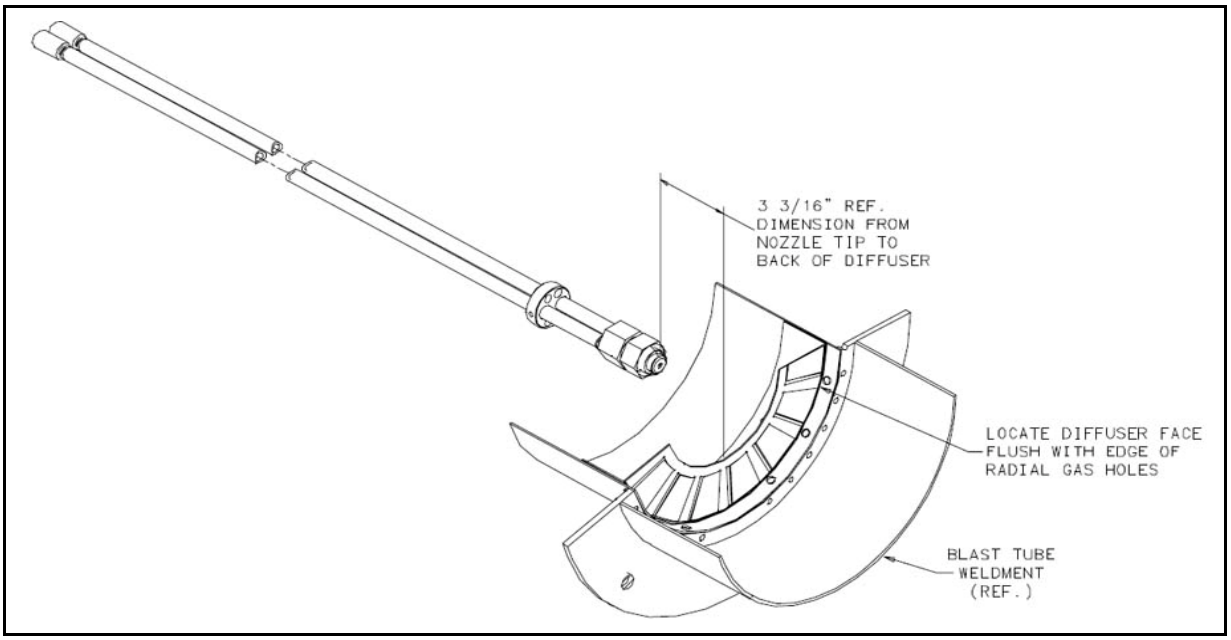


FIGURE 4-6. FP-4, 8400-12600

Pilot Turndown Test

For burners equipped with a gas pilot, conduct the following test:

1. Turn the burner switch "ON." This will start the blower motor and initiate the pre-purge sequence. Make sure a pressure gauge 0" to 10" W.C. or manometer is installed in the pilot line to monitor the pilot gas pressure.
2. When the pilot comes on, put the programmer timer on pilot hold by placing the "RUN-TEST" switch of the flame safeguard to the "TEST" position.

NOTE: Refer to the flame safeguard control manual instructions.

3. Check the flame signal strength. Adjust the flame signal by increasing or decreasing pilot gas pressure with the regulator spring. A normal setting is 3" to 4" W.C.
4. Perform a pilot turndown test by reducing the pilot pressure very slowly until the scanner loses sight of the flame and produces a flame lockout. Note the minimum pressure level.
5. After adjusting the pressure back to a normal level, set the programmer to the "RUN" position. Main flame will come on and the burner is in the low fire position.
6. Start and stop the burner several times to ensure proper pilot setting.

Setting Combustion

These procedures assume that the pre-startup tasks, checklist, electrical interference test, and pilot turndown tests have been performed in accordance with the instructions in this manual.

Allow the boiler to fully warm up before making adjustments for most efficient combustion. Refer to the boiler instruction manual for the boiler controls settings.

Gas Burners

The gas burners adjustments on a full modulation burner consist of the gas pressure regulator, butterfly gas valve, low and high gas pressure switches, and air dampers.

1. Open the manual gas shutoff cocks.
2. Check the gas pressure at the inlet of the regulator and the pressure downstream of the regulator. Make sure they are in accordance with the regulator specifications. The gas pressure required at the manifold is the pressure that is required to fire the burner at its rated capacity. To adjust the regulator, unscrew the cap located on top and turn the adjustment screw clockwise to increase pressure, or counterclockwise to decrease pressure.
3. Set the "AUTO-MANUAL" switch to the "MANUAL" position.
4. Position the manual flame control potentiometer in the "CLOSED" (low fire) position.
5. Turn the burner switch to the "ON" position. The burner will start and be in the low fire position.
6. After a few seconds, the O2 analyzer should have an accurate reading of the O2 present in the flue gas. Normally, O2 levels are set between 4% to 6% at low fire, with less than 50 ppm CO. To obtain the proper readings, adjust the gas butterfly opening and low fire air shutter. Take note of the readings and pressures at the burner manifold and gas train.

7. Operate the boiler at low fire until it is up to operating pressure (steam) or temperature (hot water). Then increase the fuel input to the boiler by turning the manual flame control potentiometer towards "OPEN" in small increments. This will cause the butterfly valve to open, allowing more gas into the burner.
8. At each point, allow the burner to operate for a few minutes before recording the O2, CO, and pressure readings. Observe that the O2 and CO levels remain within an acceptable limit. Adjust the pressure regulator, as necessary, to correct this situation. For burners with the cam trim option, adjust the cam screws throughout the range to obtain correct O2 and CO levels. Continue to do this until the burner reaches high fire (the potentiometer is at the "OPEN" position).
9. Adjust the high fire gas input to match maximum rating. At high fire, the butterfly valve should be near the full open position. Adjust the gas regulator so the manifold pressure matches the rating on the burner data plate. Verify and record the readings and pressures. High fire is typically 2% to 4% O2 with less than 50 ppm CO as a target value. Adjust the high fire excess air rate using the high fire shutter adjustment.
10. Modulate the burner to low fire. Again, verify the readings. The burner should be adjusted to provide correct fuel flow at a constant rate, at the low fire and high fire positions as indicated on the burner data plate. This is achieved by clocking the gas flow at the gas meter. The gas utility or gas meter calibration data should be consulted to determine the correction factors to be applied to the meter. Use the following formula to determine actual flow:

$$\text{Gas Input} = (\text{HHV}) \times \left(\frac{\text{Patm} + \text{Pgas}}{29.92}\right) \times \left(\frac{520}{\text{Tgas} + 460}\right) \times \left(3600 \frac{\text{s}}{\text{hr}}\right) \times \left(\text{RATE } \frac{\text{ft}^3}{\text{s}}\right) = \left(\frac{\text{Btu}}{\text{hr}}\right)$$

HHV = The higher heating value of the gas in Btu/ft3 (contact the local gas company for an exact measurement).
Patm = Atmospheric pressure in inches of mercury.
Pgas = Gas pressure ahead of the volumetric flow meter in inches of mercury.
Tgas = Gas temperature at the volumetric flow meter in degrees F.
RATE = Natural gas rate taken with the volumetric flow meter in ft3/second.

11. Adjust the low and high gas pressure switches by turning the adjusting screw until the indicator moves to a pressure slightly lower than normal operating pressure for the low gas pressure switch, and slightly higher for the high gas pressure switch (usually 20% below and 20% higher than normal pressure).
12. Tighten all linkages and marked settings. Complete the Startup report.
13. Turn the "MANUAL-AUTO" switch to "AUTO." The burner will now modulate according to the load demand to the boiler.

Oil Burners

The oil burner adjustments consist of the oil metering valve and air shutters. the firing rate is regulated by a metering valve in the nozzle return line. At low fire, the arrow on the valve points to approximately number 7, and at high fire it is in the closed position (no return flow), approximately at number 2. The oil metering valve position will vary the oil pressure to the nozzle. An oil pressure gauge should be installed in the return line to monitor the oil pressure. Oil pressure at low fire is approximately 80 psi to 100 psi and 300 psi at high fire.

1. Set the MANUAL-AUTO switch in the "MANUAL" position.
2. Set the manual flame control potentiometer in the "CLOSED" (low fire) position.

3. Turn the burner switch to the "ON" position. The burner will start and be in low fire.
4. Adjust low fire with the metering valve position to have approximately 80 psi to 90 psi, and adjust the low fire air shutter for a clean fire. Record the combustion reading from the flue gas analyzer, normally 8% to 11% CO_2 and less than No. 2 Smoke (Bacharach).
5. Operate the boiler at low fire until it is up to operating pressure (steam) or temperature (hot water). Then increase the fuel input to the boiler by turning the manual flame control potentiometer towards "OPEN" in small increments. This will cause the metering valve to close, resulting in an increase in the oil pressure feeding the burner nozzle.
6. At each point, allow the burner to operate for a few minutes before recording the CO_2, CI, Smoke, and pressure readings. Observe that the CO_2 and CI levels remain within an acceptable limit. Adjust the oil pressure as necessary, to correct his situation. For burners with the cam trim option, adjust the cam screws throughout the range to obtain correct CO_2 and CO levels. Continue to do this until the burner reaches high fire (the potentiometer is at the "OPEN" position).
7. Adjust the high fire fuel input to match maximum oil pressure. At high fire, the metering valve should be in the fully closed position and the pressure should be 300 psi. Verify and record the readings and pressures. High fire is typically 11% to 13% Co_2 with less than No. 2 Smoke. Adjust the high fire excess air rate using the high fire shutter adjustment.
8. Modulate the burner to low fire. Verify the readings once again. The burner should be adjusted to provide correct fuel flow at a constant rate, at the low fire and high fire position as indicated on the burner data plate.
9. Tighten all linkages and marked settings. Complete the Startup Report.
10. Turn the "MANUAL-AUTO" switch to "AUTO." The burner will now modulate according to the load demand to the boiler.

Combination Gas-Oil Burners

In general, the combination fueled system is to be started first using oil, because, as a fuel, oil has a greater combustion air requirement than natural gas. After being completely adjusted for oil combustion, the burner is re-started and adjusted using natural gas as fuel. Combustion adjustment of the combination burner for natural gas involves balancing the input rate only against the existing flow of combustion air, as established initially for oil.

NOTE: Do not readjust the air shutters when turning the combination burner for combustion of natural gas.

1. Set the "MANUAL-AUTO" switch to "MANUAL."
2. Position the manual flame control potentiometer in the "CLOSED" (low fire) position.
3. Turn the fuel selector switch to the "OIL" position.
4. Proceed with startup and adjustments using the same procedures defined above for oil burners
5. After the system has been completely adjusted for oil firing, turn the burner switch "OFF" and position the fuel selector switch to "GAS."
6. Proceed with startup and adjustments using the same procedures defined above for gas burners. Do not alter the air setting set for oil. Correct the O_2 levels by adjusting the butterfly valve.

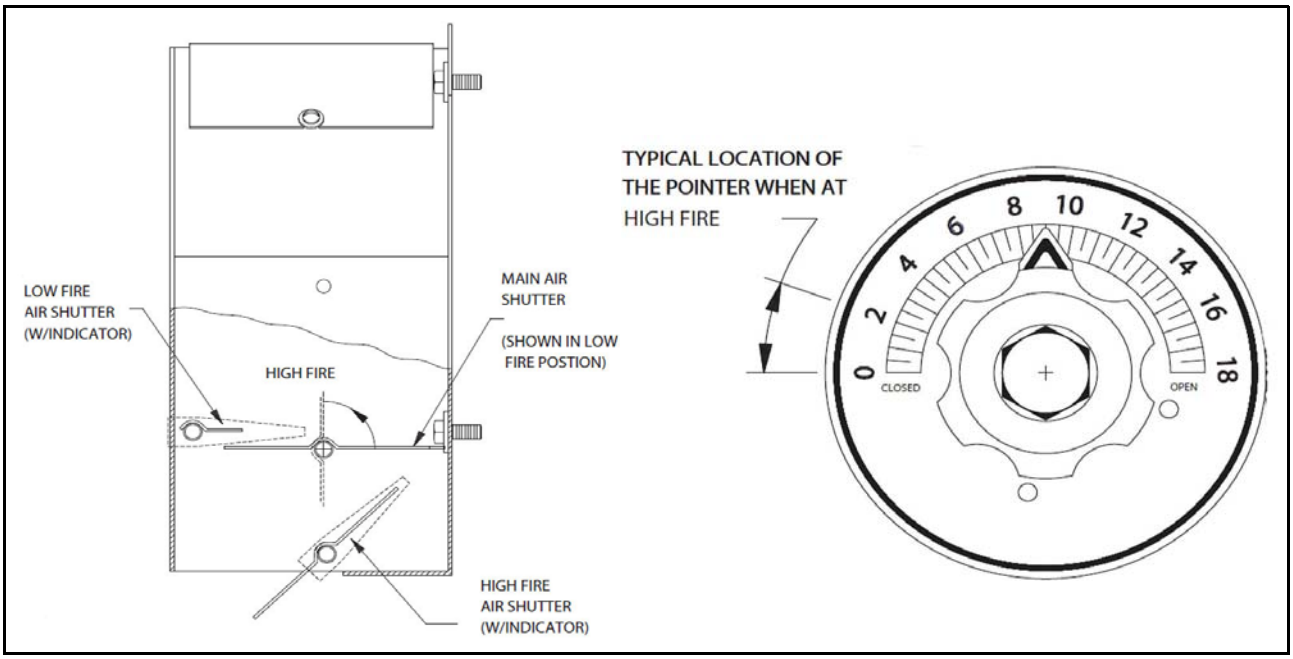


FIGURE 4-7. Shutter Positions and Metering Valve Dial

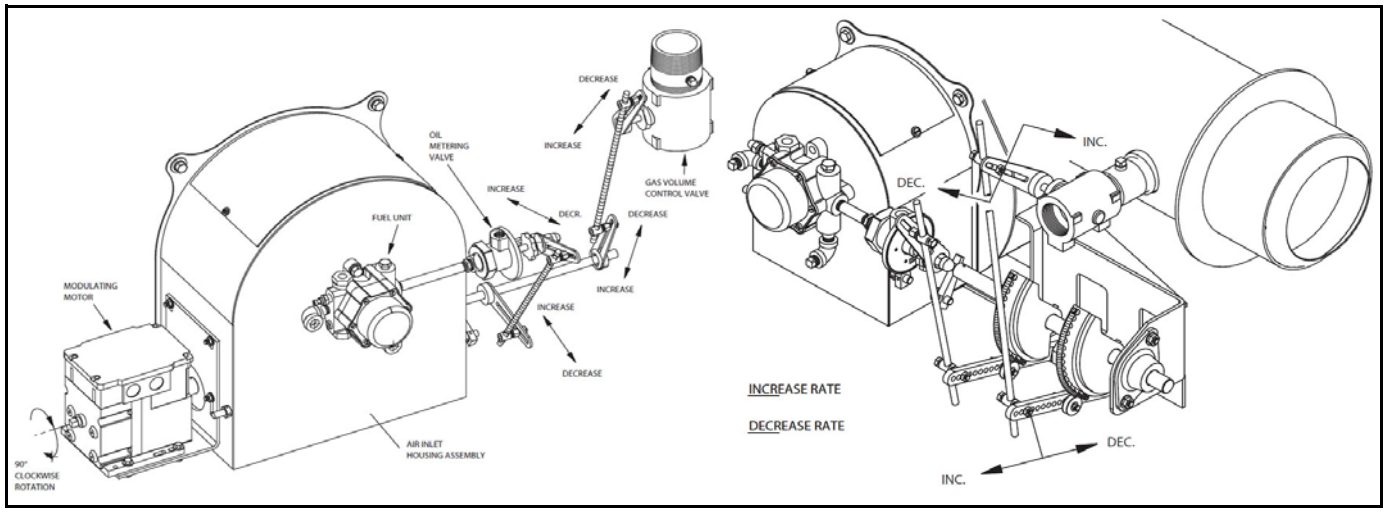


FIGURE 4-8. Linkage Adjustments

4.2 - Profire D/LND

Operating Controls

The control panel contains a flame safeguard programming control, motor starters, relays, time delays, and terminal strips mounted internally on a panel subbase. Lights, switches, potentiometers, a control circuit breaker, and flame safeguard displays are mounted externally on the panel as indicated:

Component	Details
On-Off Burner Switch	For gas or oil only.
Fuel Selector Switch	Gas-Off-Oil For combination gas-oil burners only. a) Gas Position: Selects gas as the firing fuel. b) Off Position: Burner off. c) Oil Position: Selects oil as the firing fuel. **NOTE:** When changing from oil to gas fuel, allow the programmer to complete post-purge and shut down before moving the selector switch to the gas position. This will allow the interlock circuit to de-energize at either the oil-air pump or the compressor.
Control Circuit Breaker	Supplementary low overcurrent protection only. No larger than 15 amps.
Auto-Manual Modulation Selector Switch	a) Auto Position: Selects boiler modulation control. b) Manual Position: Selects 135 ohm potentiometer for manual modulating control.
Manual Modulating Control 135 ohm	Increases or decreases the burner firing rate manually.
Signal Lamps	a) Power On (white): Illuminates when the control circuit is energized (powered). b) Ignition (amber): Illuminates when the ignition transformer is powered, and gas pilot valve is energized (open). c) Main Fuel (green): Illuminates when the main fuel valve or valves (gas or oil) are energized (open). d) Flame Failure (red): Illuminates when the flame safeguard system fails to detect pilot or main flame.

Flame Safeguard Control

The flame safeguard programmer incorporates a flame sensing cell (scanner) to shut down the burner in the event of pilot flame or main flame failure. Other safety controls shut down the burner based on sequence of operation as shown in the manufacturer's flame safeguard manual.

⚠ Warning

Read the flame safeguard manual and fully understand its contents before attempting to operate this equipment. Failure to follow this instruction may result in serious personal injury or death.

Combustion Air Handling System

The combustion air handling system consists of three major components:

Component	Details
Damper Assembly	A rotary damper regulates the combustion air volume and is positioned by a modulating motor. The damper is normally almost closed in the low fire position and opens as the burner drives toward a high fire position.
Motor Driven Impeller	The diameter of the impeller determines available air pressure and the width determines air capacity in cubic feet per minute. Alternate motor-impeller combinations are available for 50 cycle or 60 cycle power and for firing against either moderate or high furnace pressure. At altitudes up to 2,000 ft. above sea level, model "S" impellers are recommended for up to 1.5" W.C. furnace pressure. Model "P" impellers are recommended for furnace pressures from 1.5" to 4.0" W.C. For higher altitudes and higher furnace pressure, motor and impeller combinations are determined at the factory.
Stator Cone	The stator cone in the air housing transforms the rotating air velocity pressure to static pressure prior to air entry into the blast tube.

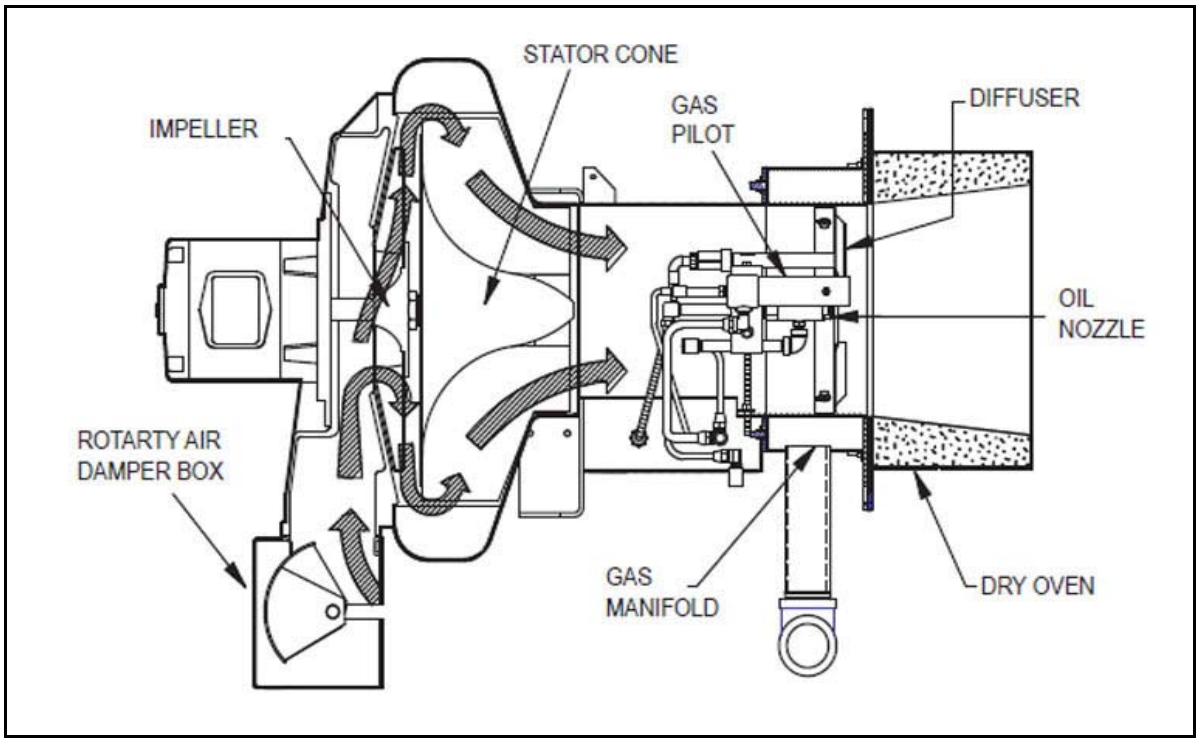


FIGURE 4-9. Damper, Impeller, and Stator Cone

Firing Rate Controls

Regardless of the fuel used, burner input is fully modulated between low fire and high fire on boiler demand. The firing rate is controlled by the potentiometer-regulated modulating motor. The combustion air control damper, oil metering pump, and/or gas volume butterfly valve are controlled through variable rate rod and lever linkages. The modulating motor rotates 90º from low to high position. Flow rate through each component is adjusted by positioning the control rods on the levers and the angular position of levers on shafts. The lever on the modulating motor shafts actuate the high fire position proving switch.

Firing Head

Access to the firing head is provided by swinging open the impeller housing. First, disconnect the damper linkage, release the housing latch, and swing the housing to the open position. An internal gas pilot is standard on all burners. Pilot gas pressure is adjusted at the pilot pressure regulator.

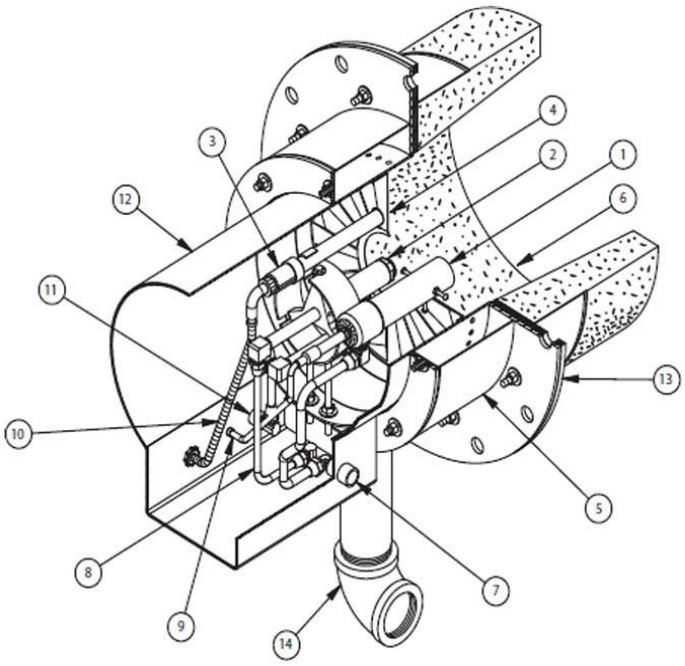


FIGURE 4-10. Firing Head Assembly

4.2.1 - Oil System

Air atomization

D Model burners use compressed air for atomization. Atomizing air is independent of combustion air. Either of two air/oil systems are used, depending on burner size and fuel. One system uses an integral air compressor/oil metering unit mounted on the burner and is driven by a separate motor. The other system is supplied with a separate compressor module for mounting near the burner.

3-Way Solenoid Valve

Metered oil enters the common port of the 3-way solenoid valve. During shutdown, pre- and post-purge the valve is de-energized (N.C. port closed) and all metered fuel oil returns to the storage tank. When the valve is energized, metered oil is directed to the nozzle through the N.C. port.

Nozzle Assembly

The nozzle assembly consists of four main parts:

- Body
- Compression Spring
- Swirler
- Tip

The swirler is held against the nozzle tip by the compression spring.

The nozzle body has inlet ports for air and oil lines. Metered fuel oil enters the nozzle body and flows through a tube to the swirler. Oil is forced from the core of the swirler to the side ports where it meets with atomizing air.

Atomizing air enters and passes through the nozzle body to grooves in the swirler, where it mixes with fuel oil. Air/oil passes through grooves and out of the nozzle orifice in a cone of atomized oil. Proper velocity and angle of the fine spray ensures good mixing with the combustion air, providing quiet starts and excellent combustion efficiency. During pre- and post-purge, the nozzle tip is purged with air. This prevents afterdrip or baked-on residue.

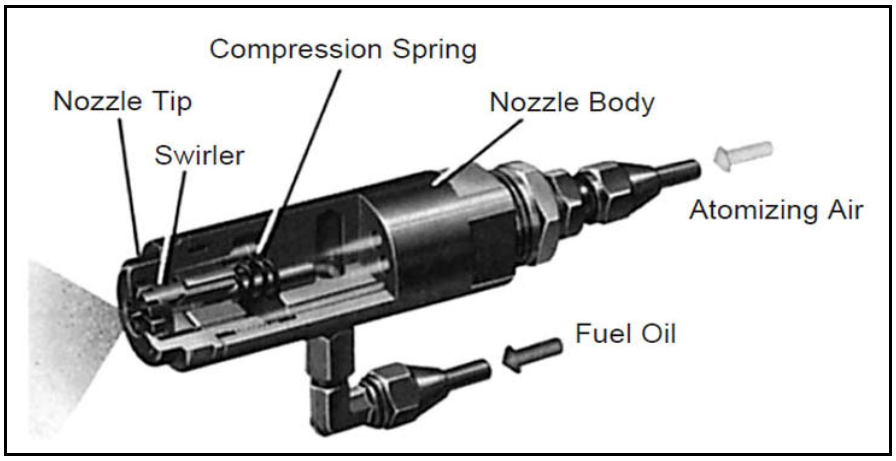


FIGURE 4-11. **Oil Nozzle**

Additional oil system components include:

- **Oil Strainer** - Prevents foreign matter from entering the burner oil system.
- **Atomizing Air Proving Switch** - Pressure actuated switch contacts close when sufficient atomizing air pressure is present. The oil valve will not open unless switch contacts are closed.
- **Air/Lube Oil Tank** - Burner mounted tank stores compressed air for oil atomization and oil for compressor lubrication. Contains wire mesh filter to separate lube oil from compressed air.
- **Integral Air/Oil Unit** - (models to size D145). These models utilize an integral air compressor/oil metering unit which is separately driven at 1725 rpm and mounted on the burner.

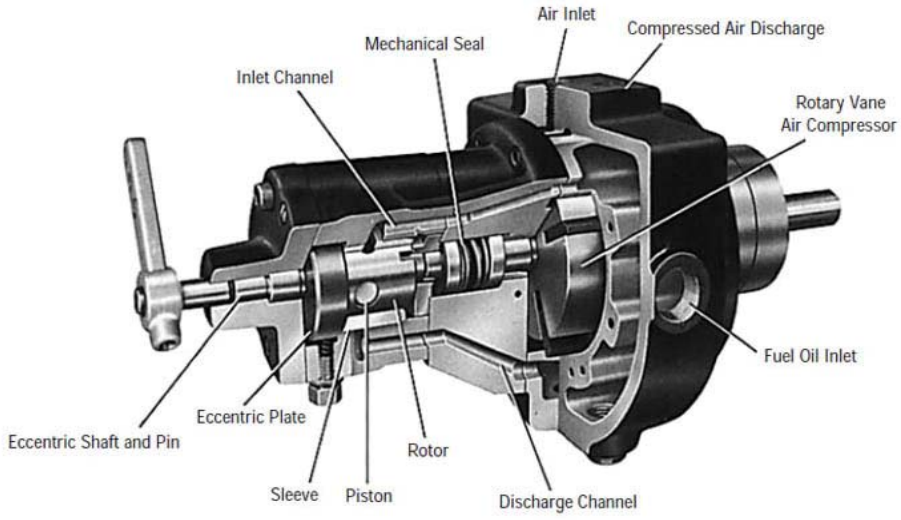


FIGURE 4-12. **Integral Air/Oil Unit**

- **Air Compressor** - Air is drawn into the vane-type, rotary compressor section of the air/oil unit through an air cleaner. The compressed air flows to an air-lube oil tank which serves the multiple purpose of lube oil mist recovery, lube oil sump, and air storage. The compressor is cooled and lubricated continuously by oil under pressure from the bottom of the tank. Oil vapor is extracted from the compressor air by a mist eliminator in the upper section of the tank. Atomizing air flows to the nozzle at a constant volume, but air pressure increases as the firing rate increases. Atomizing air is regulated by an adjusting valve in the return air line on integral metering units or in the air inlet on air compressor module burners.

Oil Metering

Fuel oil under nominal pressure in the circulating loop, flows to the adjustable positive displacement, volumetric metering unit. Oil metering is accomplished by changing the piston stroke by means of an eccentric shaft and pin assembly. The pistons reciprocate in a rotor assembly, turning in a hardened steel sleeve having oil inlet and discharge slots. During each revolution the pistons go through the following cycle:

1. Inlet Cycle. The piston is at the bottom dead center position. At this position the cavity between the top of the piston and the outside diameter of the rotor fills with oil.
2. Discharge Cycle (180º from inlet cycle). The piston is at the top dead center position. At this position, the oil is forced out of the discharge port to the nozzle. The piston stroke length is determined by the position of the eccentric shaft and plate. The piston adjustment plate is positioned by an adjustable eccentric shaft. The eccentric shaft is positioned by the modulator through adjustable linkage. Counterclockwise rotation of the eccentric shaft increases the piston stroke (more oil delivered to the nozzle); clockwise rotation decreases the amount of oil delivered. When the eccentric shaft is stationary, at any position, the stroke of the pistons remains constant, delivering a constant volume of oil regardless of viscosity.

Separate Compressor Module

For models equipped with a burner mounted oil metering unit and a separate compressor module, the system functions as follows:

1. **Air Compressor Module.** Air is supplied by a positive displacement rotary vane compressor. This provides a constant volume of atomizing air regardless of pressure. The compressor module includes motor, air-oil reservoir tank, air filter, and lube oil cooling coil. Air enters the compressor through the filter. The air flows from the compressor into the air-oil separating and reservoir tank. Filtering material and baffles separate the lube oil from the compressed air. The tank air pressure forces lubricating oil from the tank to the compressor to lubricate bearings and vanes. A sight glass indicates the level of lubricating oil in the air/oil reservoir. Lubricating oil must be visible in the gauge glass at all times. Air compression heat is absorbed in part by the flow of lube oil, creating a hot oil mist. The air/oil mist is cooled by a coil assembly. Lube oil is also cooled before entering the compressor.
2. **Oil Metering.** The oil metering unit is cored with channels through the housing. Fuel oil circulates through these channels keeping the metering unit warm to prevent heavy oils from congealing when the burner is idle. The operation of the oil metering unit is the same as the integral air/oil unit.
3. **Operation.** Fuel is delivered to the positive displacement metering pump at 10 to 15 psi. Metered oil is delivered to the common port of a 3-way solenoid valve for transfer to the burner nozzle through the normally closed port or back to the storage tank through the normally open port. During pre- and post-purge, metered oil is returned to the tank. During normal firing, all metered oil is delivered to the nozzle. Heavy oil burners have a supplementary nozzle line heater between the metering and the 3-way valve. Air enters a rotary vane compressor through an air cleaner where it is compressed to atomizing pressure. Air flows from the compressor to an air/oil tank which serves the multiple purpose of dampening air pulsation, lube oil mist recovery, lube oil and atomizing air storage. The compressor rotor is cooled and lubricated continuously by oil under pressure from the air/oil tank. Oil vapor is extracted by a mist eliminator in the upper section of the tank. Atomizing air from the upper tank section is delivered to the nozzle at a constant volume. Air pressure increases as the burner firing rate increases. Atomizing pressure may be adjusted by the needle valve located on the air-oil pump. The valve allows air to be bled from the tank to the compressor inlet. Delivery rate of the fuel oil metering pump is controlled by the modulating motor through adjustable linkage.

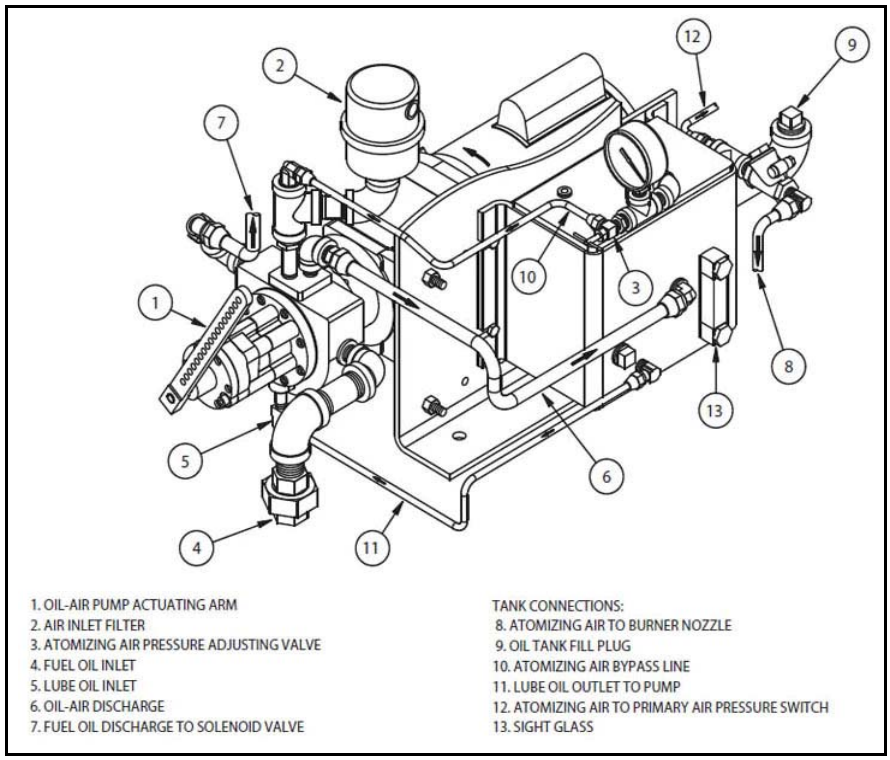


FIGURE 4-13. Integral Oil-Air Metering System and Tank

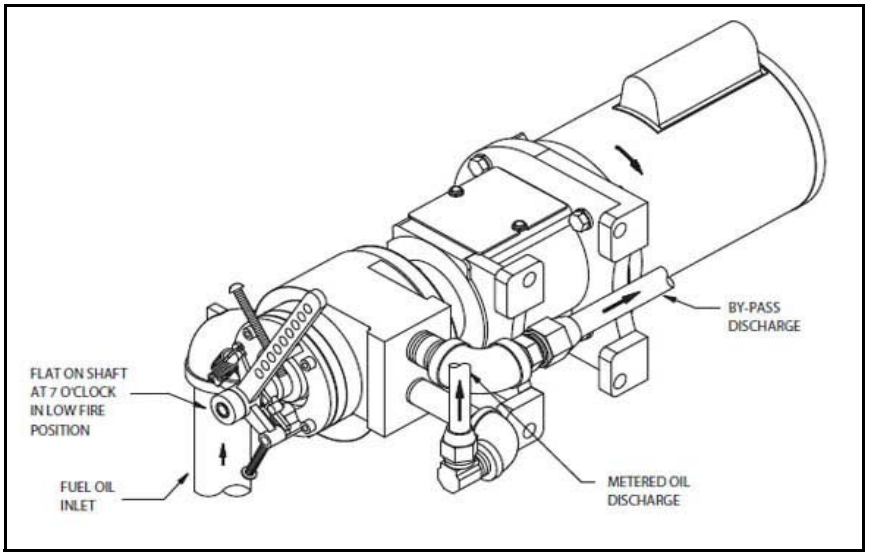


FIGURE 4-14. Fuel Oil Metering System (Used With Separate Compressor

4.2.2 - Gas System

Gas is introduced into the combustion zone from a circular manifold through multiple ports in the manifold. Firing rate is determined by the size and number of ports, by manifold pressure and by combustion zone pressure. The firing rate is regulated by a rotary, butterfly type throttling valve at the manifold inlet. The valve is actuated by an adjustable linkage from the modulating motor. Depending upon specific requirements, one or two safety shutoff, motorized main gas valves are provided for installation in the gas train upstream of the butterfly valve. Safety shut-off gas valves are wired into the programming control to automatically open and close at the proper time in the operating sequence.

Main Gas Train Components

Component	Description
Gas Volume Valve	The butterfly type valve is positioned by linkage from the modulating motor and controls the rate of flow of gas.
Main Gas Valves	Electrically operated safety shutoff valve(s) that open to admit gas to the burner. Two motorized gas valves and one w/closure interlock standard.
Main Gas Regulator	Regulates gas train pressure to specified pressure required at the inlet to the gas train. Input is set by main gas pressure regulator adjustment.
Main Gas Cocks	For manual shutoff of the gas supply upstream of the pressure regulator. A second shutoff cock downstream of the main gas valve(s) provides a means of testing for leakage through the gas valve(s).
High Gas Pressure Switch	A pressure actuated switch that remains closed when gas pressure is below a pre-selected setting. Should the pressure rise above the setting, the switch contacts will open causing main gas valve(s) to close. This switch requires manual reset after being tripped.
Low Gas Pressure Switch	A pressure actuated switch that remains closed when gas pressure is above a pre-selected setting. Should the pressure drop below this setting, the switch contacts will open, causing main gas valve(s) to close. This switch requires manual reset after being tripped.

Pilot Gas Train Components

Component	Description
Gas Pilot Valve	A solenoid valve that opens during the ignition period to admit fuel to the pilot. It closes after main flame is established.
Gas Pressure Regulator	Reduces gas pressure to that required by the pilot.
Gas Pilot Shutoff Cock	For manually closing the pilot gas supply.

Operation

Metered gas flows through the main gas shutoff cock, through the pressure regulator to the automatic gas valves and butterfly valve to the gas manifold.

The butterfly gas valve modulates flow to burner input demand. The butterfly valve is positioned through mechanical linkage by the modulating motor. The air control damper is positioned simultaneously by the modulating motor.

The automatic gas valve(s) cannot be energized unless the combustion air proving switch is closed. The low and high gas pressure switches must be closed to prove proper gas pressure.

A normally open vent valve, if required, is located between the two automatic gas valves. This valve is shut when the automatic gas valves are open. When the automatic valves are closed, the vent valve is open for venting gas to the outside, should any be present.

4.2.3 - Preparations for Startup

When the installation is complete and all electrical, fuel, water and vent stack connections are made, make certain these connections are tight. The operator should become familiar with the burner, boiler controls, and components. Adjustment procedures should be reviewed prior to firing. The wiring diagram should also be studied along with the operating sequence of the burner programmer.

Read and understand starting instructions before attempting to operate the burner. Before attempting to start the burner, the following checks must be made:

Component	Description
Burner	Check the electrical power supply to the burner in accordance with the nameplate voltage on all motors and the control circuit. Check the direction or rotation of the motors. Open the housing to check the electrode setting (refer to Chapter 5). Check the gas pilot pressure at the pilot gas regulator. The normal setting is 3" to 5" W.C. For protection in shipment, the flame safeguard control chassis is shipped unmounted. Check all screw connections before attaching the flame safeguard chassis to the base. Screws must be secure to assure low resistance connections. The relay chassis is mounted on the sub-base with a screw which, when tightened, completes the connection between the sub-base and chassis contacts. Press the manual reset button to be sure safety switch contacts are closed. Check the control linkage for proper movement of the air volume damper and fuel metering components. This can be done by loosening the linkage at the actuator level and manipulating it by hand. Check the air shutter and adjust the low fire setting.
Boiler	Check the boiler water level. Be sure all boiler valves are installed correctly and positioned properly. Set the high limit control slightly above the desired temperature. Set modulating controls at the desired temperature or pressure.
Firing Preparations for Oil Burners	Prior to initial firing, oil flow pressure and temperature should be verified. Inspect the compressor lube oil sump level. Add oil to bring the oil level to the midpoint or slightly higher in the reservoir sight glass. Make certain that the drive belts or couplings are aligned and properly adjusted. To verify air flow and pressure, momentarily flip the switch "ON" and immediately turn it "OFF." The programmer will continue through its cycle, however, without ignition or energizing the fuel valves. Observe the air pressure gauge. With the compressor running and no oil flow, the pressure should be approximately 10 PSI. The schematic flow diagrams in Chapter 1 indicate the flow of fuel and atomizing air. If the burner is a duel fuel model, make certain that the main gas shut off cock is closed and the fuel selector switch is set to "OIL."

Oil Burners

Refer to the piping diagrams. Open all valves in the oil suction and return lines. The burner oil metering units are not capable of creating suction. Fuel oil must be supplied to the metering unit at a nominal 10 to 15 PSI pressure by a circulating supply pump.

Air-Oil Tank (Lube Oil)

Check the lube oil level in the air-oil tank. Inspect oil level regularly. Loss of oil will damage the compressor. Fill the tank with non detergent SAE30 oil to a level midway up the sight glass. Do not overfill the tank.

For a normal environment use SAE30 oil. For a 32º F and below environment sue SAE 10 oil. Change the oil every 2000 hours of operation.

Gas Burners

A representative of the gas utility should turn on the gas. Determine by a test gauge upstream of the burner regulator that sufficient pressure exists at the entrance to the gas train. The gas pressure regulator must be adjusted to the pressure required and the pressure setting recorded.

On combination fuel models, set the selector switch to "Gas." On initial startup, it is recommended that the main gas shutoff cock remain closed until the programmer has cycled through pre-purge and pilot sequences to determine that the main gas valve opens. Turn the burner switch "OFF" and let the programmer finish its cycle. Check to see that the gas valve closes tightly. Set the high and low gas pressure switches.

Check for leaks and determine there is adequate gas pressure available at the burner for operating at full capacity. Check with the local utility if necessary. Check gas pressure at the pilot and the main burner. Close the manual gas valve.

4.2.4 - Electrical Interference Test

Prior to putting the burner into service, conduct the following test to ascertain that the ignition spark will not cause the flame relay to pull in.

Gas Fired

1. Close the pilot and the main line manual gas valves.
2. Start the burner and at the time of the pilot trial with just the electrical ignition system energized, the flame relay should not pull in (be energized).
3. Upon completion of a successful test, proceed with startup procedures.

Oil Fired

1. Disconnect the electrical power to the burner.
2. Disconnect the electric oil safety shutoff valve.
3. Reconnect electric power to the burner.
4. Close the pilot line manual gas valve (if used).
5. Start the burner and at the time of the pilot trial, with just the electrical ignition system energized, the flame relay should not pull in.
6. Upon completion of a successful test, disconnect the power supply.
7. Reconnect the oil safety shutoff valve and turn on the manual pilot gas valve.
8. Reconnect the power supply and proceed with startup procedures.

4.2.5 - Gas Pilot Flame Adjustment

The gas pilot flame is regulated by adjusting the pressure setting of the pilot regulator. A normal setting is 3" to 6" W.C. when the pilot is burning. The flame must be sufficient to be proven by the flame detector and ignite the main flame.

Although it is possible to visibly adjust the size of the pilot flame, obtain a proper DC volt or microamp reading of the flame signal.

The flame safeguard amplifier has a meter jack for this purpose. At initial startup and during planned maintenance, test the pilot flame signal, pilot turndown, and safety switch lockout.

⚠ Warning

Read the flame safeguard manual and fully understand its contents before attempting to operate this equipment. Failure to do so may result in serious personal injury or death.

⚠ Warning

Should a starting failure occur for any reason, combustible fumes may fill the combustion chamber. Never attempt to re-light the burner under these conditions without first purging the chamber.

⚠ Warning

Keep fingers away from the combustion air intake below the damper. The damper is actuated with sufficient force to cause severe injury. Repeat the procedure until the high fire rate is reached. Always make high and intermediate rate adjustments when the burner has reached the low fire position. DO NOT disturb the low fire setting.

4.2.6 - Startup Sequence

The programming control sequences the operation of all controls and components through the starting, ignition, firing, and shutdown cycle. The burner and control system are in starting condition when:

- The operating and high limit control (temperature or pressure) are below their cutoff setting.
- All power supply switches are closed.
- Power is present at the control panel.

1. Begin starting sequence, with burner switch off, and with all manual valves closed. Switch main power on.
2. When firing oil, open the manual oil valves.
3. When firing on gas, open the main manual gas valve.
4. When firing on gas, manually reset the high and low gas pressure switches.
5. Place the gas/oil selector switch in position for the fuel to be used. With all limit and operating controls calling for heat, the burner will follow the Flame Safeguard Sequence.
6. When the burner motor starts, open the gas cock.
7. If firing on gas, when the main fuel lamp lights indicating pilot flame proven, slowly open the second shutoff cock downstream of the main gas valve(s).
8. Refer to the manufacturer's literature on primary control sequence of operations.

4.2.7 - Shutdown Sequences

Automatic Shutdown

When the limit or operating controls open:

1. Fuel valves close. The main fuel lamp goes off. Flame safeguard timer starts.
2. The flame safeguard timer and burner motor stop. The burner is ready for startup on the next call for heat.

Manual Shutdown

1. Turn the gas/oil selector switch "OFF." The burner shuts down in Automatic Shutdown.
2. When the burner motor stops, close all manual valves.

Safety Shutdown

If at any time during the operating cycle a flame failure occurs, the burner shuts down as in Automatic Shutdown, with an additional post-purge, and the flame failure lamp is energized.

1. The lockout switch on the flame safeguard control must be manually reset before the burner will fire again.
2. If a low water condition occurs, the burner shuts down as in Automatic Shutdown.
3. If a high or low gas pressure condition occurs while firing on gas, the burner shuts down as in Automatic Shutdown.
    - The condition must be corrected and the respective gas pressure switch manually reset before the burner will fire again on gas.

4.2.8 - Startup and Operating

Gas Burners

1. Close the main and pilot gas cocks. Make sure the "ON-OFF" switch is in the "OFF" position and the fuel selector switch is on "GAS."
2. Actuate the manual reset button of the flame safeguard control to close the safety switch contacts.
3. Set the "MANUAL-AUTO" switch to "MANUAL."
4. Set the manual potentiometer in the low fire position.
5. Open the gas pilot cock.
6. Set the "ON-OFF" switch to "ON." The burner will start and pre-purge. After pre-purge, the ignition transformer and the gas pilot solenoid are energized. Before proceeding, conduct electrical interference and pilot turndown tests if not previously done.
7. On initial startup it is recommended that the main gas shutoff cock remain closed until the programmer has cycled through pre-purge and pilot sequence. Then determine that the main gas valve opens. When this is confirmed, turn the burner switch "OFF" and allow the programmer to finish its cycle. Check to see that the gas valve has closed tightly. If ignition does not occur, turn the burner switch "OFF" and allow the programmer to recycle for a new ignition trial.
8. Turn the burner "ON" and after pilot ignition when the flame relay pulls in, the slow opening, motorized, main gas valve is energized. Slowly open the downstream manual shutoff gas cock. The main flame should ignite at this time. The gas valve and air damper continue advancing until high fire is reached.
9. Do not repeat unsuccessful light off attempts without rechecking burner and pilot adjustment. Vent fuel vapors from the combustion chamber after each unsuccessful light off attempt. Set the gas low fire rate by adjusting the butterfly valve and air linkage. When low fire is adjusted, shut down the burner. Restart several times to be sure the low fire setting is suitable. Readjust if necessary. Never start the burner with fuel vapor in the furnace. In case of an emergency, open the main power switches and close all fuel valves. After combustion adjustments are satisfactorily set, allow the heating vessel to slowly reach normal operating pressure or temperature.
10. Turn the potentiometer switch to the high fire position. Check high fire at this point using combustion instruments.
11. Do not disturb established low fire adjustment. Allow the burner to return to low fire position before adjusting high or intermediate settings.

High fire combustion analysis typically is 9% to 10.5% CO2. When conditions covered above are assured, refer to **Normal Operation** below.

Oil Burners

1. Set the fuel selector to "OIL." On initial startup of a combination burner, it is recommended that oil firing be adjusted before gas firing. The gas low firing rate is set to match oil low fire rate.
2. Be sure the "ON-OFF" switch is in the "OFF" position and the fuel selector switch is on "OIL." Actuate the manual reset button of the flame safeguard control to close the safety switch contacts. Be sure the "MANUAL-AUTO" switch is in the "MANUAL" position. Set the manual modulating control potentiometer to the "LO" fire position. Open the pilot gas valve (if used).

3. Set the "ON-OFF" switch to "ON." The burner will start and pre-purge. After pre-purge, the ignition transformer and the gas pilot are energized. Before proceeding, conduct electrical interference and pilot turndown tests if not previously done. Refer to Chapter 4, Sections 4.3 and 4.4.
4. Observe the primary atomizing air pressure gauge on the air/oil tank. The gauge reading should be approximately 10 psi during pre-purge.
5. When the pilot flame is proven, the programmer will proceed to the main flame position. Allow the burner to operate in low fire, to warm the boiler before moving to high fire.

Typically, for No. 2 through No. 4 oil, CO2 is 8% to 11% and No. 5 and No. 6 oil is 8% to 13% at low fire.

6. Turn the manual potentiometer switch to the high fire position. Check high fire combustion at this point. Do not disturb previously established low fire adjustment. Allow the burner to return to low fire position before adjusting high or intermediate settings. The primary atomizing air pressure will increase automatically with the oil flow rate.

Typically, for No. 2 through No. 4 oil, CO2 is 10% to 13% and No. 5 and No. 6 oil is 11% to 15% at high fire.

When conditions covered above are assured, refer to **Normal Operation** below.

4.2.9 - Normal Operation

Normal operation must be with the "MANUAL-AUTO" switch selector on "AUTO."

In automatic operation, the operating cycle always proceeds sequentially through pre-purge, pilot ignition, main flame ignition, run, and post-purge. The length of purge and ignition trial vary according to the type of programmer used.

During the run cycle, burner input is regulated to the load demand by the modulating pressure or temperature control on the boiler. The burner will continue to modulate until the operating pressure or temperature is reached.

Programmer control operation should be tested when the burner is initially placed into service, when a control is replaced, and at scheduled intervals in the maintenance program.

4.2.10 - Shutdown

When the operating limit control setting is reached or the burner switch is turned "OFF," the following sequence occurs:

1. The fuel valve(s) de-energize and flame extinguishes. The blower motor continues running during post-purge.
2. At the end of the post-purge, the blower motor is de-energized. The programmer returns to its starting position and stops. the unit is ready to restart.

Abnormal shutdown might result from motor overload, flame outage, low water, current or fuel supply interruption, combustion or atomizing air pressure below minimum level, tripped circuit breakers, blown fuses, or other interlock devices. Check for cause and correct before restarting the burner.

Safety shutdown caused by ignition or flame failure will actuate a red indicator light and energize an audible alarm (if so equipped). If the programmer has a non-recycling interlock circuit, any interruption in this circuit during the

pre-purge or firing cycle will cause a safety shutdown. This type of shutdown requires manual reset of the programming control and must be corrected before operation can be resumed.

⚠ Warning

An ultraviolet flame sensor electrical spark interference test must be performed after final adjustment.

4.2.11 - Adjustments

While each burner is tested at the factory for correct operation before shipment, variable conditions such as burning characteristics of the fuel used and operating load conditions may require further adjustment after installation to assure maximum operating efficiency.

Prior to placing the boiler into initial service, a complete inspection should be made of all controls, connecting piping, wiring and all fastenings such as nuts, bolts, and setscrews to be sure that no damage or mis-adjustments occurred during shipping and installation.

A combustion efficiency analysis made during the initial startup will help to determine what additional adjustments are required in a particular installation.

Efficient combustion cannot be properly judged by flame appearance, although it may help in making preliminary settings.

The proper settings of air-fuel ratios must be determined by flue gas analysis. Combustion gas analysis indicates the air to fuel ratio and the degree of complete combustion. Instruments are available to measure carbon dioxide (CO2), oxygen (O2), and carbon monoxide (CO).

Stack Temperature

Net stack temperature is obtained by subtracting the ambient temperature from the flue gas temperature. A high net stack temperature indicates wasted heat. Stack temperature should be as low as possible without causing flue gas condensation.

Stack heat loss can be reduced by decreasing either the temperature or the volume of the flue gas, or both. Flue gas temperature is reduced by improving heat transfer or by reducing excess combustion air. A certain amount of excess air is necessary to complete combustion. More efficient burners require minimum excess air.

Smoke Measurement

Smoke measurements can be made using a variety of different methods. The standards will vary somewhat according to the equipment used, and instructions accompanying the instrument should be followed.

Smoky combustion can result from:

- improper air delivery
- insufficient draft
- improper fuel viscosity
- improper fuel-air ratio

- excessive air leaks in the combustion chamber
- improper fuel oil temperature

Gas Adjustments

Low fire combustion analysis typically is 7% to 9% CO2 and less than .04% CO (400 ppm). A high fire reading typically is 9% to 10.5% CO2 and less than 04% CO.

Fuel Oil Adjustments

Adjust for a "clean fire." Typically for No. 2 through No. 4 oil, CO2 is 8% to 11% at low fire and 10% to 13% at high fire. For No. 5 and No. 6 oil, CO2 is 8% to 13% at low fire and 11% to 15% at high fire.

4.2.12 - Electrical Interference Test

Prior to putting the burner into service, conduct the following test to ascertain that ignition spark will not cause the flame relay to pull in.

Gas Fired

1. Close the pilot and main line manual gas valves.
2. Start the burner and at the time of the pilot trial with just the electrical ignition system energized, the flame relay should not pull in (be energized).
3. Upon completion of a successful test, proceed with startup procedures.

Oil Fired

1. Disconnect the electrical power to the burner.
2. Disconnect the electric oil safety shutoff valve.
3. Reconnect electric power.
4. Close the pilot line manual gas valve, if used.
5. Start the burner and at the time of the pilot trial, with just the electrical ignition system energized, the flame relay should not pull in.
6. Upon completion of a successful test, disconnect the power supply.
7. Reconnect the oil safety shutoff valve and turn on the manual pilot gas valve.
8. Reconnect the power supply and proceed with startup procedures.

4.2.13 - Gas System

Gas Pressure

Gas must be supplied at a pressure high enough to overcome the pressure loss in the burner gas train and furnace pressure while running at full input. Refer to the nameplate inside the control panel for gas pressure requirements at the train inlet and manifold. The pressures listed are based on nominal 1000 Btu/cu. ft. natural gas at elevations up to 2000 feet above sea level.

Gas Flow

The volume of gas is measured in cubic feet as determined by a meter reading. The gas flow rate required depends on the heating value (Btu/cu. ft.). The supplying utility can provide this information as well as pressure correction factors. To determine the required number of cubic feet per hour of gas, divide burner input (Btu/hr.) by the heating value (Btu/cu. ft.).

NOTE: When checking the input rate, make sure no other equipment is operating on the same meter.

Gas Pilot Flame Adjustment

The gas pilot flame is regulated by adjusting the pressure setting of the pilot regulator. Normal setting is 3" to 6" W.C. when the pilot is burning. The flame must be sufficient to be proven by the flame detector and ignite the main flame.

Although it is possible to visibly adjust the size of the pilot flame, obtain a proper DC volt or microamp reading of the flame signal.

The flame safeguard amplifier has a meter jack for this purpose. At initial startup and during planned maintenance, test the pilot flame signal, pilot turndown, and safety switch lockout.

An ultra-violet flame sensor electrical spark interference test must be performed after final adjustment. See Section 4.3 for additional information.

Main Gas Pressure Regulator

The gas pressure required at the burner manifold is the pressure that is required to fire the burner at its rated capacity. The gas pressure regulator must be adjusted to achieve this pressure to assure full input. Refer to manufacturer's literature for regulator adjustment.

Low Gas Pressure Switch

Turn the adjusting screw until indicator moves to a pressure setting slightly below the operating gas pressure. The control will break a circuit if pressure is below this set point. The control should be finally adjusted to prevent operation with low gas pressure, but not at a pressure so close to normal operating pressure that unnecessary shutdowns occur. The switch must be manually reset after tripping. To reset, allow gas pressure to rise and press the manual reset button.

High Gas Pressure Switch

Turn the adjusting screw until the indicator moves to a pressure setting slightly above the maximum operating gas pressure. The control will break a circuit if pressure exceeds this value. The control should be adjusted to prevent operation with excessive gas pressure, but not at a pressure so close to normal operating pressure that unnecessary shutdowns occur. This switch must be manually reset after tripping. To reset, allow the gas pressure to drop and press the manual reset button.

Gas Combustion Adjustment

After operating for a sufficient period of time to assure a warm boiler, make adjustments for most efficient combustion. The butterfly gas valve directly controls the rate of flow. The low fire light-off setting should be regarded as preliminary until proper gas pressure for high fire operation is established.

Determine the actual gas flow from a meter reading at high fire. With the butterfly valve open and with regulated gas pressure set, the actual flow rate should be quite close to the required input. If corrections are necessary, increase or decrease the gas pressure by adjusting the gas pressure regulator, following the manufacturer's directions for regulator adjustment.

When proper gas flow is obtained, take a flue gas analysis reading.

With the high fire air-fuel ratio established, the gas pressure regulator needs no further adjusting.

Recheck low fire and adjust if necessary.

Proper setting of the air/fuel ratios at all rates must be determined by combustion analysis. See Section 4.2 of additional information.

NOTE: Check for CO through the entire firing range.

Secondary Valve Adjustment: Gas Models D 378 & 420

The secondary valve feeds gas to the inner spuds. A slot in the valve stem in relationship to the shut/open scale on the valve indicates the blade position. In the low fire starting position, the stem slot should be positioned at the left hand 1/4 mark and travel in a counterclockwise direction to the mid fire shut position. Continuing in a counterclockwise direction, the stem slot should stop at the right hand 1/4 mark. This is the high fire position. Both low and high fire positions are approximate. Adjustments to the valve should be made on the secondary valve linkage arm. To increase the travel, move the linkage arm closer to the pivot point. To decrease the travel, move the linkage arm away from the pivot point. The primary valve which feeds the outer spuds should be adjusted as normal.

Secondary Valve Adjustment: Dual Manifold

Each zone is controlled by a butterfly valve linked to a 14 point adjustment cam. The primary large butterfly valve controls the main gas orifices and the secondary small butterfly valve controls the pre-mix gas spuds.

Refer to the adjustment section to set up the burner. In the low fire position, the secondary valve controlling the pre-mix spuds is almost closed. After all adjustments are made throughout the modulating range, go back and relight the burner. Upon startup, check that the fire is not burning behind the diffuser. If this happens, close the secondary valve until this situation is corrected. Repeat several times.

4.2.14 - Oil System

Oil Metering System

Fuel oil supply to the integral metering unit must be at 10 psi to 15 psi and up to 20 psi on separate metering units. The oil spray should ignite as soon as the oil solenoid valve opens. If the oil spray fails to ignite, move the metering unit adjustment lever a few degrees counterclockwise. This increases the amount of oil at low fire and makes ignition easier, it will also increase the oil on high fire, so this must be checked later. Once adjusted, the pump should

operate with a minimum amount of adjustment. If a burner failure is caused by the oil metering pump, check the following:

1. See that the oil tanks are not empty.
2. That all oil valves between the burner and the tank are open.
3. That the suction line is not airbound.
4. That the low fire setting has not been disturbed.
5. That there is pressure at the integral metering unit, but not to exceed 15 psi (20 psi on a separate metering unit).
6. That the pump turns freely.
7. Check for a clogged strainer at the suction side of the circulating pump.
8. Check for a dirty burner strainer.
9. Check for a plugged or carboned nozzle. This will show up as excessive primary air pressure.
10. That the oil bypass valve is not bypassing the metered fuel oil.

Internal wear of the pump may take place due to the presence of dirt in the oil and in time, this will result in excessive clearances which reduces the pump capacity.

If the oil metering pump fails to deliver capacity or meters erratically, replace the oil and air pump as a unit and return the old pump for repair or exchange (where allowed).

Atomizing Air Pressure

Atomizing air in the air/oil tank is regulated by adjusting the valve in the return air line on integral metering units or in the air inlet on air compressor module burners. The air pressure is indicated by the pressure gauge at the air/oil tank.

A minimum of 10 psi air pressure in low fire is suggested. As the firing rate increases, the air pressure also increases. Air pressure will be less with light oils. If any change in atomizing air pressure is made, check ignition several times for reliable light off. Adjustments should be set to obtain reliable ignition with best low and high fire combustion results.

If the required atomizing air pressure cannot be maintained, a lack of lubricating oil may be the cause or the intake filter may be dirty.

Atomizing Air Proving Switch

The knurled nut between the switch and bellows is turned in to raise the pressure setting. The minimum amount of atomizing air is during pre- and post-purge. during pre-purge, adjust the switch until it breaks the circuit. Readjust the switch above this circuit break point to actuate under a condition of minimum pressure, but not so close as to cause nuisance shutdowns. Since the pressure of the atomizing air is at minimum when no fuel is present at the nozzle, adjustment of the switch should be made while the unit is purging, but not firing.

Low Oil Pressure Switch

The low oil pressure switch is adjusted at the minimum setting of 4 psi. Turning the knob clockwise will increase pressure, counterclockwise will decrease pressure.

4.2.15 - Linkage: Modulating Motor

The linkage consists of adjustable cams, levers, rods and ball joints that transmit motion from the modulating motor to the air damper, gas butterfly valve, and oil metering unit. When properly adjusted, coordinated movement of the air and fuel control devices provide proper fuel/air ratios through the firing range. In linkage adjustments, several important factors serve as guides:

- Modulating motor must be able to complete its full travel. Restrictions will damage motor and/or the linkage.
- Lever and rod adjustments should be made with the motor in the low fire position.

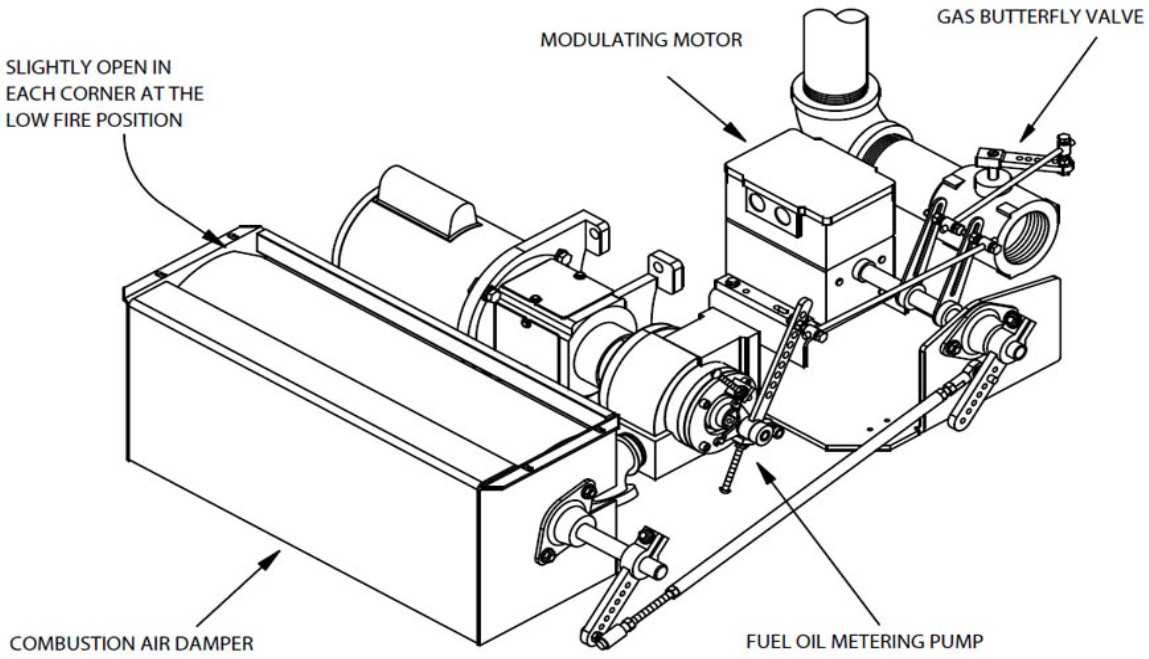


FIGURE 4-15. **Low Fire Position**

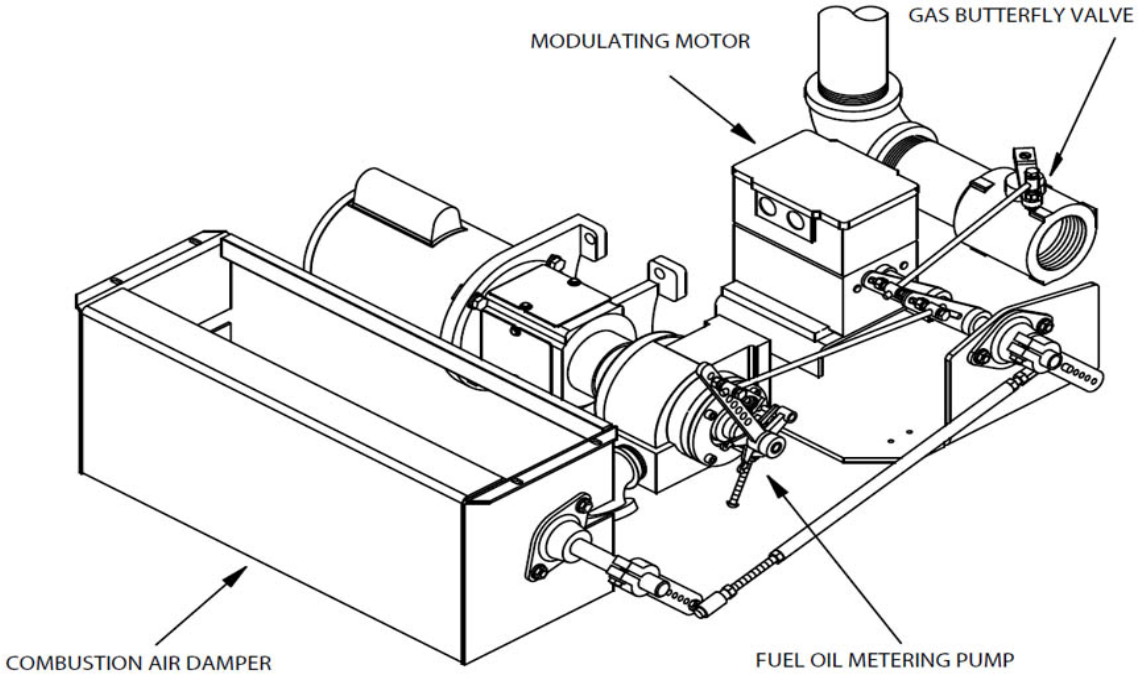


FIGURE 4-16. **High Fire Position**

The modulating motor will be stopped at the end of its stroke by an internal limit switch. Combustion gas analysis indicates the air to fuel ratio and the degree of complete combustion. The closer the rod comes to parallel with the lever, the slower the rod moves. The angles of the driven levers on the jackshaft can be adjusted to vary the rate of change. The closer the rod to the hub of the lever, the less distance it will travel. Increasing the lever length on the damper, metering unit and valve(s) decreases flow rate.

4.2.16 - Cam Trim Adjustment

After low and high fire adjustments are complete, final adjustment is made with the cam assembly to obtain a good air/fuel ratio throughout the entire firing range. The input of combustion air is fixed at any given point in the modulating cycle. The fuel input may be varied to obtain correct flue gas readings. The adjustment is made to the metering cam by means of the 14 adjusting screws which are turned in (clockwise from the hex-socket end) to increase the flow of fuel, and out (counterclockwise from the hex-socket end) to decrease it. a 3/32" hex key is required. It will be necessary to cut off the short end of a hex key to approximately 3/8" to adjust the first two socket head setscrews at the low fire position. Take a combustion analysis at various points of the cam profile. Adjustment can be made without cycling the burner then, then operate the automatic modulating cycle to assure satisfactory results. Tighten the locking setscrews.

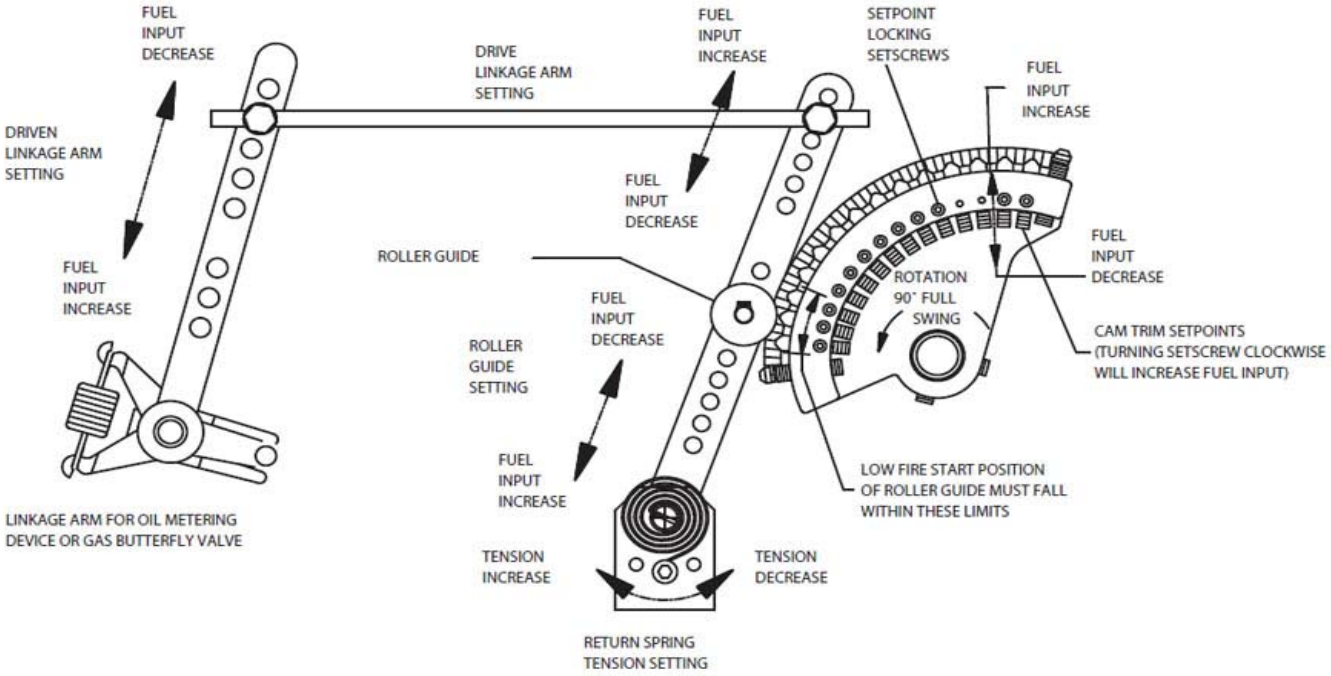


FIGURE 4-17. Cam Trim Adjustment

NOTE: It is essential that the cam spring, cam follower bearing wheel, and cam follower arm at the pivot point be greased sparingly every month to ensure smooth operation of the cam assembly. Regular automotive bearing grease should be used.

4.2.17 - Firing Rate Controls

Firing rate adjustments are made at the modulating motor linkages to the combustion air inlet damper, air-oil metering pump, and main gas butterfly valve. Settings are determined by the operating length of the levers and the angular position on the shafts. Increasing the lever lengths on damper, pump, or valve decreases the flow rate. Driving and driven levers are approximately parallel, but the angles can be adjusted to vary the rate of change. The most rapid rod travel occurs when the lever is perpendicular to the rod. The closer the rod comes to being parallel with the lever, the slower the rod moves. Always allow the burner to return to low fire position before adjusting high or intermediate settings. Do not alter low fire settings. Normally, the air control damper will be approximately 1" open in low fire position. Excessive opening in low fire can cause pilot ignition problems. Air to the pilot is supplied under pressure to compensate for variations in furnace pressure, but the damper must be in low fire position for reliable ignition.

⚠ Warning

Keep fingers away from the air intake below the damper. The damper is actuated with sufficient force to cause serious injury.

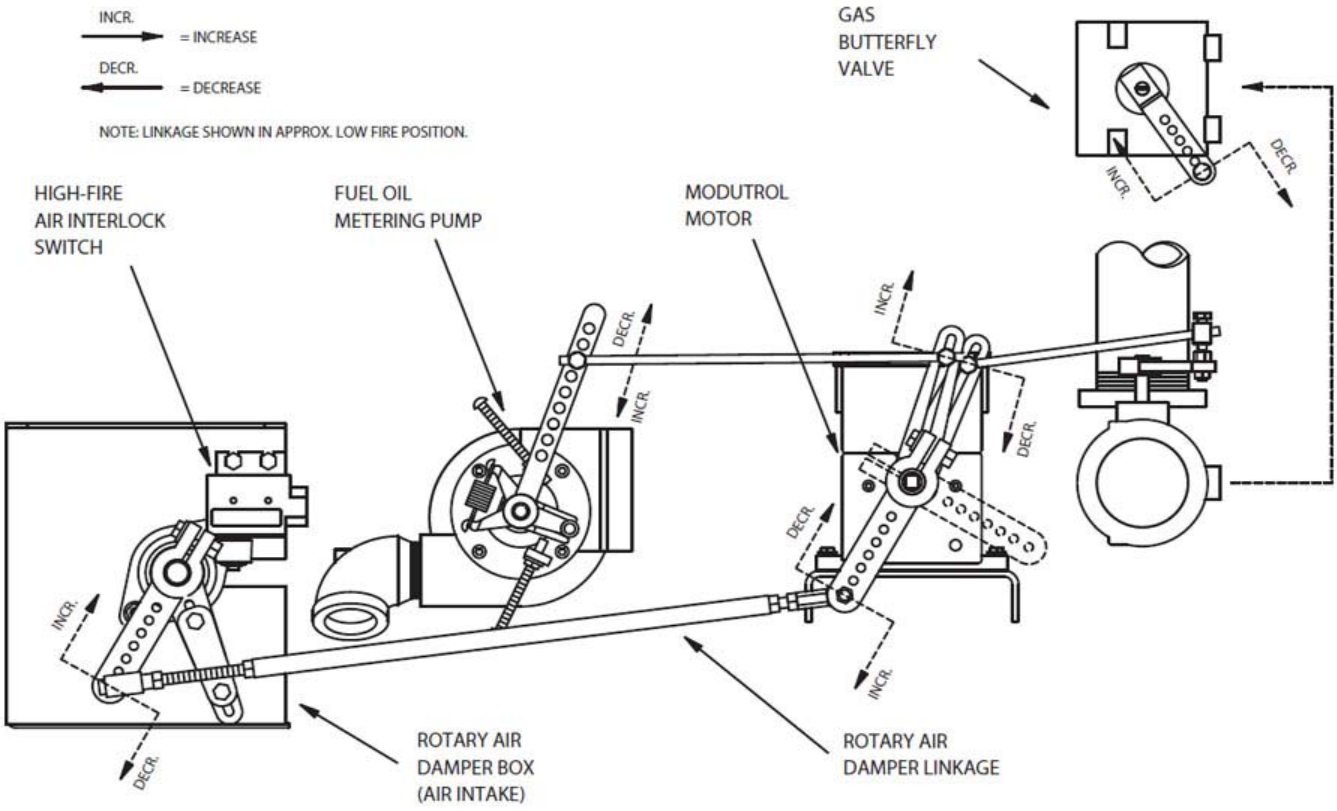


FIGURE 4-18. Firing Rate Control Adjustments

CHAPTER 5 Fireside Maintenance

⚠ Warning

Any cover plates, enclosures, or guards anchored to the burner, or any burner related equipment, must remain in position at all times. Only during maintenance and service shutdown can these cover plates, enclosures, or guards be removed. They must be replaced and securely anchored before testing, adjusting, or running burner or burner related equipment.

⚠ Caution

It is important to provide support for the housing when in the open position to prevent damage to the hinges and other components.

A maintenance program avoids unnecessary downtime, costly repairs, and promotes safety. It is recommended that a record be maintained of daily, weekly, monthly, and yearly maintenance activities.

Electrical and mechanical devices require systematic and periodic inspection and maintenance. Any "automatic" features do not relive the operator form responsibility, but rather free him from certain repetitive chores, providing time for upkeep and maintenance.

Unusual noise, improper gauge reading, leak, sign of overheating, etc. can indicate a developing malfunction, requiring corrective action.

5.1 - Fireside Cleaning

Soot and non-combustibles are effective insulators, and, if allowed to accumulate, will reduce heat transfer to the water and increase fuel consumption. Soot and other deposits can be very moisture-absorbent, and may attract moisture to form corrosive acids that will deteriorate fireside metal.

Cleanout should be performed at regular and frequent intervals, depending upon load, type, and quality of fuel, internal boiler temperature, and combustion efficiency. A stack temperature thermometer can be used as a guide to cleanout intervals since an accumulation of soot deposits will raise the flue gas temperature.

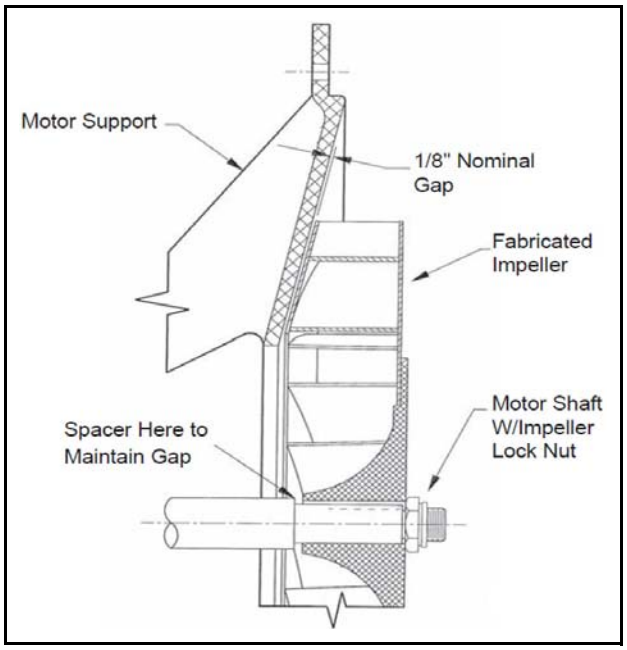
Tube cleaning is accomplished by opening the front and rear doors. Tubes may be brushed from either end. All loose soot and accumulations should be removed. Any soot or other deposits should be removed from the furnace and tube sheets.

The flue gas outlet and stack should be inspected annually and cleaned as necessary. Commercial firms are available to perform the work. The stack should be inspected for damage and repaired as required.

The fireside should be thoroughly cleaned prior to any extended layup of the boiler. Depending upon circumstances, a protective coating may be required.

5.2 — D/LND Burner

5.2.1 - Impeller and Stator Cone



Proper clearance between the impeller and the inlet housing and between the impeller and stator cone is not critical

and is set at 1/8" nominal. When installing or removing the impeller, it is mandatory to use an impact wrench.

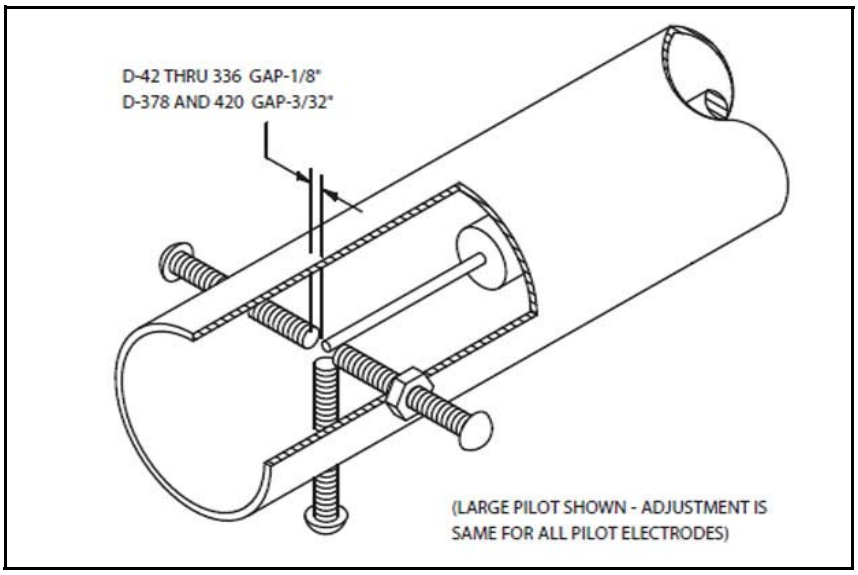
NOTE: Under no circumstance should anything other than an impact wrench be used. Inserting a bar through the impeller blade and using it as a lever will only damage the blade and will void the 5 year impeller warranty. If the impeller is changed to a different width, the stator cone position may require adjustment. This is accomplished by means of slotted mounting holes in the blast tube. Loosen the three screws to reposition the cone.

5.2.2 - Firing Head Inspection

1. Disconnect the damper linkage.
2. Release the impeller housing latch and swing the housing open for access to the firing head.
3. Inspect the flame scanner lens to be sure it is clean and the support tube is in proper position to sight the flame through the hole in the diffuser.
4. Inspect the lead wire to the ignition electrode. It must be firmly attached and the insulation should be clean and free of cracks.
5. The oil nozzle should be inspected periodically depending on the grade of oil burned and the cleanliness of the environment.

5.2.3 - Pilot and Ignition Electrode

The ignition transformer requires little attention other than making sure the ignition wire is firmly attached to the transformer and the electrode.



Be sure the wire insulation is in good condition and not grounded. Failure to keep the ignition electrode clean and properly set can cause faulty operation. The pilot assembly is supported by a socket in the diffuser and gas inlet tube. No adjustment is required except proper positioning of the electrode wire.

5.2.4 - Flame Scanner

The scanner must be clean. Even a small amount of contamination will reduce the flame signal. Wipe the scan- ner lens with a clean soft cloth.

5.2.5 - Diffuser

The diffuser is factory set and does not require attention under normal operating conditions. If fouled with carbon, the diffuser should be removed for cleaning.

1. First remove the electrode and scanner leads, the gas pilot assembly, air and oil tubes, and the nozzle support assembly before attempting to remove the diffuser.
2. Mark the diffuser's relative position to the blast tube with a scribed or pencil line where the three mounting screws are located, to insure that the diffuser is placed back in the same position.
3. Remove the three screws holding the diffuser to the blast tube and slowly pull the diffuser along the blast tube towards the firing head. Keep the diffuser as parallel as possible. If it should become stuck or tight, do not apply any tool which would distort the shape or blade configuration. A small wooden block tapped gently against the diffuser's outer edge will help expedite its removal.
4. Clean all carbon from the diffuser vanes and reinstall in reverse order of disassembly, aligning the diffuser with the scribed marks. Do not attempt to drive the diffuser back along the blast tube with anything other than a small block of wood tapped against the diffuser's outer edge.
5. When reinstalling, be sure the diffuser is centered with the proper distance as shown in Figures 5-2 and 5-3.

5.2.6 - Firing Rate Controls

Check all rods and linkages. Make sure all connections are tight. Adjust if necessary. Perform a combustion test as explained in Chapter 4, and readjust the burner if necessary.

NOTE: It is essential that the cam spring, cam follower bearing wheel, and cam follower arm at the pivot point be greased sparingly every month to ensure smooth operation of the cam assembly. Regular automotive bearing grease should be used.

5.2.7 - Burner Mounting Inspection

The seal between the burner flange and furnace front plate must not permit combustion gases to escape. Peri- odic inspection is important. Replace the gasket if necessary. Inspect the burner head for signs of discoloration. A change in the head color paint might indicate gas leakage between the dry oven and the boiler refractory. If leakage occurs, refer to Chapter 2, Section 2.4 for proper sealing procedure.

5.2.8 - Fuel Oil System

Oil Nozzle

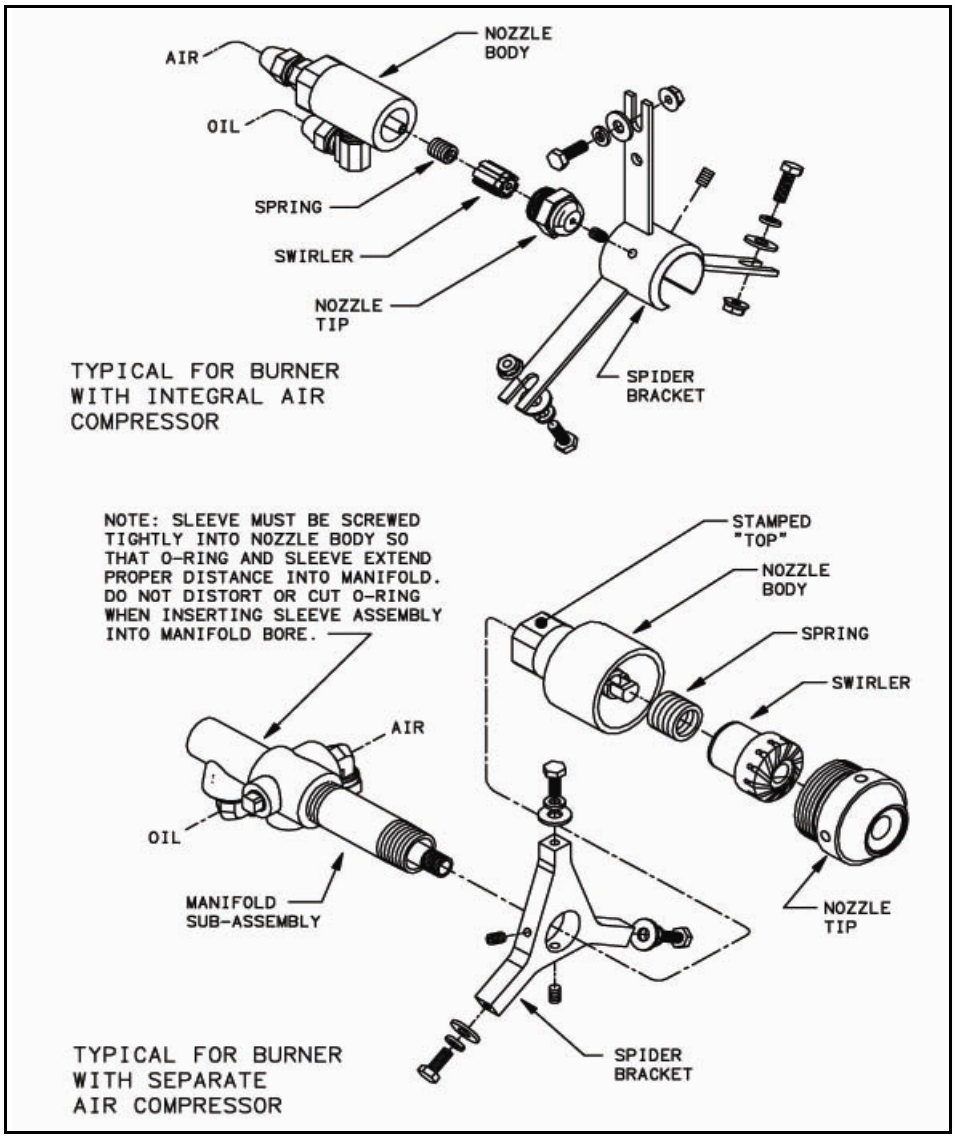
For successful burner operation use the proper style nozzle tip and keep the orifice clean. Standard nozzle tips furnished on the burners are of a special emulsifying type which delivers a spray of extreme fineness and at an angle which insures proper mixing with the air stream. Unsatisfactory performance and loss of efficiency can result from

the use of non-standard nozzle tips. If the burner flame becomes stringy or lazy, it is possible that the nozzle spring is not properly in place or the nozzle is clogged. This problem is usually indicated by an abnormally high reading on the atomizing air pressure gauge on the air-oil tank.

To remove the nozzle:

1. Disconnect the oil and air tubes from the nozzle assembly.
2. Loosen the three 1/4" screws holding the nozzle spider bracket to the support ring.
3. Withdraw the nozzle and bracket assembly.
4. Clean the nozzle tip by unscrewing the tip from the nozzle body. Use care not to distort the tube.
5. Hold the nozzle body in a vise or use two wrenches, one on the body and one on the tip.
6. Disassemble the nozzle tip.
7. Carefully clean all parts in solvent and reassemble the nozzle.

To insure proper atomizing, the tip must be screwed in tightly with the swirler seating spring pressing the swirler tight against the nozzle tip. Turn the swirler a few times to be sure it fits snugly in the nozzle and the spring is pressing the two parts firmly together. When reinstalling, be sure the nozzle is centered with the proper distance from the diffuser.



Caution
Do not attempt to use a wire or a sharp metal tool to clean the nozzle orifice as this will distort the fine orifice and ruin the nozzle. Use a sharp pointed piece of soft wood.

Fuel Oil Circulating Pump

Failure or the circulating pump to deliver sufficient oil may be due to one of the following conditions:

1. Insufficient fuel oil in the storage tank.
2. Suction line or check valve clogged.

3. Air leaks or air traps in the suction line. If the line has a high point at which an air trap can occur, the line must be changed.
4. Oil strainer clogged (line strainer or burner strainer).
5. Suction line piping too small.
6. Pump rotating in wrong direction.
7. Three-phase pump motor operating on single phase because of fuse failure.
8. Low voltage applied to pump motor.

Air-Oil Metering Pump

Caution
The metering pump is lubricated by fuel oil and must not be operated longer than one minute if it is not pumping oil. Failure to comply will result in premature pump failure and void any warranty implied or otherwise.

The integral air-oil metering pump for light oil employs a seal on the shaft to prevent oil leakage. Internal wear can take place due to dirt in the oil and may in time result in excessive clearances, reducing pump capacity. Once adjusted, the pump will continue to operate with a minimum of readjustment. If burner failure appears to be caused by the metering pump, check the following:

1. See that the oil is at a sufficient level in both the fuel oil tank and the air-oil tank on the burner.
2. Make sure all valves between the fuel oil tank and the burner are open.
3. Be sure the oil suction line is not airbound and check the suction line strainer.
4. Check the low fire setting of the metering pump to be sure it has not been disturbed.
5. Make sure the pump turns freely.
6. Inspect the burner oil nozzle for clogging.

Caution
Do not attempt to disassemble the oil metering pump in the field. Any attempt will void the warranty or the exchange policy.

Whenever an oil metering pump fails to deliver full capacity or pressure, order a replacement pump at once and return the old pump for repair or exchange (where allowed).

Primary Air Pump or Compressor

The air compressor itself requires little maintenance, however, its life is dependent upon sufficient clean, cool lubricating oil. The oil level in the air-oil tank must be checked regularly. Lack of oil will damage the compressor. Disassembly or field repairs to the air compressor are not recommended. Check the air-oil tank sight glass for proper oil level. The level should be kept at the midpoint of the sight glass. The compressor rotor must turn freely. All tube connections must be air tight.

Caution
Do not attempt field repair of the compressor. Installation of a new compressor is mandatory. Send the old compressor in for repair or exchange (where allowed).

Alignment of the compressor and motor sheaves and proper belt tension are important.

Belt tension is adjusted according to the displacement of the belt with thumb pressure. The displacement should be 3/8" to 1/2".

To adjust, loosen the two bolts on the compressor mounting flange and the three setscrews which hold the compressor in place.

The mounting flange is slotted at the top, which permits belt tightening. If the slot in the mounting flange is insufficient for obtaining proper belt tension, the modular base has two extra holes for this purpose.

Move the top bolt to the next hole and adjust. Tighten bolts and setscrews. Replace the belt guards. If the belt becomes frayed or cracked, replace it.

Air Cleaner

Never operate the compressor without the air cleaner in place. The cleaner should be cleaned at regular inter- vals. The correct oil level must be maintained in the air cleaner. Use the same oil used for air compressor lubri- cation.

Air-Oil Tank

Check the lube oil level in the air-oil tank. Inspect oil level regularly as loss of oil will damage the compressor. Change oil every 2000 hours of operation. The air-oil tank should be drained once a year and thoroughly flushed. Remove the mist eliminator pads from the upper section of the tank, wash thoroughly in kerosene and dry. Refill with non detergent SAE30 oil to a level midway up the sight glass. For normal environment use SAE30 oil. For a 32 ° F and below environment, use SAE 10 oil.

Oil Level Sight Gauge

The oil level sight gauge can be cleaned by removing it from the air-oil tank and soaking it in a detergent solution. If cleaning the gauge proves unsatisfactory, replace it.

Compressor Oil Filter (Lube Oil Strainer)

The lube oil strainer prevents foreign materials from entering the compressor. The strainer screen must be cleaned at regular intervals. The screen is easily removed for cleaning by unscrewing the bottom plug. Immerse in solvent and thoroughly clean.

Nozzle Line Heater

Nozzle line heaters damaged by water accumulation do not qualify for warranty or exchange service. Failure to prevent water accumulation inside the heater manifold constitutes improper care.

Completely drain the heater manifold periodically. This should be part of the preventive maintenance program. maintenance consists primarily of removing the heating element from the manifold and scraping any accumulation of carbonized oil or sludge deposits from the heat exchange surfaces.

Before braking electrical connections to the heating elements, mark all wires and terminals to assure correct replacement of wires.

Periodic cleaning is necessary to prevent overheating or burnout of the elements. If operation of the heater becomes sluggish, examine the elements and clean as required.

Inspect the manifold each time the heater is removed. Flush all accumulated sludge and sediment before it is turned on.

Oil Strainers

Oil strainers should be cleaned frequently to maintain a free and full flow of fuel. The strainer screen must be removed and cleaned at regular intervals. The screen should be removed and cleaned thoroughly by immersing it in solvent and blowing it dry with compressed air. Light oil strainers should be cleaned each month.

5.2.9 - Gas System

Motorized Main Gas Valves

Should the valve fail to operate, check for voltage at the valve. Make certain that the main shutoff cock is closed prior to testing. The actuator is not field repairable nor should it be disassembled. Replace the actuator if the valve fails to operate. After replacement, cycle the valve with the fuel shutoff to determine that it opens and closes. If the valve has a visual indicator, observe its position for correct operation.

Caution
All power must be disconnected before servicing the valves.

Solenoid Valves

A slight hum from the solenoid is normal when the coil is energized. Should the valve fail to operate, check that there is voltage at the valve coil. If there is no voltage at the coil, check for loose wiring connections. If there is proper voltage at the valve coil and the valve still fails to open, replace the coil. Refer to the manufacturer's bulletin for correct procedure in coil replacement.

Should it become necessary to replace the complete valve, be sure that the flow is in the direction of the arrow on the body.

Test for gas leaks and check the valve action several times to ensure proper operation before attempting to relight the burner.

5.2.10 - Electrical System

Because of the many types of flame safeguard systems applicable to this equipment, complete descriptions of all D

Series burner electrical systems are beyond the scope of this manual. An individual electrical schematic drawing is shipped with each burner and complete operation and troubleshooting instructions are available from the various flame safeguard system manufacturers.

5.2.11 - Electric Motors

Motor supply voltage must not vary more than 10% from nameplate ratings. At initial startup and at least once a year thereafter, check the motor current with a meter while the burner is in high fire position. If the reading exceeds the nameplate rating plus service factor, determine the cause and correct it immediately. In dusty locations, clean the motor regularly to assure adequate cooling. Lubricate in accordance with the manufacturer's instructions.

5.3 — FP Burner

5.3.1 - Gas System

Check the gas train for leaks. Check the gas valves and verify the low and high gas pressure settings.

Solenoid Valves

A faint hum from the solenoid is normal when the coil is energized. Should the valve fail to operate, check that there is voltage at the valve coil. If there is no voltage at the coil, check for loose wiring connections. If there is proper voltage at the valve coil and the valve still fails to open, replace the coil. Refer to the manufacturer 's bulletin for correct coil replacement procedures.

Should it become necessary to replace the complete valve, be sure that the flow is in the direction of the arrow on the valve body.

Test for gas leaks and check valve action several times to ensure proper operation before attempting to relight the burner.

Caution
All power must be disconnected before servicing valves.

Motorized Main Gas Valves

Should the valve fail to operate, check for voltage at the valve. Make certain that the main shutoff cock is closed prior to testing. The actuator is not field repairable nor should it be disassembled. Replace the actuator if the valve fails to operate.

After replacement, cycle the valve with the fuel shut off to determine that it opens and closes. If the valve has a visual indicator, observe its position for correct operation.

5.3.2 - Oil System

The oil filter should be cleaned at regular intervals. An increased inlet vacuum reading may indicate a clogged filter. Follow the strainer manufacturer's maintenance schedule.

Maintenance checks on the flexible coupling between the fuel unit and motor for alignment, tightness and wear, and oil piping connection tightness should also be made at regular intervals. Access the coupling by removing the airbox cover and loosening the two setscrews on the flex coupling.

The oil nozzle should be checked periodically. Inside the nozzle lies a small screen that keeps out any particle not caught by the strainer. These particles will interfere with the normal oil flow pattern exiting the nozzle. A distorted flame can indicate a clogged nozzle. Inspect and clean the nozzle and screen. To clean the screen, swirler, and tip, unscrew the tip from the nozzle body. Clean nozzle parts in solvent. Never use wire or sharp metal tools to clean the nozzle orifice. A metal tool will distort the orifice and ruin the nozzle. Reassemble the nozzle. The tailpiece must be screwed in with the swirler seating tight against the tip to ensure proper atomization. Reassemble the nozzle into the nozzle body. If a nozzle is replaced, it must be replaced with an identical nozzle (make, size, and spray angle).

5.3.3 - Drawer Assembly

The drawer assembly may be removed for inspection and service:

1. Shut off the burner, turn the “ON-OFF” switch to the “OFF” position.
2. Shut off all electric power to the burner.
3. Disconnect the fuel lines from the drawer assembly access cover.
4. After making note of where the bolts are located in relationship to the access cover slots, remove the drawer assembly access cover bolts. Pull the drawer partially out of the housing.
5. Reach inside and disconnect the ignition cables from the electrodes for direct spark applications.
6. Pull the drawer assembly completely out of the housing.

To re-install:

1. Insert the assembly part way into the housing.
2. Reconnect the ignition cables, if applicable, and seat the assembly fully.
3. Install the access cover bolts loosely.
4. Slide the cover to the original location and tighten the bolts.
5. Reconnect the fuel lines.

5.3.4 - Ignition Electrode, Cable, and Pilot

Failure to keep electrodes clean and set in the proper position accounts for much faulty burner operation. Not only must the gap be correct, but the electrode points must be carefully located with respect to the nozzle. Sometimes difficulty in securing the electrodes in their clamps can be corrected by using light metal shims around the porcelain. Defective or cracked porcelains require replacement to prevent short circuiting of the spark. A gradual wearing away of the electrode tips may require re-spacing of the points or replacement of the electrode.

The pilot should be checked monthly for loosening of components and carbon buildup. Before removing the pilot,

ensure that the fuel supply is shut off.

On direct spark oil units, once the drawer assembly has been removed, check the electrode to nozzle gap and adjust if necessary. Refer to the drawer assembly drawings in Chapter 4.

For burners equipped with a gas pilot, the pilot is located on the side opposite to the main gas entrance:

1. Close the gas pilot cock.
2. Disconnect the pilot gas supply line.
3. Remove the screws on the pilot access plate.
4. Disconnect the high voltage ignition cable by pulling it straight back, away from the pilot assembly. The pilot gun assembly will slide back away from the flame side of the burner.
5. Once the pilot assembly is clear of the burner head bracket, turn the pilot assembly and retract it through the access hole.
6. Inspect the electrode and adjust the gap, if necessary.
7. Thoroughly clean and adjust the porcelain insulated electrodes.
8. Correct all variations from the clearance dimensions.
9. If the insulation on the high-voltage cables becomes cracked or charred, install new cables. Ignition cables should not be exposed to moisture, abrasion, or rough handling.
10. See that the connectors are in perfect contact with the cable ends by unscrewing the snap portion of the connector.

5.3.5 - Flame Scanner

The scanner must be clean. Even a small amount of contamination will reduce the flame signal. Wipe the scanner lens with a clean soft cloth. Check pilot and flame signal strength.

5.3.6 - Burner Mounting Inspection

The seal between the burner flange and furnace front plate must not permit combustion gases to escape. Periodic inspection is important.

5.4 — Extended Shutdown

When shutting down the burner for an extended period of time, the operator should use the following general guidelines to protect the burner from its surrounding elements. This will add to the operating life of the burner:

1. Turn the main electrical disconnect switch to the burner to "Off."
2. Close all main fuel valves.
3. If the burner operates in a damp environment, cover it with plastic to protect all electrical components from moisture. Remove the flame safeguard control and store in a dry atmosphere.

5.5 — Emergency Shutdown

In case of emergency, shut down the burner by turning the "On/Off" switch to the "Off" position. Turn the fuel selector switch to the "Off" position. Shut off the main manual fuel shutoff valves on the fuel supply line. The unit can also be shut down with the main electrical power disconnect. Inspect the burner carefully and troubleshoot before restarting the unit.

5.6 — Burner Maintenance Schedule

Item	Service By	Remarks
DAILY		
Gauges, Monitors, Indicators	Operator	Make visual inspection and record readings in log.
Instrument and Equipment Settings	Operator	Make visual check against recommended specifications.
Low Water, Fuel Cutoff, Alarms	Operator	Refer to instructions.
WEEKLY		
Firing Rate Control	Operator	Verify factory settings.
Igniter	Operator	Make visual inspection. Check flame signal strength.
Pilot and Main Fuel Valves	Operator	Open limit switch. Make audible and visual check. Check valve position indicators, and check fuel meters.
Flame Failure Controls	Operator	Close manual fuel supply for (1) pilot and (2) main fuel cock and/or valve(s). Check safety shutdown timing. Record in log.
Flame Signal Strength Controls	Operator	Read and log the flame signal for both pilot and main flame. Notify Service if readings are very high, very low, or fluctuating.
Linkages	Operator	Check all burner linkages for tightness. Tighten if required.
MONTHLY		
Low Fan Pressure Interlock	Operator	Manually adjust until switch opens.
High and Low Gas Pressure Interlocks	Operator	Refer to instructions. Manually adjust until switch opens.
Scanner and Diffuser	Operator	Check, inspect and clean for soot buildup.
Pilot Assembly	Operator	Check for loosening of components, erosion, or carbon buildup.
ANNUALLY		
Strainer (Oil Units)	Operator	Replace or clean the oil strainer element.
Impeller	Operator	Inspect and clean the combustion impeller.
Combustion Test	Service Tech	Perform a complete combustion test. Adjust burner if necessary. Read and log data.
Pilot Turndown Test	Service Tech	Required after any adjustment to flame, scanner, or pilot adjustment.
Operating Controls	Service Tech	Refer to instructions.

5.7 — Troubleshooting

This chapter assumes that the unit has been properly installed and adjusted and that it has been running for some time. It is further assumed that the operator has become thoroughly familiar with both burner and manual by this time.

⚠ Warning

Troubleshooting should be performed only be personnel who are familiar with the equipment and who have read and understood the contents of this manual. Failure to follow these instructions could result in serious injury or death.

⚠ Warning

Disconnect and lockout the main power supply in order to avoid the hazard of electrical shock. Failure to follow these instructions could result in serious injury or death.

The tables below are intended to simplify locating the source of the trouble. Methods of correcting the trouble, once identified, may be found elsewhere in this manual.

If the burner will not start or operate properly, the troubleshooting section should be referred to for assistance in pinpointing problems that may be not readily apparent.

The program relay (flame safeguard) has the capability to self-diagnose and to display a code or message that indicates the failure condition. Refer to the unit's manual for specifics and suggested remedies.

Familiarity with the programmer and other controls in the system may be obtained by studying the contents of this manual. Knowledge of the system and its controls will make troubleshooting that much easier. Costly downtime or delays can be prevented by systematic checks of actual operation against the normal sequence to determine the stage at which performance deviates from normal. Following a set routine may possibly eliminate overlooking an obvious condition, often one that is relatively simple to correct.

If an obvious condition is not apparent, check each continuity of each circuit with a voltmeter or test lamp. Each circuit can be checked and the fault isolated and corrected. In most cases circuit checking can be accomplished between appropriate terminals on the terminal boards in the control cabinet or entrance box. Refer to the wiring schematic supplied for terminal identification.

⚠ Warning

The cause for loss of flame or any other unusual condition should be investigated and corrected before attempting to restart. Failure to do so may result in serious injury or death.

⚠ Warning

Do not repeat unsuccessful lighting attempts without rechecking the burner and pilot adjustments. Damage to the boiler or serious injury or death may result.

⚠ Warning

Do not relight the pilot or attempt to start the main burner, either oil or gas, if the combustion chamber is hot and/or if gas or oil vapor combustion gasses are present in the furnace or flue passages or when excess oil has accumulated. Promptly correct any conditions causing leakage. Failure to follow these instructions could result in serious injury or death.

5.7.1 — Burner Does Not Start

Possible Cause	Check and Correct
No voltage at program relay power input terminals.	1. Main disconnect switch open. 2. Blown control circuit fuse. 3. Loose or broken electrical connection.
Program relay safety switch requires resetting.	Reset.
Limit circuit not completed - no voltage at end of limit circuit program relay terminal.	1. Pressure or temperature is above setting of operation control. (Load demand light will not glow.) 2. Water below required level • Low-water light (and alarm horn) should indicate this condition. • Check manual Reset button, if provided, on low-water control. 3. Fuel pressure must be within settings of low pressure and high pressure switches.
Fuel valve interlock circuit not completed.	Fuel valve auxiliary switch not closed.

5.7.2 — No Ignition

Possible Cause	Check and Correct
Lack of spark.	1. Electrode grounded or porcelain cracked. 2. Improper electrode setting. 3. Loose terminal on ignition cable, cable shorted. 4. Inoperative ignition transformer. 5. Insufficient or no voltage at pilot ignition circuit terminal.
Spark but no flame.	1. Lack of fuel - no gas pressure, closed valve, empty tank, broken line, etc. 2. Inoperative pilot solenoid. 3. Insufficient or no voltage at pilot ignition circuit terminal. 4. Too much air.
Low-fire switch open in low-fire proving circuit.	1. Damper motor not closed, slipped linkage, defective switch. 2. Damper jammed or linkage binding.
Running interlock circuit not completed.	1. Combustion or atomizing air proving switches defective or not properly set. 2. Motor starter interlock contact not closed.
Flame detector defective, sight tube obstructed, or lens dirty.	Replace defective detector, clear obstruction, clean lens.

5.7.3 — Pilot Flame, but No Main Flame

Possible Cause	Check and Correct
Insufficient pilot flame.	Adjust pilot flame.
On gas fired unit:	1. Manual gas cock closed. 2. Main gas valve inoperative. 3. Gas pressure regulator inoperative.
On oil fired unit:	1. Oil supply cut off by obstruction, closed valve, or loss of suction. 2. Supply pump inoperative. 3. No fuel. 4. Main oil valve inoperative. 5. Check oil nozzle, gun, and lines.
Flame detector defective, sight tube obstructed or lens dirty.	Replace defective detector, clear obstruction, clean lens.
Insufficient or no voltage at main fuel valve circuit terminal.	Adjust voltage.

5.7.4 — Burner Stays in Low-Fire

Possible Cause	Check and Correct
Pressure or temperature above modulating control setting.	Adjust pressure or temperature.
Manual-automatic switch in wrong position.	Place switch in correct position.
Inoperative modulating motor.	Repair or replace motor.
Defective modulating control.	Repair or replace control.
Loose binding, cams, setscrews, etc.	Tighten and adjust as required.

5.7.5 — Shutdown Occurs During Firing

Possible Cause	Check and Correct
Loss or stoppage of fuel supply.	Inspect fuel supply lines and adjust or repair as required.
Defective fuel valve, loose electrical connection.	Repair or replace valve, secure connections.
Flame detector weak or defective.	Repair or replace detector as required.
Lens dirty or sight tube obstructed.	Clean lens, remove obstruction.
The programmer lockout switch has not tripped.	Check the limit circuit for an opened safety control and adjust.
If the programmer lockout switch has tripped:	1. Check fuel lines and valves. 2. Check the flame detector. 3. Check for open circuit in running interlock circuit. 4. The flame failure light is energized by ignition failure, main flame failure, inadequate flame signal, or open control in the running interlock circuit.
Improper air/fuel ratio (lean fire).	1. Slipping linkage. 2. Damper stuck open. 3. Fluctuating fuel supply. • Temporary obstruction in fuel line. • Temporary drop in gas pressure.
Interlock device inoperative or defective.	Repair or replace as required.

5.7.6 — Modulating Motor Does Not Operate

Possible Cause	Check and Correct
Manual-automatic switch in wrong position.	Place switch in correct position.
Linkage loose or jammed.	Adjust linkage as required.
Motor does not drive to open or close during pre-purge or close on burner shutdown.	1. Motor defective. 2. Loose electrical connection. 3. Damper motor transformer defective.
Motor does not operate on demand.	1. Manual-automatic switch in wrong position. 2. Modulating control improperly set or inoperative. 3. Motor defective. 4. Loose electrical connection. 5. Damper motor transformer defective.

CHAPTER 6 Parts

6.1 - Front Smoke Box

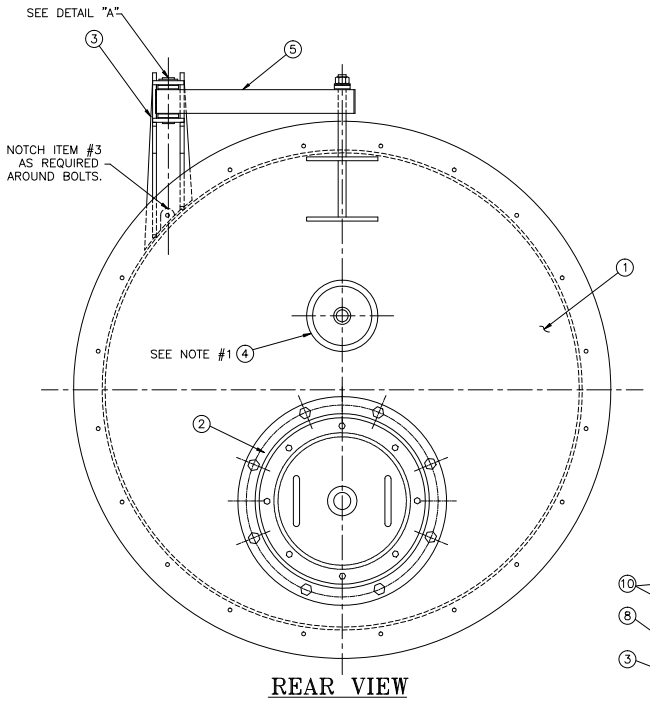
REPLACEMENT DOORS, INSULATED						
BOILER SIZE	60”	67”	78”	85”	96”	106”
LEFT HAND DOOR	465-2499	465-2501	465-2503	465-2505	465-2507	465-2509
RIGHT HAND DOOR	465-2500	465-2502	465-2504	465-2506	465-2508	465-2510

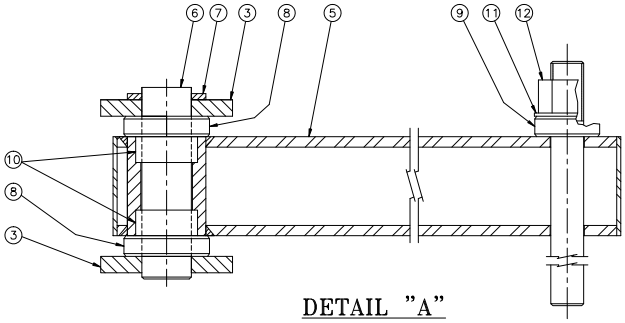
6.2 - Rear Door

ITEM	QTY	PART NO.	DESCRIPTION	USED ON
1	1	457C03445	REAR DOOR, INSULATED	60" W/O COMB. DOOR
	1	457-03446	REAR DOOR, INSULATED	60" W/ COMB. DOOR
	1	457C03441	REAR DOOR, INSULATED	67" W/O COMB. DOOR
	1	457-03442	REAR DOOR, INSULATED	67" W/ COMB. DOOR
	1	457C03449	REAR DOOR, INSULATED	78" W/O COMB. DOOR
	1	457-03450	REAR DOOR, INSULATED	78" W/ COMB. DOOR
	1	457C03453	REAR DOOR, INSULATED	85" W/O COMB. DOOR
	1	457-03454	REAR DOOR, INSULATED	85" W/ COMB. DOOR
	1	457C03447	REAR DOOR, INSULATED	96" W/O COMB. DOOR
	1	457-03448	REAR DOOR, INSULATED	96" W/ COMB. DOOR
	1	457C03451	REAR DOOR, INSULATED	106" W/O COMB. DOOR
	1	457-03452	REAR DOOR, INSULATED	106" W/ COMB. DOOR
2	1	465-02389	CRAWLWAY PLUG ASSEMBLY (465A02019)	60" – 67"
	1	465-02372	CRAWLWAY PLUG ASSEMBLY (465A02019)	78" – 85"
	1	465-02380	CRAWLWAY PLUG ASSEMBLY (465A02019)	96" – 106"
3	1	085C03276	PEDESTAL ASSEMBLY	60"
	1	085C03303	PEDESTAL ASSEMBLY	67"
	1	085C03278	PEDESTAL ASSEMBLY	78"
	1	085C03292	PEDESTAL ASSEMBLY	85"
	1	085C03282	PEDESTAL ASSEMBLY	96"
	1	085C03307	PEDESTAL ASSEMBLY	106"
4	1	428A00037	COMBUSTION RELIEF DOOR, 12"	SEE NOTE #1
	1	428-00017	COMBUSTION RELIEF DOOR, 7"	SEE NOTE #1
5	1	287-00073	DAVIT ARM DETAILS (287C00072)	60"
	1	287-00078	DAVIT ARM DETAILS (287C00072)	67"
	1	287-00075	DAVIT ARM DETAILS (287C00072)	78"
	1	287-00084	DAVIT ARM DETAILS (287C00072)	85"
	1	287-00079	DAVIT ARM DETAILS (287C00072)	96"
	1	287-00090	DAVIT ARM DETAILS (287C00072)	106"
6	1	135-03633	SIZED ROD, 1–1/2" OD x 5.8125"	60" – 96"
	1	135-03634	SIZED ROD, 1–1/2" OD x 6.8125"	106"
7	1	066-00573	RING, RETAINER, PEDESTAL PIN, REAR DOOR	ALL
8	2	807-00439	BEARING, BALL THRUST, ANDREWS No. D–17	ALL
9	1	807-00438	BEARING, BALL THRUST, ANDREWS No. D–9	ALL
10	2	807-00440	BEARING, NEEDLE ROLLER, TORINGTON No.B–2412	ALL
11	1	952-00132	WASHER, FLAT, 1"	ALL
12	1	869-00157	NUT, SELF LOCKING HEX– 1"–8UNC	ALL

NOTES:

1.) ITEM 4 IS OPTIONAL, USED ONLY WHEN REQUIRED BY CUSTOMER.

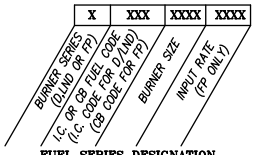




6.3 - Burner 30 PPM

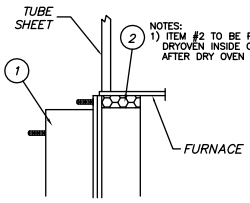
BOILER / BURNER CHART					ITEM #1		ITEM #4 (SEE NOTE #4)		ITEM #13		"A"		"B"		"C"	
BOILER DIA.	BOILER (HP)	BURNER MODEL-SIZE STANDARD	BEFORE 4/1/2013 30 PPM	AS OF 4/1/2013 30 PPM	DRY OVEN STANDARD	DRY OVEN 30 PPM	BURNER SUPPORT STANDARD	BURNER SUPPORT 30 PPM	BURNER GASKET STANDARD	BURNER GASKET 30 PPM	STD	30 PPM	STD	30 PPM	STD	30 PPM
60"	100	FP-3-4200	LND-54S	LND-42	059-07724	059-07725	530-00619	530-00560	032-02664	BY I.C.	2	2	12	6	N/A	6
	125	FP-3-5400	LND-63P	LND-54	059-07724	059-07725	530-00619	530-00560			2	2	12	6	N/A	6
67"	150	FP-3-6300	LND-84P	LND-74	059-07726	059-07727	530-00618	530-00560	032-02664	BY I.C.	2	2	16	24	N/A	N/A
	200	FP-4-8400	LND-105P	LND-84	059-07728	059-07727	530-00617	530-00560	032-02665		2	2	16	24	N/A	N/A
78"	250	FP-4-10500	LND-145S	LND-105	059-07729	059-07730	530-00616	530-00607	032-02665	BY I.C.	2	2	16	24	N/A	N/A
	300	FP-4-12600	LND-145P	LND-125	059-07729	059-07730	530-00616	530-00607			2	2	16	24	N/A	N/A
85"	350	D145P	LND-175P	LND-145	059-07731	059-07718	530-00605	530-00605	BY I.C.	BY I.C.	2	2	12	24	N/A	N/A
	400	D175P	LND-210P	LND-175	059-07718	059-07718	530-00605	530-00615			2	4	12	24	N/A	N/A
96"	500	D210P	LND-252P	LND-210	059-07732	059-07733	530-00558	530-00558	BY I.C.	BY I.C.	4	4	16	16	N/A	12
	600	D252P	LND-300P	LND-252	059-07733	059-07733	530-00558	530-00558			4	4	16	16	12	12
106"	700	D300P	LND-378P	LND-336	059-07722	059-07723	530-00606	530-00606	BY I.C.	BY I.C.	4	4	16	16	12	12
	800	D378P	LND-420P	LND-378	059-07723	059-07723	530-00606	530-00606			4	4	16	16	12	12

BURNER MODEL FORMAT

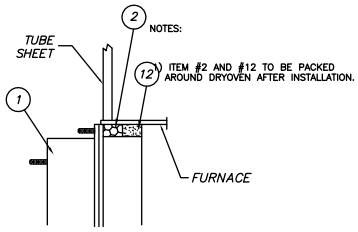


FUEL SERIES DESIGNATION

CB CODE	DESCRIPTION	IC CODE
100 =	LIGHT OIL	= L
200 =	LIGHT OIL & GAS	= LG
400 =	HEAVY OIL & GAS	= EG
600 =	HEAVY OIL	= E
700 =	GAS ONLY	= G

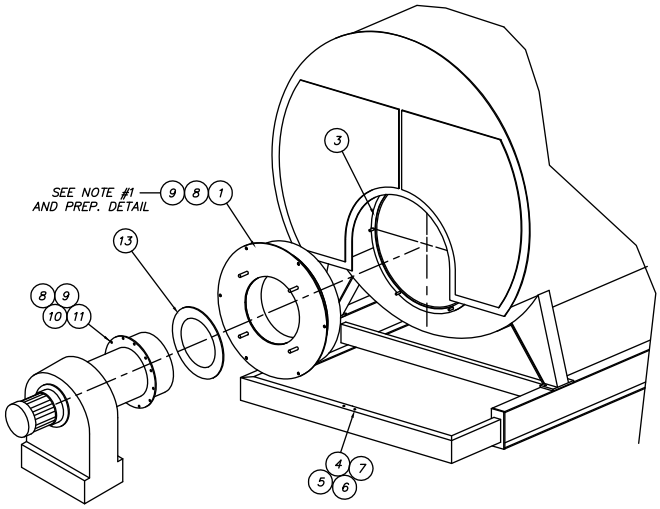


PREP. DETAIL
(60"–78" DIA)



PREP. DETAIL
(85"–106" DIA)

USED ON	ITEM	QTY.	PART NUMBER	DESCRIPTION	OPTION CODE
	①	1	SEE TABLE	DRY OVEN	SEE TABLE
60"–96"DIA. 106"DIA.	②	1	872–01075	SUPERWOOL 607MAX, BLANKET,INSUL.,1–1/2" @ 2400°F. 10" x 139" / SUPERWOOL 607MAX, BLANKET,INSUL.,1–1/2" @ 2400°F. 7" x 139"	SEE TABLE
	③	1	872–00622	ROPE, FIBERFRAX, 1/2"DIA, 2300°F. X 144" LG.	SEE TABLE
	④	1	SEE TABLE	BURNER SUPPORT	SEE TABLE
	5	2	869–00021	NUT,1/4"	FP BURNER
		"A"	869–00030	NUT,3/8"	–
	6	2	952–00082	LOCKWASHER,1/4"	FP BURNER
		"A"	952–00093	LOCKWASHER,3/8"	–
	7	2	868–00137	CAPSCREW,1/4" x 1" LG.	FP BURNER
		"A"	868–00158	CAPSCREW,3/8" x 1–1/2" LG.	–
	8	"B"	869–00015	NUT,HEX., 1/2" – 13UNC	–
	9	"B"	952–00094	LOCKWASHER,1/2"	–
	10	"C"	869–00017	NUT,HEX., 5/8" – 11UNC	–
	11	"C"	952–00084	LOCKWASHER,5/8"	–
85" DIA	12	35 LBS	872–00225	REFRACTORY, COATING, 3300°F	–
96" DIA		42 LBS			
106" DIA		45 LBS			
	13	1	SEE TABLE	GASKET, BURNER TO DRY OVEN	FP BURNER



6.4 - Burner 9 PPM

USED ON	ITEM	QTY.	PART NUMBER	DESCRIPTION	OPTION CODE
	①	1	SEE TABLE	DRY OVEN	SEE TABLE
60"–96"DIA.	②	1	872–01075	BLANKET,INSUL.,1–1/2" @ 2400°F. 10" x 139"	SEE TABLE
106"DIA.				BLANKET,INSUL.,1–1/2" @ 2400°F. 7" x 139"	
	③	1	872–00622	ROPE, FIBERFRAX, 1/2"DIA, 2300°F. X 144" LG.	SEE TABLE
	④	1	SEE TABLE	BURNER SUPPORT	SEE TABLE
	5	2	869–00021	NUT,1/4"	FP BURNER
		"A"	869–00030	NUT,3/8"	–
	6	2	952–00082	LOCKWASHER,1/4"	FP BURNER
		"A"	952–00093	LOCKWASHER,3/8"	–
	7	2	868–00137	CAPSCREW,1/4" x 1" LG.	FP BURNER
		"A"	868–00158	CAPSCREW,3/8" x 1–1/2" LG.	–
	8	"B"	869–00015	NUT,HEX., 1/2" – 13UNC	–
	9	"B"	952–00094	LOCKWASHER,1/2"	–
	10	"C"	869–00017	NUT,HEX., 5/8" – 11UNC	–
	11	"C"	952–00084	LOCKWASHER,5/8"	–
85"DIA.	12	35 LBS	872–00225	REFRACTORY, COATING, 3300°F	–
96"DIA.		42 LBS			
106"DIA.		45 LBS			
	13	1	SEE TABLE	GASKET, BURNER TO DRY OVEN	FP BURNER
106"DIA.	14	1	149–1550	SIZED BEAM, 4" @13#/FT X 67–3/4" LG.	S1 BURNER

BURNER MODEL FORMAT

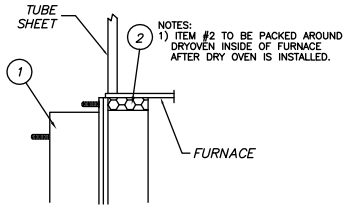
X	XXX	XXXX	XXXX

BURNER SERIES (DLND OR FP) — I.C. OR CB FUEL CODE (I.C. CODE FOR DLND) (CB CODE FOR FP) — BURNER SIZE — INPUT RATE (FP ONLY)

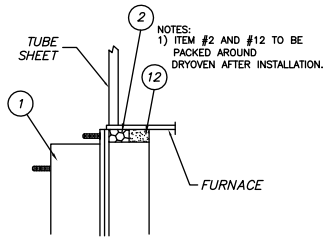
FUEL SERIES DESIGNATION

CB CODE	DESCRIPTION	IC CODE
100 =	LIGHT OIL	= L
200 =	LIGHT OIL & GAS	= LG
400 =	HEAVY OIL & GAS	= EG
600 =	HEAVY OIL	= E
700 =	GAS ONLY	= G

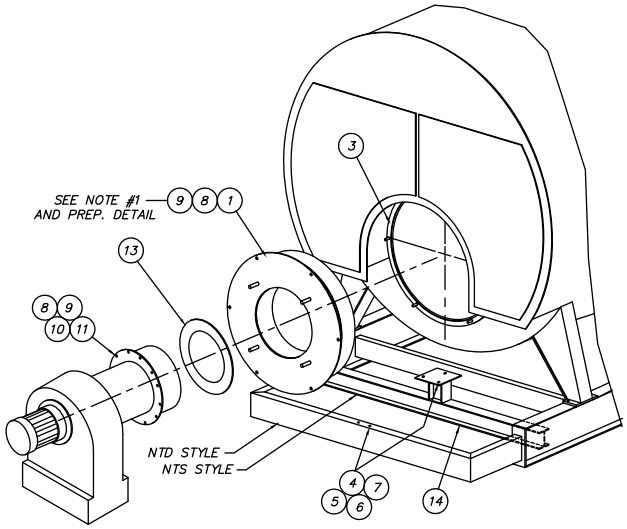
BOILER / BURNER CHART				ITEM #1		ITEM #4 (SEE NOTE #4)		ITEM #13		"A"		"B"		"C"	
BOILER DIA.	BOILER (HP)	BURNER MODEL–SIZE		DRY OVEN		BURNER SUPPORT		BURNER GASKET							
		9 PPM	15 PPM	9 PPM	15 PPM	9 PPM	15 PPM	9 PPM	15 PPM	9 PPM	15 PPM	9 PPM	15 PPM	9 PPM	15 PPM
60"	100	–	–	–	–	–	–	BY I.C.		–	–	–	–	–	–
	125	–	–	–	–	–	–			–	–	–	–	–	–
67"	150	–	–	–	–	–	–			–	–	–	–	–	–
	200	–	–	–	–	–	–			–	–	–	–	–	–
78"	250	–	–	–	–	–	–			–	–	–	–	–	–
	300	–	–	–	–	–	–			–	–	–	–	–	–
85"	350	–	–	–	–	–	–			–	–	–	–	–	–
	400	–	–	–	–	–	–			–	–	–	–	–	–
96"	500	NTD 210	–	059–07915	–	530–00642	–			4	–	16	–	12	–
	600	–	–	–	–	–	–			–	–	–	–	–	–
106"	7/800	–	NTS1336	–	059–08183	–	530–648			6	–	16	–	16	–
	805	–	NTS376LGA–158–1P	–		–				–	6	–	16	–	12



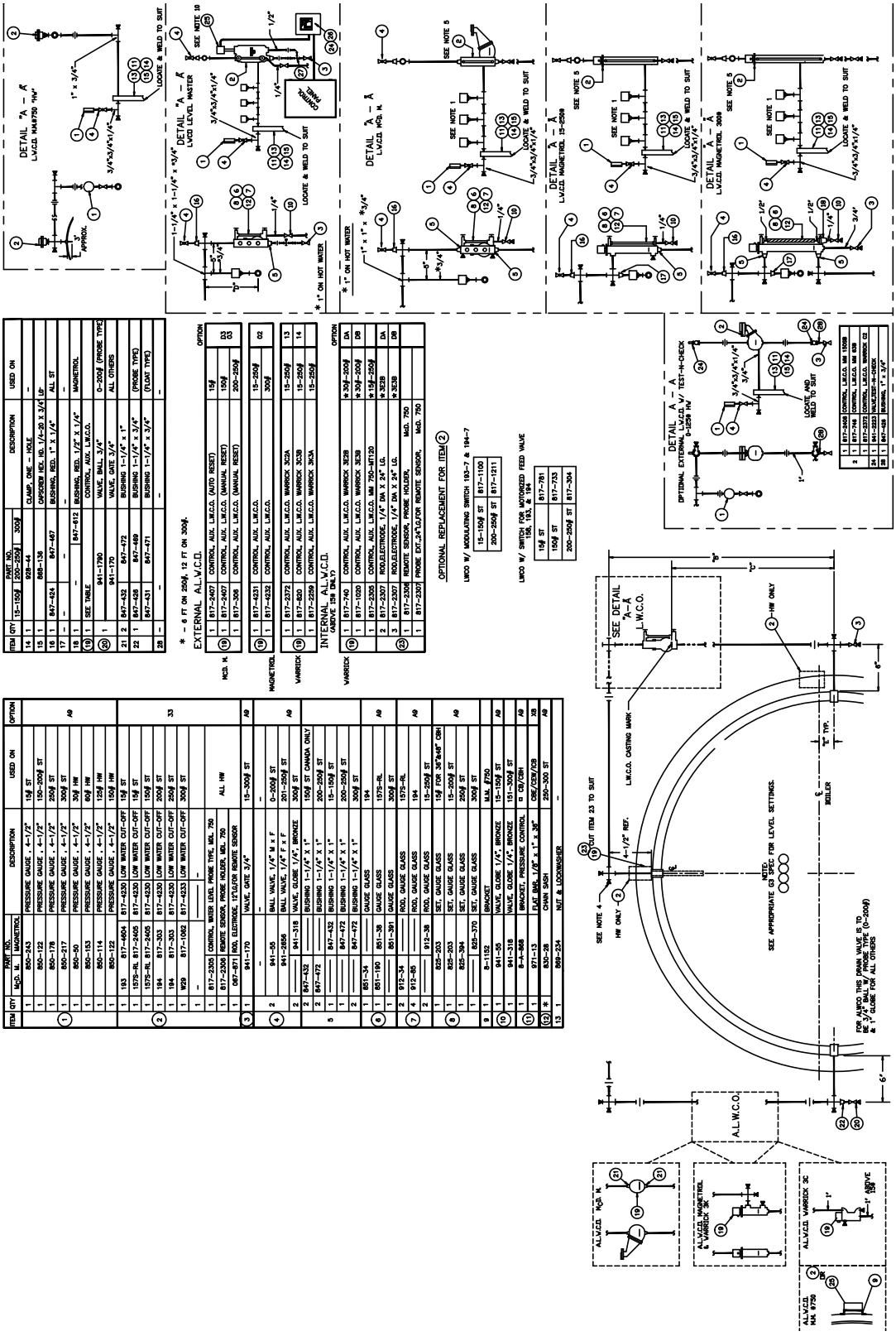
PREP. DETAIL
(60"–78" DIA)



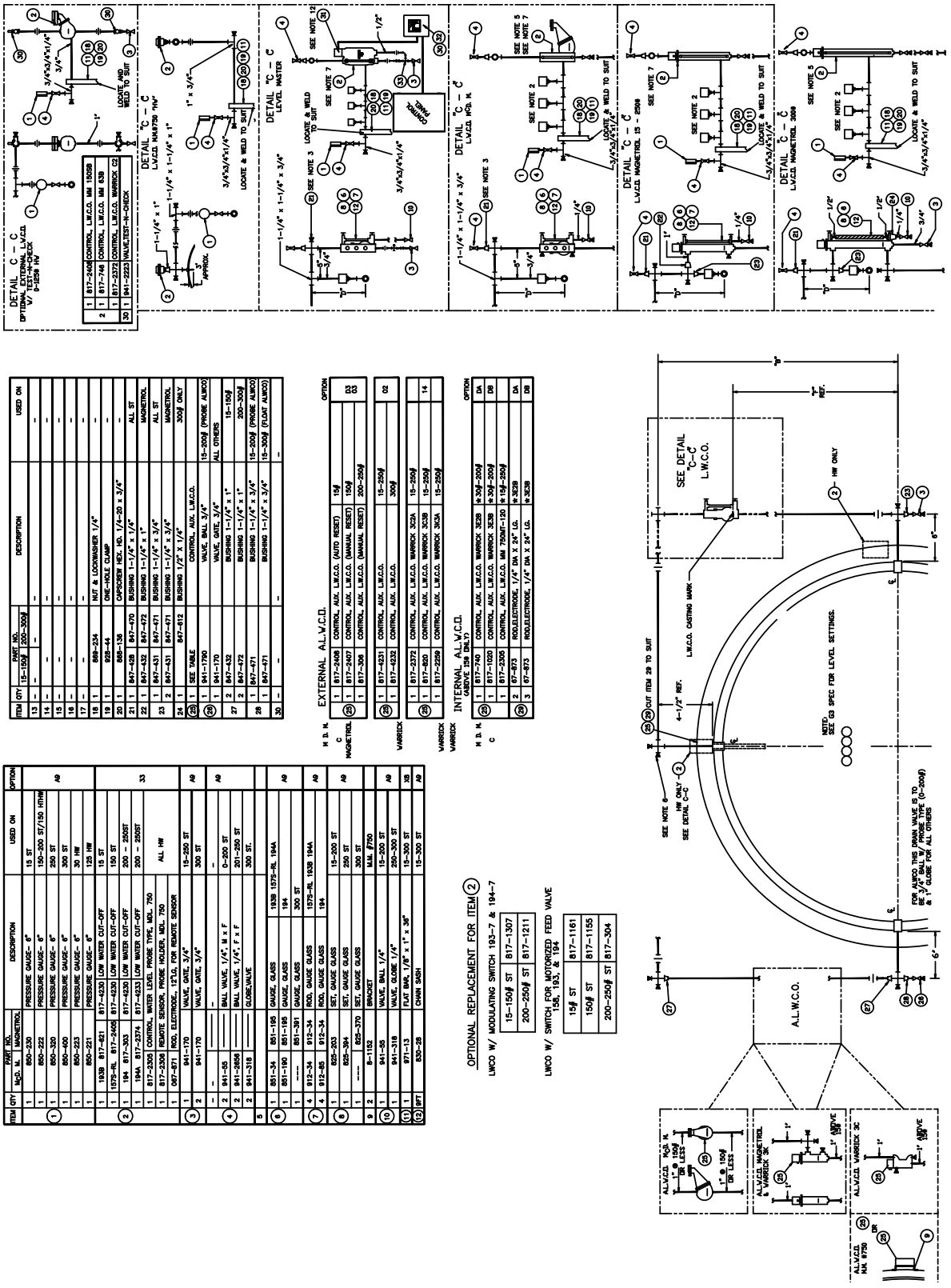
PREP. DETAIL
(96"–106" DIA)



6.5 - Water Column 60”-67”



6.6 - Water Column 78”-85”



6.7 - Water Column 96"-106"

		McD. M.	MAGNETROL				
(1)	1	850-264		PRESSURE GAUGE- 8-1/2"		15 ST	A9
	1	850-230		PRESSURE GAUGE- 6"		15 ST 67"	
	1	850-104		PRESSURE GAUGE- 8-1/2"		150-200 ST	
	1	850-222		PRESSURE GAUGE- 6"		150-200 ST 67"	
	1	850-150		PRESSURE GAUGE- 8-1/2"		250 ST	
	1	850-320		PRESSURE GAUGE- 6"		250 ST 67"	
	1	850-172		PRESSURE GAUGE- 8-1/2"		300 ST	
	1	850-400		PRESSURE GAUGE- 6"		300 ST 67"	
(2)	1	193B 817-621		817-4230	LOW WATER CUT-OFF	15 ST	
	1	157S-RL 817-2405		817-4230	LOW WATER CUT-OFF	15 ST	
	1	W-25-CLA 817-163		817-4230	LOW WATER CUT-OFF	15 ST	
	1	157S-RL 817-2405		817-4230	LOW WATER CUT-OFF	150 ST	
	1	194 817-303		817-4230	LOW WATER CUT-OFF	200 ST	
	1	194A 817-2374		817-4230	LOW WATER CUT-OFF	200 ST	
	1	194 817-303		817-4230	LOW WATER CUT-OFF	250 ST	
	1	194A 817-2374		817-4230	LOW WATER CUT-OFF	250 ST	
	1	W29 817-1962			LOW WATER CUT-OFF	300 ST	
(3)	1	941-170		VALVE, GATE 3/4"		15-250 ST	A9
	2	941-170		VALVE, GATE 3/4"		300 ST	
(4)	–	–	———	–		–	A9
	2	941-55	———	BALL VALVE, 1/4", M x F		0-200 ST	
	2	941-2656	———	BALL VALVE, 1/4", F x F		201-250 ST	
	2	———	941-318	VALVE, GLOBE 1/4", BRASS		300 ST	
(5)	1	8-A-3172		BRACKET, STEAM GAUGE		78" CB/LE/CBW AL 4W/CBI/CBSS	A9
	1	8-3252		BRACKET, STEAM GAUGE		96" CB/LE/CBW	
	1	8-3340		BRACKET, STEAM GAUGE		96"CBW/92-106"CB/96"-106"4WG	
(6)	1	851-34	851-195	GAUGE, GLASS	193B 194A 157S-RL	MAG.	A9
	1	851-190	851-195	GAUGE, GLASS	194	MAG.	
	1	———	851-391	GAUGE, GLASS	300 ST		
(7)	4	912-34	912-34	ROD, GAUGE GLASS	193B 194A 157S-RL	MAG.	A9
	4	912-85	912-34	ROD, GAUGE GLASS	194	MAG.	
(8)	1	825-394		SET, GAUGE GLASS		0-250 ST	A9
	1	———	825-370	SET, GAUGE GLASS		300 ST	
(10)	1	941-55		VALVE, BALL 1/4"		15-200 ST	A9
	1	941-318		VALVE, GLOBE, 1/4"		250-300 ST	

ITEM	QTY	PART NO.	DESCRIPTION	USED ON	OPTION
(11)	1	8-A-868	BRACKET, PRESS. CONTROL	□15-300 ST	A9
	1	971-13	FLAT BAR, 1/8" x 1" x 36"	CEW/ICB/4WG	X8
(12)	*	830-28	CHAIN SASH	15-300 ST	A9

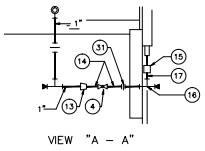
ITEM	QTY	PART NO. 15-150#	PART NO. 200-250#	PART NO. 300#	DESCRIPTION	USED ON
13	1	847-1687	858-1009	858-1009	COUPLING 1" X 1/4"	–
14	3	857-448		857-726	BRASS NIPPLE, 1/4" x 1-1/2"	–
15	1	858-856		858-768	COUPLING 1/4" R.H. THREAD	67" DIA. ONLY
16	1	859-54		859-32	BRASS TEE 1/4"	–
17	1	857-452		857-676	BRASS NPL. (X-HEAVY) 1/4" x 1-1/2"	67" DIA. ONLY
18	1	869-234			NUT & LOCKWASHER 1/4"	–
19	1	928-44			ONE-HOLE CLAMP	–
20	1	868-136			CAPSCREW HEX. HD. 1/4-20 x 3/4"	–
21	1	847-428	847-470		BUSHING 1-1/4" x 1/4"	ALL ST
22	1	847-432	847-472	———	BUSHING 1-1/4" x 1"	MAGNETROL
23	1	847-431	847-471		BUSHING 1-1/4" x 3/4"	ALL ST
	2	847-431	847-471		BUSHING 1-1/4" x 3/4"	MAGNETROL
24	1	———		847-612	BUSHING 1/2" X 1/4"	MAGNETROL
(25)	1	SEE TABLE			CONTROL, AUX. L.W.C.O.	
(26)	1	941-1790			VALVE, BALL 3/4"	15-200# (PROBE TYPE)
	1	941-170			VALVE, GATE 3/4"	ALL OTHERSS
27	2	847-432			BUSHING 1-1/4" x 1"	15-150#
	2	847-472			BUSHING 1-1/4" x 1"	200-300#
28	1	847-471			BUSHING 1-1/4" x 3/4"	15-200# (PROBE TYPE)
	1	847-471			BUSHING 1-1/4" x 3/4"	ALL OTHERS
30	–	–			–	–
31	1	858-193	858-172		UNION, FEMALE, 1/4"	ALL

EXTERNAL A.L.W.C.O.

					OPTION
McD. M. (25)	1	817-2408	CONTROL, AUX. L.W.C.O. (AUTO RESET)	15#	
	1	817-2407	CONTROL, AUX. L.W.C.O. (MANUAL RESET)	150#	D3
	1	817-306	CONTROL, AUX. L.W.C.O. (MANUAL RESET)	200-250#	D3
MAGNETROL (25)	1	817-4231	CONTROL, AUX. L.W.C.O.	15-250#	02
	1	817-4232	CONTROL, AUX. L.W.C.O.	300#	
WARRICK (25)	1	817-2372	CONTROL, AUX. L.W.C.O. WARRICK 3C2A	15-250#	13
	1	817-820	CONTROL, AUX. L.W.C.O. WARRICK 3C3B	15-250#	14
	1	817-2259	CONTROL, AUX. L.W.C.O. WARRICK 3K3A	15-250#	

INTERNAL A.L.W.C.O.
(ABOVE 15# ONLY)

					OPTION
WARRICK (25)	1	817-740	CONTROL, AUX. L.W.C.O. WARRICK 3E2B	*30#-200#	DA
WARRICK	1	817-1020	CONTROL, AUX. L.W.C.O. WARRICK 3E3B	*30#-200#	DB
McD. M.	1	817-2305	CONTROL, AUX. L.W.C.O. MM 750 MT-120	*15#-200#	
(29)	2	67-873	ROD,ELECTRODE, 1/4" DIA X 24" LG.	*3E2B EXCEPT 83" CBR	
	3	67-873	ROD,ELECTRODE, 1/4" DIA X 24" LG.	*3E3B EXCEPT 83" CBR	
	2	67-708	ROD,ELECTRODE, 1/4" DIA X 27" LG.	*3E2B 83" CBR	DA
	3	67-708	ROD,ELECTRODE, 1/4" DIA X 27" LG.	*3E3B 83" CBR	DB
	1	817-2306	REMOTE SENSOR, PROBE HOLDER,	MDL. 750	
	1	817-2383	PROBE EXT., 36"LG, FOR REMOTE SENSOR,	MDL. 750	



VIEW "A – A"

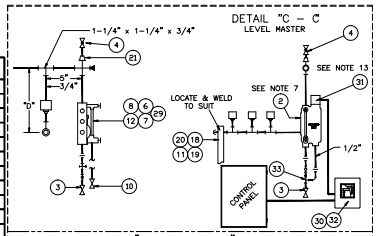
OPTIONAL REPLACEMENT FOR ITEM (2)

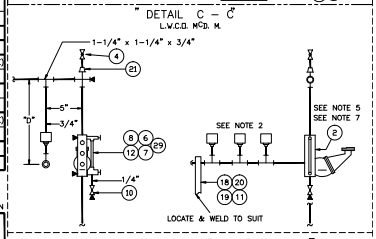
LWCO W/ MODULATING SWITCH 193-7 & 194-7

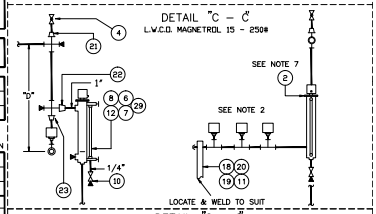
15-150# ST	817-1307
200-250# ST	817-1211

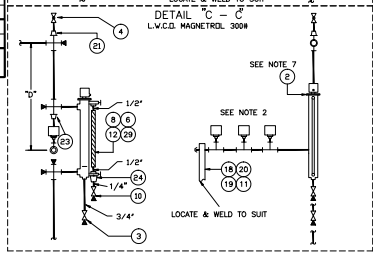
LWCO W/ SWITCH FOR MOTORIZED FEED VALVE 158, 193, & 194

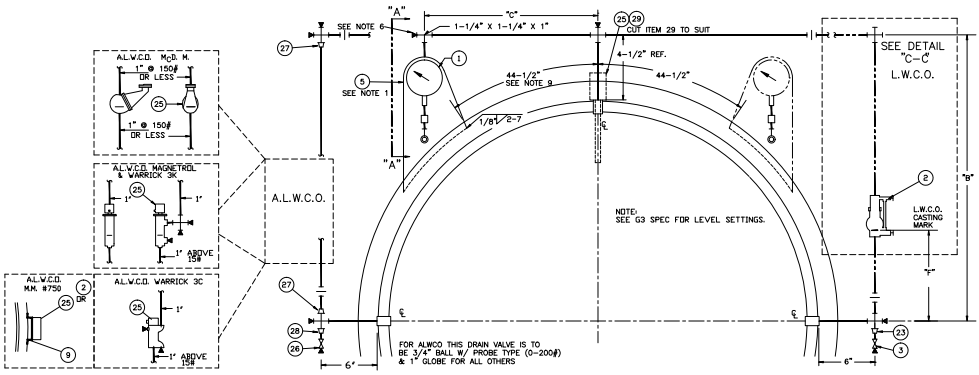
15# ST	817-1161
150# ST	817-1155
200-250# ST	817-304











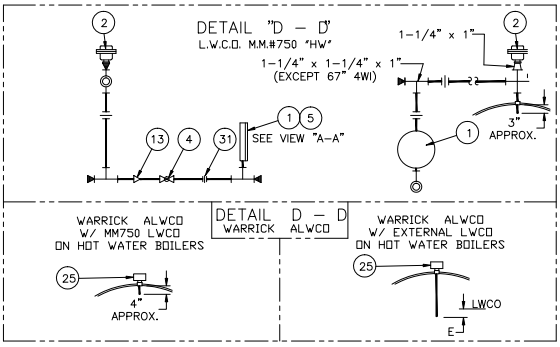
6.7 - Water Column 96”-106” cont’d

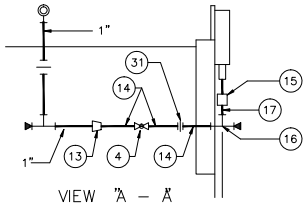
ITEM	QTY	PART NO. McD. M.	PART NO. MAGNETROL	DESCRIPTION	USED ON
1	1	850–101		PRESSURE GAUGE– 8–1/2”	30 HW
		850–223		PRESSURE GAUGE–6”	30 HW 67”
		850–103		PRESSURE GAUGE– 8–1/2”	125 HW
		850–821		PRESSURE GAUGE– 6”	125 HW 67”
		850–104		PRESSURE GAUGE– 8–1/2”	150 HTHW
		850–222		PRESSURE GAUGE– 6”	150 HTHW 67”
2	1	817–2305		CONTROL, WATER LEVEL PROBE TYPE, MDL. 750	ALL HW
		817–2306		REMOTE SENSOR, PROBE HOLDER, MDL. 750	
		067–871		ROD,ELECTRODE 12”LG, FOR REMOTE SENSOR	
3	1	941–1790		VALVE, BALL 3/4”	15–200 (PROBE)
		941–170		VALVE, GATE 3/4”	0–300 (FLOAT)
4	1	941–55		VALVE, BALL, 1/4”	0–150#
5	1	8–A–3172		BRACKET, STEAM GAUGE	78” CB/LE/CBW, ALL 4WI
	1	8–3252		BRACKET, STEAM GAUGE	96” CB/LE/CBW
	1	8–3340		BRACKET, STEAM GAUGE	96”CEW/92–106”CB/96”–106”4WG
	1	8–A–3172		BRACKET, STEAM GAUGE	67”
	1	8–A–3172		BRACKET, STEAM GAUGE	83” CBR
9	2	8–1152		BRACKET	M.M. #750

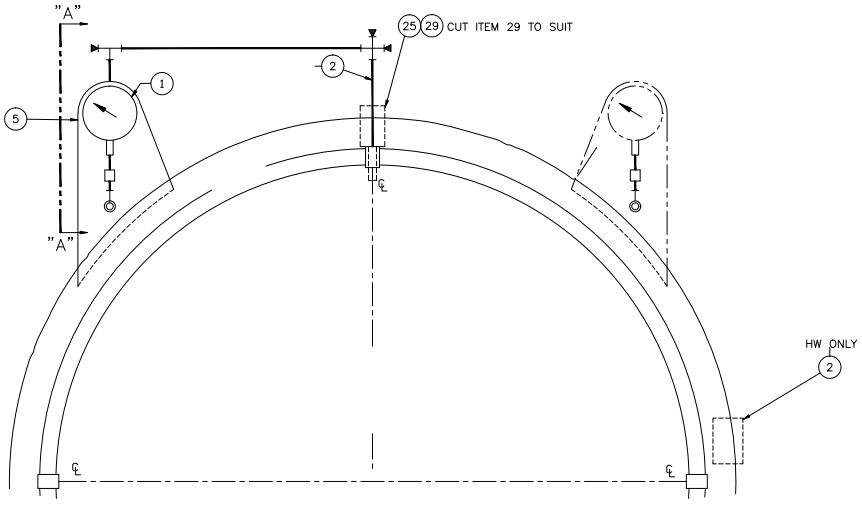
ITEM	QTY	PART NO. 15–150#	DESCRIPTION	USED ON
13	1	847–1687	COUPLING 1” X 1/4”	–
14	3	857–448	BRASS NIPPLE, 1/4” x 1–1/2”	–
15	1	858–856	COUPLING 1/4” R.H. THREAD	67” DIA. ONLY
16	1	859–54	BRASS TEE 1/4”	–
17	1	857–452	BRASS NPL. (X–HEAVY) 1/4” x 1–1/2”	67” DIA. ONLY
24	1		BUSHING 1/2” X 1/4”	–
25	1	SEE TABLE	CONTROL, AUX. L.W.C.O.	
27	2	847–432	BUSHING 1–1/4” x 1”	15–150#
	2	847–472	BUSHING 1–1/4” x 1”	200–300#
28	1	847–431	BUSHING 1–1/4” x 3/4”	15–150#
	1	847–471	BUSHING 1–1/4” x 3/4”	200–300#
29		SEE TABLE	SEE TABLE	–
30	N/A		–	–
31	1	858–193	UNION, FEMALE, 250#, BRONZE, 1/4”	15–250#
	1	858–172	UNION, FEMALE, 300#, MI, BLK, 1/4”	251–300#

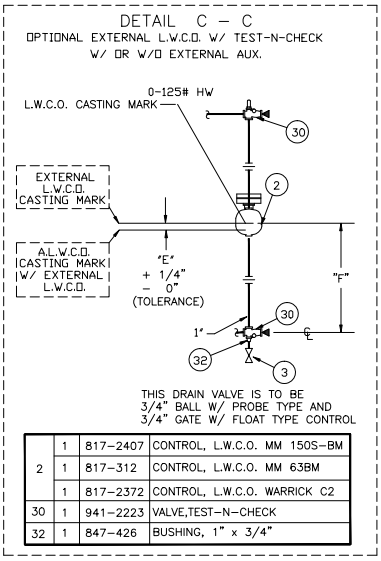
INTERNAL A.L.W.C.O.

WARRICK	25	1	817–740	CONTROL, AUX. L.W.C.O. WARRICK 3E2B	☆ 30#–200#
WARRICK		1	817–1020	CONTROL, AUX. L.W.C.O. WARRICK 3E3B	☆ 30#–200#
McD. M.		1	817–2305	CONTROL, AUX. L.W.C.O. MM 750 MT–120	☆ 15#–200#
	29	2	67–873	ROD,ELECTRODE, 1/4” DIA X 24” LG.	☆ 3E2B EXCEPT 83” CBR
		3	67–873	ROD,ELECTRODE, 1/4” DIA X 24” LG.	☆ 3E3B EXCEPT 83” CBR
		2	67–708	ROD,ELECTRODE, 1/4” DIA X 27” LG.	☆ 3E2B 83” CBR
		3	67–708	ROD,ELECTRODE, 1/4” DIA X 27” LG.	☆ 3E3B 83” CBR
		1	817–2306	REMOTE SENSOR, PROBE HOLDER,	MDL. 750
		1	817–2383	PROBE EXT., 36”LG, FOR REMOTE SENSOR,	MDL. 750



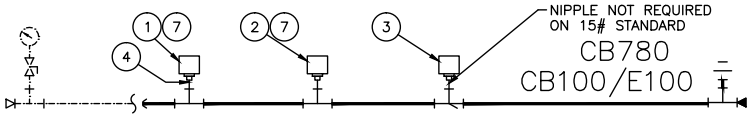






2	1	817–2407	CONTROL, L.W.C.O. MM 150S–BM
	1	817–312	CONTROL, L.W.C.O. MM 63BM
	1	817–2372	CONTROL, L.W.C.O. WARRICK C2
30	1	941–2223	VALVE,TEST–N–CHECK
32	1	847–426	BUSHING, 1” x 3/4”

6.8 - Pressure Controls

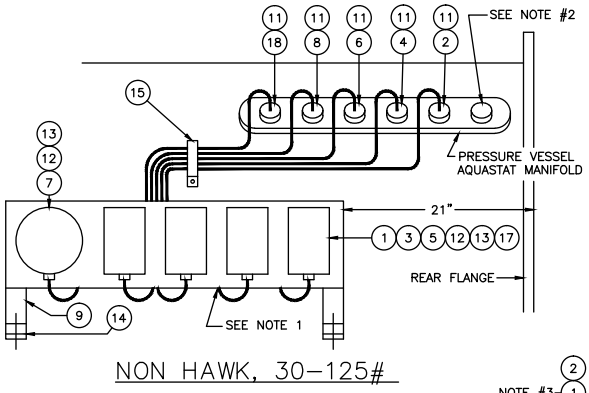


15#	16#–150#	151#–200#	201#–250#	300#	BILL OF MATERIAL				
PART NO.	PART NO.	PART NO.	PART NO.	PART NO.	ITEM	QTY	PART NO.	DESCRIPTION	USED ON
817–4095	817–4093	817–4883	817–4147	817–4091	①	1	SEE TABLE	CONTROL PRESSURE (OLC)	CB780/CB100/E100
817–4094	817–4092	817–4148	817–4149	817–4073	②	1	SEE TABLE	CONTROL PRESSURE (HLC)	–
817–251	817–204	817–234	817–234	817–234	③	1	SEE TABLE	CONTROL PRESSURE (MC)	48"– 106" CB780/CB100/E100
857–448	857–448	857–448	857–448	857–726	4	3	SEE TABLE	NIPPLE – 1/4" x 1–1/2"	–
–	–	880–605	880–605	–	⑦	2	SEE TABLE	LIMIT STOP ASSY SEE NOTE 7	UL & CSD–1

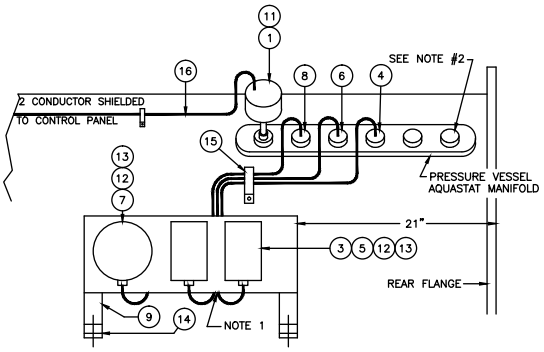
6.9 - Temperature Controls (Hot Water)

HAWK 281–360	HAWK 240–280	HAWK 170–240	CB780/CB100/E100 281–360 DEG F. HTHW	CB780/CB100/E100 240–280 DEG F. HTHW	CB780/CB100/E100 30–125# HW 170–240 DEG F.
817–5167	817–5167	817–5167	832–2091 **	832–2091 **	817–1244
N/A	N/A	N/A	937–772	937–772	817–378
817–4289	817–4291	817–4098	817–4289	817–4291	817–2402
817–699	817–399	817–399	817–699	817–399 (5)(8)	817–399 (5)(8)
817–4292	817–4290	817–400	817–4292	817–4290	817–400
817–699	817–399	817–399	817–699	817–399 (5)(8)	817–399 (5)(8)
937–710	937–710	937–787	937–710	937–710	937–787
937–673	937–673	937–27	937–673	937–673	937–27
937–658	937–658	817–3103	937–658	937–658	817–3103
		817–641			817–641
008–995	008–995	008–995	008–995	008–995	008–967
			008–995	008–995	008–995
–	–	–	–	–	–
1	3	4	–	2	5

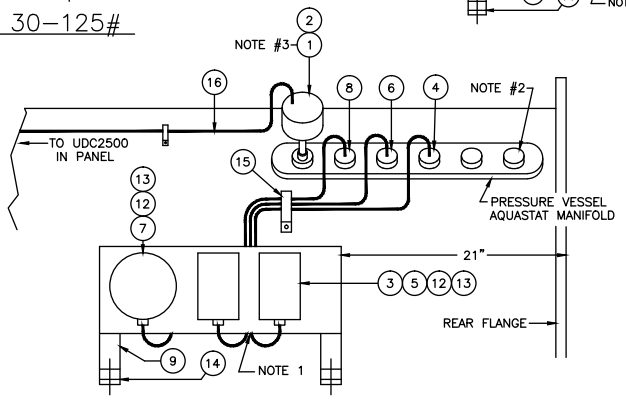
BILL OF MATERIAL				
ITEM	QTY	PART NO.	DESCRIPTION	USED ON
1	1	SEE TABLE	TEMPERATURE CONTROL, MODULATING (MC)	–
2	1	SEE TABLE	WELL, SEPARABLE	
3	1	SEE TABLE	TEMPERATURE CONTROL, HIGH LIMIT (HLC)	–
4	1	SEE TABLE	WELL, SEPARABLE	
5	1	SEE TABLE	TEMPERATURE CONTROL, OPERATING LIMIT (OLC)	–
6	1	SEE TABLE	WELL, SEPARABLE	
7	1	SEE TABLE	THERMOMETER	15–200HP
		SEE TABLE	THERMOMETER	250–800HP
8	1	SEE TABLE	WELL, SEPARABLE	15–200HP
		SEE TABLE	WELL, SEPARABLE	250–800HP
9	1	SEE TABLE	BRACKET, LIMIT CONTROLS (DWG. 008–B–937)	15–200HP
		SEE TABLE	BRACKET, LIMIT CONTROLS (DWG. 008–B–937)	250–800HP
10				
11	SEE TABLE	847–466	BUSHING, REDUCING, 3/4" x 1/2", F.S.	–
12	9	860–4	MACH. SCR. #10–32 x 3/4"	
13	9	869–9	NUT, MACH. SCR. #10–32	
14	4	841–571	SHT. MTL. SCR. #10–32 x 5/8"	
15	1	928–39	STRAP, PIPE	
16	NOTE #4	950–414	WIRE, THERMOCOUPLE, TYPE–J	–
17	1	817–491	TEMPERATURE CONTROL, (LFHC) (9)	30/125# ICB
18	1	817–399	WELL, SEPARABLE (9)	30/125# ICB



NON HAWK, 30–125#



ALL HAWK



NON HAWK, H.T.H.W.

6.10 - Feedwater Piping

ITEM	QTY	PART NO. 15–150# ST	PART NO. 200#–300# ST	DESCRIPTION	USED ON	OPTION
1	2	941–236	941–316	VALVE, GATE, 1–1/4"	50–125A H.P.	TE
	2	941–333	941–693	VALVE, GATE, 1–1/2"	125–150 / 100S–225S H.P.	TF
	2	941–237	941–172	VALVE, GATE, 2"	200–300 H.P.	TG
	2	–	941–172	VALVE, GATE, 2"	350–800 H.P.	TG
	2	941–950	941–850	VALVE, GATE, 2–1/2"	350–800 H.P.	TH
2	1	941–143	941–403	VALVE, GLOBE, 1–1/4"	50–125A H.P.	TE
	1	941–144	941–404	VALVE, GLOBE, 1–1/2"	125–150 / 100S–225S H.P.	TF
	1	941–405	941–406	VALVE, GLOBE, 2"	200–300 H.P.	TG
	1	–	941–406	VALVE, GLOBE, 2"	350–800 H.P.	TG
	1	941–407	941–408	VALVE, GLOBE, 2–1/2"	350–800 H.P.	TH
3	1	SEE TABLE		VALVE, FEEDWATER SEE NOTE 2	350–800 H.P.	SEE TABLE
4	1	SEE TABLE		VALVE, GLOBE SEE NOTE 3	350–800 H.P.	SEE TABLE
5	1	SEE TABLE		VALVE, CHECK SEE NOTE 3	50–125A H.P.	SEE TABLE
6	1	8B3306		BRACKET	ALL	TE,TF,TG,TH
7	1	SEE TABLE		STRAINER	SEIMENS FEEDWATER VALVE	–

TABLE–BOILER FEED VALVES ITEMS 4 & 5

HORSEPOWER	STEAM PRESS.	ITEM 4 PART NO.	ITEM 4 OPT.	ITEM 5 PART NO.	ITEM 5 OPT.
50–125A	150#	941–143		940–144	
	200#	941–403	5A	940–456	5B
	250#–300#	941–1872	5C	940–1380	
125–150 100S–225S	150#	941–144		940–145	
	200#	941–404	5D	940–2461	5E
	250#–300#	941–1873	5F	940–2161	5G
200–300	150#	941–405		940–146	
	200#	941–406	5H	940–2460	5I
	250#–300#	941–1874	5J	940–2378	
350–800	150#	941–407		940–336	
	200#	941–408	5L	940–352	5M
	250#–300#	941–1874		940–2378	

NON–FLOOR STK. ITEMS 350–800 H.P. 15–200# 2–1/2" NPT. PIPING

FITTINGS	P/N	SIZE	QTY
PLUG	858–97	2–1/2"	1
UNION	858–180	2–1/2"	2
ELBOW	859–140	2–1/2"	1
TEE	859–40	2–1/2"	3
BULK PIPE	900–343	2–1/2"	

BUSHING (STL)	SIZE
847–481	2–1/2" X 3/4"
847–482	2–1/2" X 1"
847–483	2–1/2" X 1–1/4"
847–484	2–1/2" X 1–1/2"
847–485	2–1/2" X 2"

TABLE–"SIEMENS" FEEDWATER VALVES ITEM 3.

15# ST. BLR. HP.	15# ST. PROPORTIONAL	15# ST. BLR. HP.	15# ST. ON/OFF	150–250# ST. BLR. HP.	150–250# ST. PROPORTIONAL	150–250# ST. BLR. HP.	150–250# ST. ON/OFF
50–60	949–435	50	949–436	50–80	949–435	50	949–435
70–80	949–436	60–80	949–437	100–125	949–436	60–70	949–436
100–150	949–437	100–125	949–438	150–200	949–437	80–125	949–437
200	949–438	150–200	949–439	250–350	949–438	150	949–438
250–350	949–439	250–350	949–440	400–500	949–443	200–300	949–443
400–600	949–440	400–500	949–462	600–800	949–444	350–500	949–444
700–800	949–462	600–800	949–463			*600–800	949–441

*600–800HP: NOT AVAILABLE FOR 250#

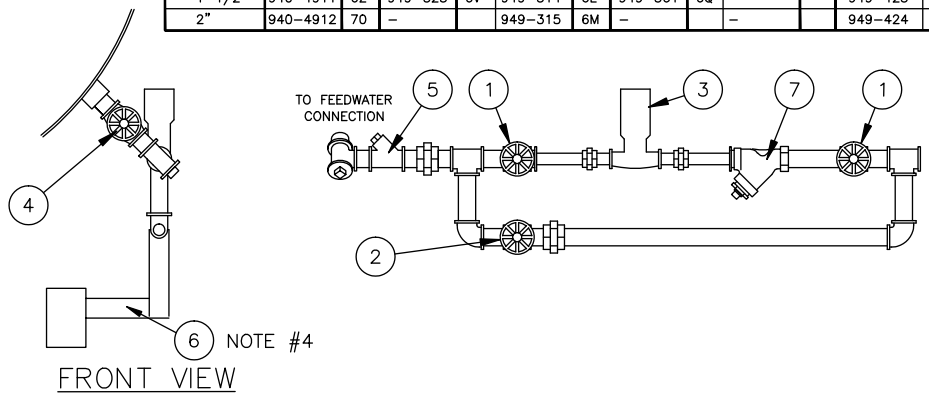
TABLE–ITEM 7.

15–250# ST. BLR. HP.	15–250# ST. PART NO.
50–125A	923–439
125–150	923–440
100S–225S	923–440
200–300	923–441
*350–800	923–441
**350–800	923–442

*350–800HP 250#
**350–800 15–200#

TABLE–FEEDWATER VALVE ITEM 3

	VENDOR NAME: JORDAN 15–300# MARK 33 SERIES		BARBER–COLMAN 15–250# PROPORTIONAL VP–SERIES		BARBER–COLMAN 15–250# ON–OFF VC–SERIES		HONEYWELL 15# STEAM		HONEYWELL 150–250# STEAM		SVF 4–20mA	SVF 0–130 OHM	BALLENGER 4–20mA	BALLENGER 0–135 OHM
VALVE SIZE	PART NO.	OPT.	PART NO.	OPT.	PART NO.	OPT.	PART NO.	OPT.	PART NO.	OPT.	PART NO.	PART NO.	PART NO.	PART NO.
3/4"	940–4908	6W	949–320	6S	949–311	6I	949–358	6N	949–83	6R	949–420	949–408	940–6723	940–6513
1"	940–4909	6X	949–321	6T	949–312	6J	949–359	6O	949–359	6O	949–421	949–409	940–6724	940–6514
1–1/4"	940–4910	6Y	949–322	6U	949–313	6K	949–360	6P	–		949–422	949–413	940–6725	940–6515
1–1/2"	940–4911	6Z	949–323	6V	949–314	6L	949–361	6Q	–		949–423	949–414	940–6726	940–6516
2"	940–4912	70	–		949–315	6M	–		–		949–424	949–415	940–6727	940–6517



6.11 - Safety Valves Steam

15 psi

Boiler HP	15#			
	1st Valve(s)		2nd Valve(s)	
	Qty	P/N	Qty	P/N
100	1	940-3923		
125	1	940-3924		
150	1	940-3924		
200	2	940-3923		
250	1	940-3923	1	940-3924
300	2	940-3924		
350	2	940-3924	1	940-3922
400	2	940-3924	1	940-3923
500	3	940-3924		
600	3	940-3924	1	940-3923
700	3	940-3924	2	940-3923
800	3	940-3924	2	940-3923

75 psi

Boiler HP	75#			
	1st Valve(s)		2nd Valve(s)	
	Qty	P/N	Qty	P/N
100	1	940-3222		
125	1	940-3222	1	940-2801
150	2	940-3222	1	940-2801
200	2	940-3222		
250	2	940-3258	1	940-3222
300	1	940-3258		
350	2	940-3258	1	940-3222
400	2	940-3258	1	940-3222
500	2	940-3258	1	940-3258
600	3	940-3258	1	940-3222
700	4	940-3258	1	940-3222
800	4	940-3258	1	940-3258

100 psi

Boiler HP	100#			
	1st Valve(s)		2nd Valve(s)	
	Qty	P/N	Qty	P/N
100	1	940-2025		
125	1	940-2973	1	940-2972
150	2	940-2973		
200	2	940-2025		
250	2	940-2025		
300	1	940-2026	1	940-2025
350	2	940-2026		
400	2	940-2026		
500	2	940-2026	1	940-2025
600	3	940-2026		
700	3	940-2026	1	940-2025
800	4	940-2026		

125 psi

Boiler HP	125#			
	1st Valve(s)		2nd Valve(s)	
	Qty	P/N	Qty	P/N
100	1	940-2422		
125	1	940-2422	1	940-2975
150	1	940-2422	1	940-2975
200	2	940-2422		
250	1	940-2213	1	940-2422
300	2	940-2213		
350	1	940-2214	1	940-2213
400	1	940-2214	1	940-2213
500	2	940-2214		
600	2	940-2214	1	940-2213
700	3	940-2214		
800	3	940-2214	1	940-2213

150 psi

Boiler HP	150#			
	1st Valve(s)		2nd Valve(s)	
	Qty	P/N	Qty	P/N
100	1	940-2138		
125	1	940-2138	1	940-2741
150	1	940-2138	1	940-2741
200	2	940-2138		
250	1	940-2109	1	940-2138
300	1	940-2109	1	940-2138
350	2	940-2109		
400	1	940-2108	1	940-2109
500	1	940-2108	1	940-2109
600	2	940-2108		
700	2	940-2108	1	940-2109
800	2	940-2108	1	940-2109

175 psi

Boiler HP	175#			
	1st Valve(s)		2nd Valve(s)	
	Qty	P/N	Qty	P/N
100	1	940-3201		
125	1	940-3201	1	940-3122
150	2	940-3162		
200	1	940-3201	1	940-3162
250	2	940-3201		
300	1	940-2223	1	940-3201
350	1	940-2223	1	940-3201
400	2	940-2223		
500	1	940-3275	1	940-2223
600	2	940-3275		
700	2	940-3275		
800	2	940-3275	1	940-2223

200 psi

Boiler HP	200#			
	1st Valve(s)		2nd Valve(s)	
	Qty	P/N	Qty	P/N
100	1	940-2979		
125	1	940-2088	1	940-2978
150	1	940-2088	1	940-2978
200	1	940-2979	1	940-2088
250	1	940-2979	1	940-2088
300	2	940-2979		
350	1	940-2980	1	940-2979
400	1	940-2980	1	940-2979
500	1	940-2980	1	940-2981
600	1	940-2980	1	940-2981
700	2	940-2981		
800	2	940-2981		

225 psi

Boiler HP	225#			
	1st Valve(s)		2nd Valve(s)	
	Qty	P/N	Qty	P/N
100	1	940-3171		
125	2	940-3131		
150	1	940-3171	1	940-3131
200	2	940-3171		
250	1	940-3210	1	940-3171
300	2	940-3210		
350	2	940-3210		
400	1	940-3246	1	940-3210
500	2	940-3246		
600	1	940-3284	1	940-3246
700	1	940-3284	1	940-3246
800	2	940-3284		

250 psi

Boiler HP	250#			
	1st Valve(s)		2nd Valve(s)	
	Qty	P/N	Qty	P/N
100	1	940-2051		
125	2	940-2983		
150	2	940-2983		
200	2	940-2051		
250	1	940-2052	1	940-2051
300	1	940-2052	1	940-2051
350	2	940-2052		
400	1	940-2984	1	940-2052
500	1	940-2984	1	940-2052
600	2	940-2984		
700	1	940-2985	1	940-2984
800	1	940-2985	1	940-2984

300 psi

Boiler HP	300#			
	1st Valve(s)		2nd Valve(s)	
	Qty	P/N	Qty	P/N
100	1	940-5010		
125	2	940-5009		
150	2	940-5009		
200	1	940-5009	1	940-5010
250	2	940-5010		
300	1	940-5089	1	940-5010
350	1	940-5089	1	940-5010
400	2	940-5089		
500	1	940-5089	1	940-5090
600	2	940-5090		
700	2	940-5090		
800	1	940-5090	1	940-5008

6.12 - Relief Valves Hot Water

30 psi

Boiler HP	15#			
	1st Valve(s)		2nd Valve(s)	
	Qty	P/N	Qty	P/N
100	1	940-962		
125	1	940-962		
150	1	940-962		
200	1	940-478	1	940-1057
250	1	940-480	1	940-1057
300	1	940-962	1	940-1057
350	1	940-476	2	940-1057
400	1	940-480	2	940-1057
500	1	940-476	3	940-1057
600	1	940-480	3	940-1057
700	1	940-476	4	940-1057
800	1	940-476	4	940-1057

125 psi

Boiler HP	15#			
	1st Valve(s)		2nd Valve(s)	
	Qty	P/N	Qty	P/N
100	1	940-601		
125	1	940-601		
150	1	940-888		
200	1	940-888		
250	1	940-888		
300	1	940-2952		
350	1	940-2952		
400	1	940-2952		
500	1	940-584	1	940-473
600	1	940-601	1	940-473
700	1	940-888	1	940-473
800	1	940-888	1	940-473

6.13 - Misc. Light Oil Components

DESCRIPTION	PART NO.	SIZE	VOLT./HZ	BURNER
PUMP	905–1342	100–150 HP	60 HZ	"D/LND"
	905–1342	200–250 HP		ALL
	905–1340	300–600 HP		
	506–403	700–800 HP	200/208 V.	
	506–404	700–800 HP	230/460 V.	
	506–405	700–800 HP	575/600 V.	
STARTER	833–494	100–150 HP	60 HZ	"D/LND"
	833–494	200–600 HP		ALL
	833–776	700–800 HP		
STRAINER	843–44	100–150 HP	ALL	"D/LND"
		200 HP		ALL
	843–34	250–800 HP		
RELIEF VLV.	940–3898	100–200 HP	ALL	"D/LND"
		200 HP		"F" SERIES
	940–2296	250–800 HP		ALL

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