| Image # | # | Segment 1 Length (Pixels) | Segment 2 Length (Pixels) | Segment 3 Length (Pixels) | Segment 4 Length (Pixels) | Segment 5 Length (Pixels) | Segment 6 Length (Pixels) | Segment 7 Length (Pixels) | Segment 8 Length (Pixels) | Segment 9 Length (Pixels) | Segment 10 Length (Pixels) | Total Length (Pixels) | 1 Pixel (µm) | Grid Adjusted Length (µm) | Length Category |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| dl_m02 | 1 | 365.2 | 404.3 | | | | | | | | | 769.5 | 2.049 | 1576.9 | 1500-2000 |
| dl_m02 | 2 | 381.1 | 491.6 | 289.4 | | | | | | | | 1162.1 | 2.049 | 2381.4 | 2000-2500 |
| dl_m02 | 3 | 251.9 | | | | | | | | | | 251.9 | 2.049 | 516.2 | 500-1000 |
| dl_m02 | 4 | 491.7 | 200.3 | off page | | | | | | | | 692.0 | 2.049 | 1418.0 | 1000-1500 |
| dl_m02 | 5 | 598.4 | 93.5 | off page | | | | | | | | 691.9 | 2.049 | 1417.8 | 1000-1500 |
| dl_m02 | 6 | 402.2 | 352 | off page | | | | | | | | 754.2 | 2.049 | 1545.5 | 1500-2000 |
| dl_m02 | 7 | 595.8 | | | | | | | | | | 595.8 | 2.049 | 1220.9 | 1000-1500 |
| dl_m02 | 8 | 549 | 197 | off page | | | | | | | | 746.0 | 2.049 | 1528.7 | 1500-2000 |
| dl_m02 | 9 | 483.8 | 503.4 | off page | | | | | | | | 987.2 | 2.049 | 2023.0 | 2000-2500 |
| dl_m03 | 10 | 448.2 | 312.2 | off page | | | | | | | | 760.4 | 2.049 | 1558.2 | 1500-2000 |
| dl_m03 | 1 | 645.6 | 312.8 | off page | | | | | | | | 958.4 | 2.049 | 1964.0 | 1500-2000 |
| dl_m03 | 2 | 329.6 | | | | | | | | | | 329.6 | 2.049 | 675.4 | 500-1000 |
| dl_m03 | 3 | 303.3 | 381 | off page | | | | | | | | 684.3 | 2.049 | 1402.3 | 1000-1500 |
| dl_m03 | 4 | 626.6 | off page | | | | | | | | | 626.6 | 2.049 | 1284.0 | 1000-1500 |
| dl_m03 | 5 | 407.1 | 382.9 | off page | | | | | | | | 790.0 | 2.049 | 1618.9 | 1500-2000 |
| dl_m03 | 6 | 430.4 | 444.9 | off page | | | | | | | | 875.3 | 2.049 | 1793.7 | 1500-2000 |
| dl_m03 | 7 | 304.6 | 638.1 | off page | | | | | | | | 942.7 | 2.049 | 1931.8 | 1500-2000 |
| dl_m03 | 8 | 718 | off page | | | | | | | | | 718.0 | 2.049 | 1471.3 | 1000-1500 |
| dl_m03 | 9 | 469.9 | 511.8 | off page | | | | | | | | 981.7 | 2.049 | 2011.7 | 2000-2500 |
| dl_m03 | 10 | 579.1 | 221.2 | | | | | | | | | 800.3 | 2.049 | 1640.0 | 1500-2000 |
| dl_m04 | 1 | 566.6 | | | | | | | | | | 566.6 | 2.049 | 1161.1 | 1000-1500 |
| dl_m04 | 2 | 865.1 | off page | | | | | | | | | 865.1 | 2.049 | 1772.8 | 1500-2000 |
| dl_m04 | 3 | 430.4 | 442.5 | | | | | | | | | 872.9 | 2.049 | 1788.7 | 1500-2000 |

| Image # | # | Segment 1 Length (Pixels) | Segment 2 Length (Pixels) | Segment 3 Length (Pixels) | Segment 4 Length (Pixels) | Segment 5 Length (Pixels) | Segment 6 Length (Pixels) | Segment 7 Length (Pixels) | Segment 8 Length (Pixels) | Segment 9 Length (Pixels) | Segment 10 Length (Pixels) | Total Length (Pixels) | 1 Pixel (µm) | Grid Adjusted Length (µm) | Length Category |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| d1_m04 | 4 | 236 | | | | | | | | | | 236.0 | 2.049 | 483.6 | <500 |
| d1_m04 | 5 | 344.7 | 294.7 | 94.8 | off page | | | | | | | 734.2 | 2.049 | 1504.5 | 1500-2000 |
| d1_m04 | 6 | 624.1 | off page | | | | | | | | | 624.1 | 2.049 | 1278.9 | 1000-1500 |
| d1_m04 | 7 | 454.9 | 402.5 | 207.5 | | | | | | | | 1064.9 | 2.049 | 2182.2 | 2000-2500 |
| d1_m04 | 8 | 509.2 | | | | | | | | | | 509.2 | 2.049 | 1043.5 | 1000-1500 |
| d1_m04 | 9 | 350.6 | 237 | 168.1 | 166.9 | | | | | | | 922.6 | 2.049 | 1890.6 | 1500-2000 |
| d1_m04 | 10 | 326.5 | 389.1 | off page | | | | | | | | 715.6 | 2.049 | 1466.4 | 1000-1500 |
| d1_m05 | 1 | 291.6 | | | | | | | | | | 291.6 | 4.107 | 1197.5 | 1000-1500 |
| d1_m05 | 2 | 392.6 | | | | | | | | | | 392.6 | 4.107 | 1612.3 | 1500-2000 |
| d1_m05 | 3 | 531.4 | | | | | | | | | | 531.4 | 4.107 | 2182.4 | 2000-2500 |
| d1_m05 | 4 | 436.1 | | | | | | | | | | 436.1 | 4.107 | 1791.0 | 1500-2000 |
| d1_m05 | 5 | 320.4 | 390.8 | 224 | 34.7 | | | | | | | 969.9 | 4.107 | 3983.2 | >2500 |
| d1_m05 | 6 | 272 | | | | | | | | | | 272.0 | 4.107 | 1117.0 | 1000-1500 |
| d1_m05 | 7 | 174.3 | 177.3 | | | | | | | | | 351.6 | 4.107 | 1444.0 | 1000-1500 |
| d1_m05 | 8 | 326.6 | 230.8 | | | | | | | | | 557.4 | 4.107 | 2289.1 | 2000-2500 |
| d1_m05 | 9 | 250.1 | 169.8 | off page | | | | | | | | 419.9 | 4.107 | 1724.4 | 1500-2000 |
| d1_m05 | 10 | 346.3 | | | | | | | | | | 346.3 | 4.107 | 1422.2 | 1000-1500 |
| d2_m01 | 1 | 1023.6 | off page | | | | | | | | | 1023.6 | 2.049 | 2097.6 | 2000-2500 |
| d2_m01 | 2 | 572.1 | off page | | | | | | | | | 572.1 | 2.049 | 1172.3 | 1000-1500 |
| d2_m01 | 3 | 432.9 | 425.1 | off page | | | | | | | | 858.0 | 2.049 | 1758.2 | 1500-2000 |
| d2_m01 | 4 | 608.8 | off page | | | | | | | | | 608.8 | 2.049 | 1247.6 | 1000-1500 |
| d2_m01 | 5 | 343.5 | 137.5 | 187.2 | 289.1 | off page | | | | | | 957.3 | 2.049 | 1961.7 | 1500-2000 |
| d2_m01 | 6 | 296.3 | 255 | 298.1 | off page | | | | | | | 849.4 | 2.049 | 1740.6 | 1500-2000 |

| ALION SCIENCE AND TECHNOLOGY | BWROG Downstream Effects Scanning Electron Microscope Analysis | | |
|---|---|---|---|
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| Image # | # | Segment 1 Length (Pixels) | Segment 2 Length (Pixels) | Segment 3 Length (Pixels) | Segment 4 Length (Pixels) | Segment 5 Length (Pixels) | Segment 6 Length (Pixels) | Segment 7 Length (Pixels) | Segment 8 Length (Pixels) | Segment 9 Length (Pixels) | Segment 10 Length (Pixels) | Total Length (Pixels) | 1 Pixel (µm) | Grid Adjusted Length (µm) | Length Category |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| d2_m01 | 7 | 228 | 212 | 321.1 | 271.5 | off page | | | | | | 1032.6 | 2.049 | 2116.0 | 2000-2500 |
| d2_m01 | 8 | 565.4 | 499.5 | | | | | | | | | 1064.9 | 2.049 | 2182.2 | 2000-2500 |
| d2_m01 | 9 | 474.2 | 311.6 | off page | | | | | | | | 785.8 | 2.049 | 1610.3 | 1500-2000 |
| d2_m01 | 10 | 533.6 | 299.5 | off page | | | | | | | | 833.1 | 2.049 | 1707.2 | 1500-2000 |
| d2_m02 | 1 | 621.1 | 383.6 | off page | | | | | | | | 1004.7 | 2.049 | 2058.8 | 2000-2500 |
| d2_m02 | 2 | 463.9 | | | | | | | | | | 463.9 | 2.049 | 950.6 | 500-1000 |
| d2_m02 | 3 | 721.2 | 17.7 | | | | | | | | | 738.9 | 2.049 | 1514.2 | 1500-2000 |
| d2_m02 | 4 | 438.7 | | | | | | | | | | 438.7 | 2.049 | 899.0 | 500-1000 |
| d2_m02 | 5 | 242.3 | 384 | | | | | | | | | 626.3 | 2.049 | 1283.4 | 1000-1500 |
| d2_m02 | 6 | 452 | | | | | | | | | | 452.0 | 2.049 | 926.2 | 500-1000 |
| d2_m02 | 7 | 408.1 | | | | | | | | | | 408.1 | 2.049 | 836.3 | 500-1000 |
| d2_m02 | 8 | 155.6 | | | | | | | | | | 155.6 | 2.049 | 318.9 | <500 |
| d2_m02 | 9 | 582.2 | | | | | | | | | | 582.2 | 2.049 | 1193.0 | 1000-1500 |
| d2_m02 | 10 | 585.2 | 13.9 | off page | | | | | | | | 599.1 | 2.049 | 1227.7 | 1000-1500 |
| d2_m03 | 1 | 115 | 521.6 | | | | | | | | | 636.6 | 2.049 | 1304.5 | 1000-1500 |
| d2_m03 | 2 | 560 | 346 | off page | | | | | | | | 906.0 | 2.049 | 1856.6 | 1500-2000 |
| d2_m03 | 3 | 272.9 | | | | | | | | | | 272.9 | 2.049 | 559.2 | 500-1000 |
| d2_m03 | 4 | 560.3 | | | | | | | | | | 560.3 | 2.049 | 1148.2 | 1000-1500 |
| d2_m03 | 5 | 426.8 | | | | | | | | | | 426.8 | 2.049 | 874.6 | 500-1000 |
| d2_m03 | 6 | 460.4 | | | | | | | | | | 460.4 | 2.049 | 943.5 | 500-1000 |
| d2_m03 | 7 | 529.7 | | | | | | | | | | 529.7 | 2.049 | 1085.5 | 1000-1500 |
| d2_m03 | 8 | 329.7 | 489.2 | | | | | | | | | 818.9 | 2.049 | 1678.1 | 1500-2000 |
| d2_m03 | 9 | 336.9 | 457 | off page | | | | | | | | 793.9 | 2.049 | 1626.9 | 1500-2000 |

| Image # | # | Segment 1 Length (Pixels) | Segment 2 Length (Pixels) | Segment 3 Length (Pixels) | Segment 4 Length (Pixels) | Segment 5 Length (Pixels) | Segment 6 Length (Pixels) | Segment 7 Length (Pixels) | Segment 8 Length (Pixels) | Segment 9 Length (Pixels) | Segment 10 Length (Pixels) | Total Length (Pixels) | 1 Pixel (µm) | Grid Adjusted Length (µm) | Length Category |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| d2_m03 | 10 | 235.7 | 366.1 | | | | | | | | | 601.8 | 2.049 | 1233.2 | 1000-1500 |
| d2_m04 | 1 | 470.9 | 119.2 | | | | | | | | | 590.1 | 2.049 | 1209.2 | 1000-1500 |
| d2_m04 | 2 | 507.2 | | | | | | | | | | 507.2 | 2.049 | 1039.4 | 1000-1500 |
| d2_m04 | 3 | 551.1 | 263.3 | 92.7 | off page | | | | | | | 907.1 | 2.049 | 1858.8 | 1500-2000 |
| d2_m04 | 4 | 327.6 | | | | | | | | | | 327.6 | 2.049 | 671.3 | 500-1000 |
| d2_m04 | 5 | 306.7 | 333.7 | | | | | | | | | 640.4 | 2.049 | 1312.3 | 1000-1500 |
| d2_m04 | 6 | 328.1 | 216.5 | | | | | | | | | 544.6 | 2.049 | 1116.0 | 1000-1500 |
| d2_m04 | 7 | 311.2 | 540.8 | off page | | | | | | | | 852.0 | 2.049 | 1745.9 | 1500-2000 |
| d2_m04 | 8 | 525.4 | 260.8 | | | | | | | | | 786.2 | 2.049 | 1611.1 | 1500-2000 |
| d2_m04 | 9 | 416.2 | | | | | | | | | | 416.2 | 2.049 | 852.9 | 500-1000 |
| d2_m04 | 10 | 256.8 | 207.8 | 231.4 | off page | | | | | | | 696.0 | 2.049 | 1426.2 | 1000-1500 |
| d2_m05 | 1 | 487.2 | | | | | | | | | | 487.2 | 4.107 | 2000.8 | 2000-2500 |
| d2_m05 | 2 | 413.7 | 120 | 56 | 54.5 | 40.3 | | | | | | 684.5 | 4.107 | 2811.1 | >2500 |
| d2_m05 | 3 | 351.1 | 137.8 | 163.8 | | | | | | | | 652.7 | 4.107 | 2680.5 | >2500 |
| d2_m05 | 4 | 279.7 | 312.9 | | | | | | | | | 592.6 | 4.107 | 2433.7 | 2000-2500 |
| d2_m05 | 5 | 158.1 | 93.7 | | | | | | | | | 251.8 | 4.107 | 1034.1 | 1000-1500 |
| d2_m05 | 6 | 286.4 | | | | | | | | | | 286.4 | 4.107 | 1176.2 | 1000-1500 |
| d2_m05 | 7 | 211.7 | 111.8 | | | | | | | | | 323.5 | 4.107 | 1328.5 | 1000-1500 |
| d2_m05 | 8 | 281.7 | 131.2 | 145.7 | | | | | | | | 558.6 | 4.107 | 2294.1 | 2000-2500 |
| d2_m05 | 9 | 348.6 | 157.8 | | | | | | | | | 506.4 | 4.107 | 2079.7 | 2000-2500 |
| d2_m05 | 10 | 123 | 248.1 | 386.1 | | | | | | | | 757.2 | 4.107 | 3109.7 | >2500 |
| d3_m01 | 1 | 388.2 | 230.8 | 273.2 | off page | | | | | | | 892.2 | 2.049 | 1828.3 | 1500-2000 |
| d3_m01 | 2 | 420.9 | 38.1 | | | | | | | | | 459.0 | 2.049 | 940.6 | 500-1000 |

| ALION SCIENCE AND TECHNOLOGY | BWROG ECCS Strainer Bypass Test Report | | |
|---|---|---|---|
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| ALION SCIENCE AND TECHNOLOGY | BWROG Downstream Effects Scanning Electron Microscope Analysis | | |
|---|---|---|---|
| | Document No: BWROG-ECCS-TA13-003 | Rev: 0 | Page: D-12 of D-27 |

| Image # | # | Segment 1 Length (Pixels) | Segment 2 Length (Pixels) | Segment 3 Length (Pixels) | Segment 4 Length (Pixels) | Segment 5 Length (Pixels) | Segment 6 Length (Pixels) | Segment 7 Length (Pixels) | Segment 8 Length (Pixels) | Segment 9 Length (Pixels) | Segment 10 Length (Pixels) | Total Length (Pixels) | 1 Pixel (µm) | Grid Adjusted Length (µm) | Length Category |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| d3_m01 | 3 | 528.7 | 156 | off page | | | | | | | | 684.7 | 2.049 | 1403.1 | 1000-1500 |
| d3_m01 | 4 | 741.1 | 255.2 | | | | | | | | | 996.3 | 2.049 | 2041.6 | 2000-2500 |
| d3_m01 | 5 | 268.6 | 122 | | | | | | | | | 390.6 | 2.049 | 800.4 | 500-1000 |
| d3_m01 | 6 | 490.3 | | | | | | | | | | 490.3 | 2.049 | 1004.7 | 1000-1500 |
| d3_m01 | 7 | 544.3 | 303.2 | off page | | | | | | | | 847.5 | 2.049 | 1736.7 | 1500-2000 |
| d3_m01 | 8 | 351.9 | | | | | | | | | | 351.9 | 2.049 | 721.1 | 500-1000 |
| d3_m01 | 9 | 181.7 | | | | | | | | | | 181.7 | 2.049 | 372.3 | <500 |
| d3_m01 | 10 | 539.4 | off page | | | | | | | | | 539.4 | 2.049 | 1105.3 | 1000-1500 |
| d3_m02 | 1 | 395.6 | 432.7 | 384 | 142.6 | off page | | | | | | 1354.9 | 2.049 | 2776.5 | >2500 |
| d3_m02 | 2 | 329.3 | | | | | | | | | | 329.3 | 2.049 | 674.8 | 500-1000 |
| d3_m02 | 3 | 478.1 | | | | | | | | | | 478.1 | 2.049 | 979.7 | 500-1000 |
| d3_m02 | 4 | 392.9 | | | | | | | | | | 392.9 | 2.049 | 805.1 | 500-1000 |
| d3_m02 | 5 | 500.2 | | | | | | | | | | 500.2 | 2.049 | 1025.0 | 1000-1500 |
| d3_m02 | 6 | 417.3 | 429.4 | 45 | | | | | | | | 891.7 | 2.049 | 1827.3 | 1500-2000 |
| d3_m02 | 7 | 365 | | | | | | | | | | 365.0 | 2.049 | 748.0 | 500-1000 |
| d3_m02 | 8 | 377 | 444.5 | 452.6 | 56.4 | off page | | | | | | 1330.5 | 2.049 | 2726.5 | >2500 |
| d3_m02 | 9 | 478.8 | 177.9 | 131.4 | 69.5 | off page | | | | | | 857.6 | 2.049 | 1757.4 | 1500-2000 |
| d3_m02 | 10 | 235.4 | 194 | 141 | 233.3 | off page | | | | | | 803.7 | 2.049 | 1646.9 | 1500-2000 |
| d3_m03 | 1 | 277.6 | 279.3 | 278.3 | 171.1 | off page | | | | | | 1006.3 | 2.049 | 2062.1 | 2000-2500 |
| d3_m03 | 2 | 321.4 | 99 | 205.6 | | | | | | | | 626.0 | 2.049 | 1282.8 | 1000-1500 |
| d3_m03 | 3 | 461.2 | 346.6 | 236.2 | off page | | | | | | | 1044.0 | 2.049 | 2139.4 | 2000-2500 |
| d3_m03 | 4 | 554.2 | | | | | | | | | | 554.2 | 2.049 | 1135.7 | 1000-1500 |
| d3_m03 | 5 | 553.5 | 271.7 | | | | | | | | | 825.2 | 2.049 | 1691.0 | 1500-2000 |

| Image # | # | Segment 1 Length (Pixels) | Segment 2 Length (Pixels) | Segment 3 Length (Pixels) | Segment 4 Length (Pixels) | Segment 5 Length (Pixels) | Segment 6 Length (Pixels) | Segment 7 Length (Pixels) | Segment 8 Length (Pixels) | Segment 9 Length (Pixels) | Segment 10 Length (Pixels) | Total Length (Pixels) | 1 Pixel (µm) | Grid Adjusted Length (µm) | Length Category |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| d3_m03 | 6 | 568.6 | off page | | | | | | | | | 568.6 | 2.049 | 1165.2 | 1000-1500 |
| d3_m03 | 7 | 350 | 258.7 | 298.9 | 382.7 | off page | | | | | | 1290.3 | 2.049 | 2644.1 | >2500 |
| d3_m03 | 8 | 374.3 | 350 | off page | | | | | | | | 724.3 | 2.049 | 1484.2 | 1000-1500 |
| d3_m03 | 9 | 506.2 | 331.2 | | | | | | | | | 837.4 | 2.049 | 1716.0 | 1500-2000 |
| d3_m03 | 10 | 565 | off page | | | | | | | | | 565.0 | 2.049 | 1157.8 | 1000-1500 |
| d3_m04 | 1 | 257.4 | 478.2 | 351.2 | | | | | | | | 1086.8 | 2.049 | 2227.1 | 2000-2500 |
| d3_m04 | 2 | 282 | | | | | | | | | | 282.0 | 2.049 | 577.9 | 500-1000 |
| d3_m04 | 3 | 343.6 | | | | | | | | | | 343.6 | 2.049 | 704.1 | 500-1000 |
| d3_m04 | 4 | 426.4 | 396.4 | | | | | | | | | 822.8 | 2.049 | 1686.1 | 1500-2000 |
| d3_m04 | 5 | 384.9 | 403.3 | off page | | | | | | | | 788.2 | 2.049 | 1615.2 | 1500-2000 |
| d3_m04 | 6 | 178.7 | 107.3 | 364.6 | | | | | | | | 650.6 | 2.049 | 1333.2 | 1000-1500 |
| d3_m04 | 7 | 253.8 | 450.3 | | | | | | | | | 704.1 | 2.049 | 1442.8 | 1000-1500 |
| d3_m04 | 8 | 436.2 | 87.1 | off page | | | | | | | | 523.3 | 2.049 | 1072.3 | 1000-1500 |
| d3_m04 | 9 | 370.6 | 173.3 | 101.2 | | | | | | | | 645.1 | 2.049 | 1321.9 | 1000-1500 |
| d3_m04 | 10 | 415.6 | off page | | | | | | | | | 415.6 | 2.049 | 851.6 | 500-1000 |
| d3_m05 | 1 | 159.5 | 217.9 | 267.2 | 179.1 | 268.6 | 41.3 | off page | | | | 1133.6 | 4.107 | 4655.5 | >2500 |
| d3_m05 | 2 | 414.3 | 417.1 | 197 | off page | | | | | | | 1028.4 | 4.107 | 4223.4 | >2500 |
| d3_m05 | 3 | 234.5 | 268.2 | 67.9 | | | | | | | | 570.6 | 4.107 | 2343.3 | 2000-2500 |
| d3_m05 | 4 | 133.1 | 187 | | | | | | | | | 320.1 | 4.107 | 1314.6 | 1000-1500 |
| d3_m05 | 5 | 169.7 | | | | | | | | | | 169.7 | 4.107 | 696.9 | 500-1000 |
| d3_m05 | 6 | 256.6 | | | | | | | | | | 256.6 | 4.107 | 1053.8 | 1000-1500 |
| d3_m05 | 7 | 96.5 | 294.8 | 196 | 151.1 | 173.5 | off page | | | | | 911.9 | 4.107 | 3745.0 | >2500 |
| d3_m05 | 8 | 218.7 | 166.7 | 173.4 | | | | | | | | 558.8 | 4.107 | 2294.9 | 2000-2500 |

| Image # | # | Segment 1 Length (Pixels) | Segment 2 Length (Pixels) | Segment 3 Length (Pixels) | Segment 4 Length (Pixels) | Segment 5 Length (Pixels) | Segment 6 Length (Pixels) | Segment 7 Length (Pixels) | Segment 8 Length (Pixels) | Segment 9 Length (Pixels) | Segment 10 Length (Pixels) | Total Length (Pixels) | 1 Pixel (µm) | Grid Adjusted Length (µm) | Length Category |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| d3_m05 | 9 | 362.7 | 197.1 | 205.9 | | | | | | | | 765.7 | 4.107 | 3144.6 | >2500 |
| d3_m05 | 10 | 385.2 | | | | | | | | | | 385.2 | 4.107 | 1581.9 | 1500-2000 |
| r1_m01 | 1 | 249.9 | | | | | | | | | | 249.9 | 2.049 | 512.1 | 500-1000 |
| r1_m01 | 2 | 8.5 | 15 | 50 | 32 | 13 | 20.6 | 27 | | | | 166.1 | 2.049 | 340.4 | <500 |
| r1_m01 | 3 | 110.9 | 125.8 | | | | | | | | | 236.7 | 2.049 | 485.0 | <500 |
| r1_m01 | 4 | 180.7 | 75.6 | 302.7 | 93.3 | | | | | | | 652.3 | 2.049 | 1336.7 | 1000-1500 |
| r1_m01 | 5 | 97.3 | | | | | | | | | | 97.3 | 2.049 | 199.4 | <500 |
| r1_m01 | 6 | 92.3 | 91.4 | 98.5 | 468.1 | | | | | | | 750.3 | 2.049 | 1537.5 | 1500-2000 |
| r1_m01 | 7 | 61 | 82.7 | 58.5 | 39.1 | 17 | | | | | | 258.3 | 2.049 | 529.3 | 500-1000 |
| r1_m01 | 8 | 238.8 | | | | | | | | | | 238.8 | 2.049 | 489.3 | <500 |
| r1_m01 | 9 | 352.9 | | | | | | | | | | 352.9 | 2.049 | 723.2 | 500-1000 |
| r1_m01 | 10 | 174 | | | | | | | | | | 174.0 | 2.049 | 356.6 | <500 |
| r1_m02 | 1 | 282.1 | Hidden | | | | | | | | | 282.1 | 2.049 | 578.1 | 500-1000 |
| r1_m02 | 2 | 203.2 | 183.8 | Hidden | | | | | | | | 387.0 | 2.049 | 793.0 | 500-1000 |
| r1_m02 | 3 | 206.8 | 88.1 | 88.7 | | | | | | | | 383.6 | 2.049 | 786.1 | 500-1000 |
| r1_m02 | 4 | 85.6 | 311.9 | 29.2 | 80.8 | | | | | | | 507.5 | 2.049 | 1040.0 | 1000-1500 |
| r1_m02 | 5 | 213.4 | | | | | | | | | | 213.4 | 2.049 | 437.3 | <500 |
| r1_m02 | 6 | 72.4 | 156.4 | 140.2 | 101.2 | 106.2 | 36.4 | 30.1 | Hidden | | | 642.9 | 2.049 | 1317.4 | 1000-1500 |
| r1_m02 | 7 | 118.9 | 189.4 | | | | | | | | | 308.3 | 2.049 | 631.8 | 500-1000 |
| r1_m02 | 8 | 258.4 | | | | | | | | | | 258.4 | 2.049 | 529.5 | 500-1000 |
| r1_m02 | 9 | 138.5 | 248.4 | 150.5 | 97.2 | 76.7 | 76.2 | 86.8 | 164.3 | | | 1038.6 | 2.049 | 2128.3 | 2000-2500 |
| r1_m03 | 10 | 84.2 | | | | | | | | | | 84.2 | 2.049 | 172.5 | <500 |
| r1_m03 | 1 | 172 | 68.5 | 64.8 | | | | | | | | 305.3 | 2.049 | 625.6 | 500-1000 |

ALION SCIENCE AND TECHNOLOGY | BWROG Downstream Effects Scanning Electron Microscope Analysis | Document No: BWROG-ECCS-TA13-003 | Rev: 0 | Page: D-15 of D-27

| Image # | # | Segment 1 Length (Pixels) | Segment 2 Length (Pixels) | Segment 3 Length (Pixels) | Segment 4 Length (Pixels) | Segment 5 Length (Pixels) | Segment 6 Length (Pixels) | Segment 7 Length (Pixels) | Segment 8 Length (Pixels) | Segment 9 Length (Pixels) | Segment 10 Length (Pixels) | Total Length (Pixels) | 1 Pixel (µm) | Grid Adjusted Length (µm) | Length Category |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| r1_m03 | 2 | 375.7 | | | | | | | | | | 375.7 | 2.049 | 769.9 | 500-1000 |
| r1_m03 | 3 | 356.1 | Hidden | | | | | | | | | 356.1 | 2.049 | 729.7 | 500-1000 |
| r1_m03 | 4 | 54.1 | 114.5 | 288.1 | | | | | | | | 456.7 | 2.049 | 935.9 | 500-1000 |
| r1_m03 | 5 | 216.2 | | | | | | | | | | 216.2 | 2.049 | 443.0 | <500 |
| r1_m03 | 6 | 120.7 | | | | | | | | | | 120.7 | 2.049 | 247.3 | <500 |
| r1_m03 | 7 | 532.7 | | | | | | | | | | 532.7 | 2.049 | 1091.6 | 1000-1500 |
| r1_m03 | 8 | 172.9 | | | | | | | | | | 172.9 | 2.049 | 354.3 | <500 |
| r1_m03 | 9 | 270.8 | Hidden | | | | | | | | | 270.8 | 2.049 | 554.9 | 500-1000 |
| r1_m03 | 10 | 315 | 183.5 | 104.3 | 107.3 | 48.8 | | | | | | 758.9 | 2.049 | 1555.1 | 1500-2000 |
| r1_m04 | 1 | 246.2 | 29.8 | | | | | | | | | 276.0 | 2.049 | 565.6 | 500-1000 |
| r1_m04 | 2 | 378.1 | 26 | | | | | | | | | 404.1 | 2.049 | 828.1 | 500-1000 |
| r1_m04 | 3 | 148.2 | 146.5 | 394.6 | | | | | | | | 689.3 | 2.049 | 1412.5 | 1000-1500 |
| r1_m04 | 4 | 62.7 | 112.7 | 400 | 205.1 | 86.7 | | | | | | 867.2 | 2.049 | 1777.1 | 1500-2000 |
| r1_m04 | 5 | 32 | 33.2 | | | | | | | | | 65.2 | 2.049 | 133.6 | <500 |
| r1_m04 | 6 | 183.7 | 92 | | | | | | | | | 275.7 | 2.049 | 565.0 | 500-1000 |
| r1_m04 | 7 | 195.8 | 101 | 130 | | | | | | | | 426.8 | 2.049 | 874.6 | 500-1000 |
| r1_m04 | 8 | 140.9 | 169 | 129.3 | | | | | | | | 439.2 | 2.049 | 900.0 | 500-1000 |
| r1_m04 | 9 | 121.6 | 127.5 | | | | | | | | | 249.1 | 2.049 | 510.5 | 500-1000 |
| r1_m04 | 10 | 242.9 | 30.5 | 27.2 | | | | | | | | 300.6 | 2.049 | 616.0 | 500-1000 |
| r1_m05 | 1 | 287.9 | 71.2 | 76.9 | 27.7 | | | | | | | 463.7 | 4.107 | 1904.3 | 1500-2000 |
| r1_m05 | 2 | 139.3 | | | | | | | | | | 139.3 | 4.107 | 572.1 | 500-1000 |
| r1_m05 | 3 | 190.4 | | | | | | | | | | 190.4 | 4.107 | 781.9 | 500-1000 |
| r1_m05 | 4 | 209.9 | | | | | | | | | | 209.9 | 4.107 | 862.0 | 500-1000 |

| Image # | # | Segment 1 Length (Pixels) | Segment 2 Length (Pixels) | Segment 3 Length (Pixels) | Segment 4 Length (Pixels) | Segment 5 Length (Pixels) | Segment 6 Length (Pixels) | Segment 7 Length (Pixels) | Segment 8 Length (Pixels) | Segment 9 Length (Pixels) | Segment 10 Length (Pixels) | Total Length (Pixels) | 1 Pixel (µm) | Grid Adjusted Length (µm) | Length Category |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| r1_m05 | 5 | 69.3 | 213.4 | 114.1 | | | | | | | | 396.8 | 4.107 | 1629.6 | 1500-2000 |
| r1_m05 | 6 | 36.1 | 23.6 | 90 | | | | | | | | 149.7 | 4.107 | 614.8 | 500-1000 |
| r1_m05 | 7 | 919.3 | 70.2 | 205.4 | 47.4 | 31 | 38.9 | 75 | Off Page | | | 1387.2 | 4.107 | 5697.0 | >2500 |
| r1_m05 | 8 | 113.3 | 164.7 | 38.6 | | | | | | | | 316.6 | 4.107 | 1300.2 | 1000-1500 |
| r1_m05 | 9 | 258.1 | | | | | | | | | | 258.1 | 4.107 | 1060.0 | 1000-1500 |
| r1_m05 | 10 | 116.3 | 215.7 | | | | | | | | | 332.0 | 4.107 | 1363.5 | 1000-1500 |
| r2_m01 | 1 | 110.2 | 77.5 | 159 | 93.3 | | | | | | | 440.0 | 2.049 | 901.6 | 500-1000 |
| r2_m01 | 2 | 160.8 | | | | | | | | | | 160.8 | 2.049 | 329.5 | <500 |
| r2_m01 | 3 | 343.8 | | | | | | | | | | 343.8 | 2.049 | 704.5 | 500-1000 |
| r2_m01 | 4 | 307.5 | 318 | Hidden | | | | | | | | 625.5 | 2.049 | 1281.8 | 1000-1500 |
| r2_m01 | 5 | 205.4 | | | | | | | | | | 205.4 | 2.049 | 420.9 | <500 |
| r2_m01 | 6 | 436.2 | Off Page | | | | | | | | | 436.2 | 2.049 | 893.9 | 500-1000 |
| r2_m01 | 7 | 407.1 | 254.6 | | | | | | | | | 661.7 | 2.049 | 1356.0 | 1000-1500 |
| r2_m01 | 8 | 144.2 | 120.1 | | | | | | | | | 264.3 | 2.049 | 541.6 | 500-1000 |
| r2_m01 | 9 | 477.7 | | | | | | | | | | 477.7 | 2.049 | 978.9 | 500-1000 |
| r2_m01 | 10 | 120.5 | 12 | | | | | | | | | 132.5 | 2.049 | 271.5 | <500 |
| r2_m02 | 1 | 716.9 | Hidden | | | | | | | | | 716.9 | 2.049 | 1469.1 | 1000-1500 |
| r2_m02 | 2 | 147.9 | 86.5 | 29.5 | | | | | | | | 263.9 | 2.049 | 540.8 | 500-1000 |
| r2_m02 | 3 | 175.6 | | | | | | | | | | 175.6 | 2.049 | 359.8 | <500 |
| r2_m02 | 4 | 54.8 | 46 | 44.3 | 122.7 | 49 | 45.5 | 43.6 | 37.6 | | | 443.5 | 2.049 | 908.8 | 500-1000 |
| r2_m02 | 5 | 189.4 | | | | | | | | | | 189.4 | 2.049 | 388.1 | <500 |
| r2_m02 | 6 | 135.6 | | | | | | | | | | 135.6 | 2.049 | 277.9 | <500 |
| r2_m02 | 7 | 131 | 152.1 | | | | | | | | | 283.1 | 2.049 | 580.1 | 500-1000 |

| Image # | # | Segment 1 Length (Pixels) | Segment 2 Length (Pixels) | Segment 3 Length (Pixels) | Segment 4 Length (Pixels) | Segment 5 Length (Pixels) | Segment 6 Length (Pixels) | Segment 7 Length (Pixels) | Segment 8 Length (Pixels) | Segment 9 Length (Pixels) | Segment 10 Length (Pixels) | Total Length (Pixels) | 1 Pixel (µm) | Grid Adjusted Length (µm) | Length Category |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| r2_m02 | 8 | 142.9 | 127.4 | 75.8 | | | | | | | | 346.1 | 2.049 | 709.2 | 500-1000 |
| r2_m02 | 9 | 162.7 | 148 | 163 | 126.6 | 134.9 | 30.7 | Off Page | | | | 765.9 | 2.049 | 1569.5 | 1500-2000 |
| r2_m03 | 10 | 258.1 | Hidden | | | | | | | | | 258.1 | 2.049 | 528.9 | 500-1000 |
| r2_m03 | 1 | 142.4 | 144.1 | 124.9 | | | | | | | | 411.4 | 2.049 | 843.0 | 500-1000 |
| r2_m03 | 2 | 301.8 | 97.4 | 91.9 | | | | | | | | 491.1 | 2.049 | 1006.4 | 1000-1500 |
| r2_m03 | 3 | 231 | 175.2 | | | | | | | | | 406.2 | 2.049 | 832.4 | 500-1000 |
| r2_m03 | 4 | 139.5 | | | | | | | | | | 139.5 | 2.049 | 285.9 | <500 |
| r2_m03 | 5 | 237 | 197.4 | | | | | | | | | 434.4 | 2.049 | 890.2 | 500-1000 |
| r2_m03 | 6 | 165.1 | | | | | | | | | | 165.1 | 2.049 | 338.3 | <500 |
| r2_m03 | 7 | 156.1 | 84.1 | 63.7 | | | | | | | | 303.9 | 2.049 | 622.8 | 500-1000 |
| r2_m03 | 8 | 96.2 | 214.7 | 302.4 | 248.2 | | | | | | | 861.5 | 2.049 | 1765.4 | 1500-2000 |
| r2_m03 | 9 | 89.9 | 78 | 92.8 | | | | | | | | 260.7 | 2.049 | 534.2 | 500-1000 |
| r2_m03 | 10 | 140.5 | 189.5 | 110.2 | | | | | | | | 440.2 | 2.049 | 902.1 | 500-1000 |
| r2_m04 | 1 | 359.2 | 244.5 | | | | | | | | | 603.7 | 2.049 | 1237.1 | 1000-1500 |
| r2_m04 | 2 | 68.6 | 200.4 | 100.6 | 100.4 | 98.7 | 97.1 | 101.8 | 161.6 | 41.8 | 44.7 | 1015.7 | 2.049 | 2081.4 | 2000-2500 |
| r2_m04 | 3 | 49.4 | 83.9 | 75 | | | | | | | | 208.3 | 2.049 | 426.8 | <500 |
| r2_m04 | 4 | 223.8 | | | | | | | | | | 223.8 | 2.049 | 458.6 | <500 |
| r2_m04 | 5 | 153.1 | 74 | | | | | | | | | 227.1 | 2.049 | 465.4 | <500 |
| r2_m04 | 6 | 107.3 | 118.9 | 124.3 | 105.6 | 97.6 | 101 | 126.6 | 132.5 | Off Page | | 913.8 | 2.049 | 1872.6 | 1500-2000 |
| r2_m04 | 7 | 166.8 | 114.2 | 96.1 | 105.9 | | | | | | | 483.0 | 2.049 | 989.8 | 500-1000 |
| r2_m04 | 8 | 218.7 | | | | | | | | | | 218.7 | 2.049 | 448.2 | <500 |
| r2_m04 | 9 | 341.1 | | | | | | | | | | 341.1 | 2.049 | 699.0 | 500-1000 |
| r2_m04 | 10 | 103.6 | | | | | | | | | | 103.6 | 2.049 | 212.3 | <500 |

| Image # | # | Segment 1 Length (Pixels) | Segment 2 Length (Pixels) | Segment 3 Length (Pixels) | Segment 4 Length (Pixels) | Segment 5 Length (Pixels) | Segment 6 Length (Pixels) | Segment 7 Length (Pixels) | Segment 8 Length (Pixels) | Segment 9 Length (Pixels) | Segment 10 Length (Pixels) | Total Length (Pixels) | 1 Pixel (µm) | Grid Adjusted Length (µm) | Length Category |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| r2_m05 | 1 | 132.9 | 77.5 | 63.2 | | | | | | | | 273.6 | 4.107 | 1123.6 | 1000-1500 |
| r2_m05 | 2 | 157.1 | 124.8 | | | | | | | | | 281.9 | 4.107 | 1157.7 | 1000-1500 |
| r2_m05 | 3 | 140.9 | 148.9 | 11.7 | | | | | | | | 301.5 | 4.107 | 1238.2 | 1000-1500 |
| r2_m05 | 4 | 74.8 | | | | | | | | | | 74.8 | 4.107 | 307.2 | <500 |
| r2_m05 | 5 | 148 | 297.9 | Hidden | | | | | | | | 445.9 | 4.107 | 1831.2 | 1500-2000 |
| r2_m05 | 6 | 272.4 | | | | | | | | | | 272.4 | 4.107 | 1118.7 | 1000-1500 |
| r2_m05 | 7 | 105 | | | | | | | | | | 105.0 | 4.107 | 431.2 | <500 |
| r2_m05 | 8 | 35.1 | 23.1 | 40.7 | 66.8 | 17.7 | | | | | | 183.4 | 4.107 | 753.2 | 500-1000 |
| r2_m05 | 9 | 115.3 | | | | | | | | | | 115.3 | 4.107 | 473.5 | <500 |
| r2_m05 | 10 | 58.9 | 63.3 | 86.5 | | | | | | | | 208.7 | 4.107 | 857.1 | 500-1000 |
| r3_m01 | 1 | 221 | 160.7 | | | | | | | | | 381.7 | 2.049 | 782.2 | 500-1000 |
| r3_m01 | 2 | 84.1 | 96 | 76.9 | 68.1 | 105.8 | 69.4 | Off Page | | | | 500.3 | 2.049 | 1025.2 | 1000-1500 |
| r3_m01 | 3 | 197.2 | | | | | | | | | | 197.2 | 2.049 | 404.1 | <500 |
| r3_m01 | 4 | 155.3 | | | | | | | | | | 155.3 | 2.049 | 318.2 | <500 |
| r3_m01 | 5 | 98.3 | 52.2 | 52.3 | 35.2 | 38.1 | 67.9 | | | | | 344.0 | 2.049 | 704.9 | 500-1000 |
| r3_m01 | 6 | 233.3 | | | | | | | | | | 233.3 | 2.049 | 478.1 | <500 |
| r3_m01 | 7 | 90.1 | 111.6 | 117.9 | | | | | | | | 319.6 | 2.049 | 654.9 | 500-1000 |
| r3_m01 | 8 | 149.9 | 128.5 | | | | | | | | | 278.4 | 2.049 | 570.5 | 500-1000 |
| r3_m01 | 9 | 50.2 | 27.7 | 125.5 | 28.3 | 22 | 142.7 | | | | | 396.4 | 2.049 | 812.3 | 500-1000 |
| r3_m01 | 10 | 44.4 | 83.3 | 25.1 | 15.3 | | | | | | | 168.1 | 2.049 | 344.5 | <500 |
| r3_m02 | 1 | 295.3 | | | | | | | | | | 295.3 | 2.049 | 605.1 | 500-1000 |
| r3_m02 | 2 | 330.3 | 192.2 | 41.8 | 33.8 | 93.2 | 24.2 | 45.2 | | | | 760.7 | 2.049 | 1558.8 | 1500-2000 |
| r3_m02 | 3 | 307.7 | 534.5 | | | | | | | | | 842.2 | 2.049 | 1725.8 | 1500-2000 |

| Image # | # | Segment 1 Length (Pixels) | Segment 2 Length (Pixels) | Segment 3 Length (Pixels) | Segment 4 Length (Pixels) | Segment 5 Length (Pixels) | Segment 6 Length (Pixels) | Segment 7 Length (Pixels) | Segment 8 Length (Pixels) | Segment 9 Length (Pixels) | Segment 10 Length (Pixels) | Total Length (Pixels) | 1 Pixel (µm) | Grid Adjusted Length (µm) | Length Category |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| r3_m02 | 4 | 215.9 | | | | | | | | | | 215.9 | 2.049 | 442.4 | <500 |
| r3_m02 | 5 | 160.2 | 22.8 | 75.6 | 66.6 | 82.9 | 12.1 | | | | | 420.2 | 2.049 | 861.1 | 500-1000 |
| r3_m02 | 6 | 132.4 | | | | | | | | | | 132.4 | 2.049 | 271.3 | <500 |
| r3_m02 | 7 | 156.4 | | | | | | | | | | 156.4 | 2.049 | 320.5 | <500 |
| r3_m02 | 8 | 509.7 | | | | | | | | | | 509.7 | 2.049 | 1044.5 | 1000-1500 |
| r3_m02 | 9 | 74.2 | 62.3 | 197.7 | 80.3 | 120.4 | 26.9 | 124.3 | | | | 686.1 | 2.049 | 1406.0 | 1000-1500 |
| r3_m03 | 10 | 225.4 | 118.1 | 148.1 | 219.7 | | | | | | | 711.3 | 2.049 | 1457.6 | 1000-1500 |
| r3_m03 | 1 | 116.3 | 94.3 | 17.1 | | | | | | | | 227.7 | 2.049 | 466.6 | <500 |
| r3_m03 | 2 | 351.7 | | | | | | | | | | 351.7 | 2.049 | 720.7 | 500-1000 |
| r3_m03 | 3 | 103.5 | 62.6 | 77.8 | 70.6 | 82.9 | | | | | | 397.4 | 2.049 | 814.4 | 500-1000 |
| r3_m03 | 4 | 103.2 | 57.1 | | | | | | | | | 160.3 | 2.049 | 328.5 | <500 |
| r3_m03 | 5 | 290.1 | | | | | | | | | | 290.1 | 2.049 | 594.5 | 500-1000 |
| r3_m03 | 6 | 309.1 | 84.3 | 100.4 | 108 | 179.3 | 47 | Off Page | | | | 828.1 | 2.049 | 1696.9 | 1500-2000 |
| r3_m03 | 7 | 283.3 | | | | | | | | | | 283.3 | 2.049 | 580.5 | 500-1000 |
| r3_m03 | 8 | 315.8 | 119.4 | 42.1 | | | | | | | | 477.3 | 2.049 | 978.1 | 500-1000 |
| r3_m03 | 9 | 101 | | | | | | | | | | 101.0 | 2.049 | 207.0 | <500 |
| r3_m03 | 10 | 75.2 | 103.7 | 149.3 | | | | | | | | 328.2 | 2.049 | 672.5 | 500-1000 |
| r3_m04 | 1 | 213.2 | 243.6 | | | | | | | | | 456.8 | 2.049 | 936.1 | 500-1000 |
| r3_m04 | 2 | 237 | | | | | | | | | | 237.0 | 2.049 | 485.7 | <500 |
| r3_m04 | 3 | 253.6 | | | | | | | | | | 253.6 | 2.049 | 519.7 | 500-1000 |
| r3_m04 | 4 | 128.6 | 136.4 | 201.2 | 172.4 | 249.9 | Off Page | | | | | 888.5 | 2.049 | 1820.7 | 1500-2000 |
| r3_m04 | 5 | 228 | | | | | | | | | | 228.0 | 2.049 | 467.2 | <500 |
| r3_m04 | 6 | 468.7 | | | | | | | | | | 468.7 | 2.049 | 960.5 | 500-1000 |

| Image # | # | Segment 1 Length (Pixels) | Segment 2 Length (Pixels) | Segment 3 Length (Pixels) | Segment 4 Length (Pixels) | Segment 5 Length (Pixels) | Segment 6 Length (Pixels) | Segment 7 Length (Pixels) | Segment 8 Length (Pixels) | Segment 9 Length (Pixels) | Segment 10 Length (Pixels) | Total Length (Pixels) | 1 Pixel (µm) | Grid Adjusted Length (µm) | Length Category |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| r3_m04 | 7 | 109.9 | 46 | 41.8 | | | | | | | | 197.7 | 2.049 | 405.1 | <500 |
| r3_m04 | 8 | 385.9 | | | | | | | | | | 385.9 | 2.049 | 790.8 | 500-1000 |
| r3_m04 | 9 | 164.1 | 173 | 107.6 | 103 | | | | | | | 547.7 | 2.049 | 1122.3 | 1000-1500 |
| r3_m04 | 10 | 197.4 | | | | | | | | | | 197.4 | 2.049 | 404.5 | <500 |
| r3_m05 | 1 | 105.3 | 94.7 | 169.9 | 140.2 | 79.4 | Hidden | | | | | 589.5 | 4.107 | 2421.0 | 2000-2500 |
| r3_m05 | 2 | 240.2 | 52.5 | 57.1 | 116.4 | | | | | | | 466.2 | 4.107 | 1914.6 | 1500-2000 |
| r3_m05 | 3 | 103.3 | | | | | | | | | | 103.3 | 4.107 | 424.2 | <500 |
| r3_m05 | 4 | 68.7 | 92.6 | 137 | | | | | | | | 298.3 | 4.107 | 1225.1 | 1000-1500 |
| r3_m05 | 5 | 275.2 | | | | | | | | | | 275.2 | 4.107 | 1130.2 | 1000-1500 |
| r3_m05 | 6 | 66.4 | | | | | | | | | | 66.4 | 4.107 | 272.7 | <500 |
| r3_m05 | 7 | 139.8 | | | | | | | | | | 139.8 | 4.107 | 574.1 | 500-1000 |
| r3_m05 | 8 | 61.7 | 69.4 | 59.5 | 36.1 | | | | | | | 226.7 | 4.107 | 931.0 | 500-1000 |
| r3_m05 | 9 | 114.4 | | | | | | | | | | 114.4 | 4.107 | 469.8 | <500 |
| r3_m05 | 10 | 127.6 | | | | | | | | | | 127.6 | 4.107 | 524.0 | 500-1000 |
| s1_m01 | 1 | 108.2 | 250.6 | 150.9 | Off Page | | | | | | | 509.7 | 2.049 | 1044.5 | 1000-1500 |
| s1_m01 | 2 | 244.3 | 285 | | | | | | | | | 529.3 | 2.049 | 1084.6 | 1000-1500 |
| s1_m01 | 3 | 317.6 | 344.4 | | | | | | | | | 662.0 | 2.049 | 1356.6 | 1000-1500 |
| s1_m01 | 4 | 213.5 | | | | | | | | | | 213.5 | 2.049 | 437.5 | <500 |
| s1_m01 | 5 | 113 | 63.3 | | | | | | | | | 176.3 | 2.049 | 361.3 | <500 |
| s1_m01 | 6 | 719.8 | | | | | | | | | | 719.8 | 2.049 | 1475.0 | 1000-1500 |
| s1_m01 | 7 | 233.8 | 203.7 | 379.1 | Off Page | | | | | | | 816.6 | 2.049 | 1673.4 | 1500-2000 |
| s1_m01 | 8 | 324.4 | 590.6 | Off Page | | | | | | | | 915.0 | 2.049 | 1875.0 | 1500-2000 |
| s1_m01 | 9 | 249.7 | 243.7 | | | | | | | | | 493.4 | 2.049 | 1011.1 | 1000-1500 |

| Image # | # | Segment 1 Length (Pixels) | Segment 2 Length (Pixels) | Segment 3 Length (Pixels) | Segment 4 Length (Pixels) | Segment 5 Length (Pixels) | Segment 6 Length (Pixels) | Segment 7 Length (Pixels) | Segment 8 Length (Pixels) | Segment 9 Length (Pixels) | Segment 10 Length (Pixels) | Total Length (Pixels) | 1 Pixel (µm) | Grid Adjusted Length (µm) | Length Category |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| s1_m01 | 10 | 235.2 | 131.6 | 160.2 | | | | | | | | 527.0 | 2.049 | 1079.9 | 1000-1500 |
| s1_m02 | 1 | 306.2 | 268.8 | | | | | | | | | 575.0 | 2.049 | 1178.3 | 1000-1500 |
| s1_m02 | 2 | 536.1 | | | | | | | | | | 536.1 | 2.049 | 1098.6 | 1000-1500 |
| s1_m02 | 3 | 98.2 | | | | | | | | | | 98.2 | 2.049 | 201.2 | <500 |
| s1_m02 | 4 | 248.1 | 266.7 | | | | | | | | | 514.8 | 2.049 | 1054.9 | 1000-1500 |
| s1_m02 | 5 | 92.8 | 118.1 | 95.1 | 124.5 | 236.3 | 118.3 | 144.3 | 137.5 | 146.5 | | 1213.4 | 2.049 | 2486.5 | 2000-2500 |
| s1_m02 | 6 | 192.9 | | | | | | | | | | 192.9 | 2.049 | 395.3 | <500 |
| s1_m02 | 7 | 351.1 | 136 | 274.2 | | | | | | | | 761.3 | 2.049 | 1560.1 | 1500-2000 |
| s1_m02 | 8 | 349.2 | 99.3 | 30 | | | | | | | | 478.5 | 2.049 | 980.5 | 500-1000 |
| s1_m02 | 9 | 115.2 | 119.6 | | | | | | | | | 234.8 | 2.049 | 481.2 | <500 |
| s1_m03 | 10 | 65.8 | 121.5 | 105.5 | 64.8 | | | | | | | 357.6 | 2.049 | 732.8 | 500-1000 |
| s1_m03 | 1 | 225.1 | 195.3 | 270.1 | 238.9 | 376.5 | Off Page | | | | | 1305.9 | 2.049 | 2676.1 | >2500 |
| s1_m03 | 2 | 100.3 | 28.4 | 35.7 | 36.8 | 63.7 | 71 | 87.3 | 10 | | | 433.2 | 2.049 | 887.7 | 500-1000 |
| s1_m03 | 3 | 293.3 | 414.2 | 324 | 260.2 | Off Page | | | | | | 1291.7 | 2.049 | 2647.0 | >2500 |
| s1_m03 | 4 | 524.4 | | | | | | | | | | 524.4 | 2.049 | 1074.6 | 1000-1500 |
| s1_m03 | 5 | 239.7 | 175.5 | 204.8 | | | | | | | | 620.0 | 2.049 | 1270.5 | 1000-1500 |
| s1_m03 | 6 | 143 | | | | | | | | | | 143.0 | 2.049 | 293.0 | <500 |
| s1_m03 | 7 | 192.5 | 151.3 | 184.7 | 219 | 264.1 | Off Page | | | | | 1011.6 | 2.049 | 2073.0 | 2000-2500 |
| s1_m03 | 8 | 346.3 | 280.9 | | | | | | | | | 627.2 | 2.049 | 1285.3 | 1000-1500 |
| s1_m03 | 9 | 145.7 | | | | | | | | | | 145.7 | 2.049 | 298.6 | <500 |
| s1_m03 | 10 | 215.7 | | | | | | | | | | 215.7 | 2.049 | 442.0 | <500 |
| s1_m04 | 1 | 287.1 | 319.6 | | | | | | | | | 606.7 | 2.049 | 1243.2 | 1000-1500 |
| s1_m04 | 2 | 118 | 228.8 | 473.3 | 180.9 | 413.2 | Off Page | | | | | 1414.2 | 2.049 | 2898.0 | >2500 |

| Image # | # | Segment 1 Length (Pixels) | Segment 2 Length (Pixels) | Segment 3 Length (Pixels) | Segment 4 Length (Pixels) | Segment 5 Length (Pixels) | Segment 6 Length (Pixels) | Segment 7 Length (Pixels) | Segment 8 Length (Pixels) | Segment 9 Length (Pixels) | Segment 10 Length (Pixels) | Total Length (Pixels) | 1 Pixel (µm) | Grid Adjusted Length (µm) | Length Category |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| s1_m04 | 3 | 99.8 | | | | | | | | | | 99.8 | 2.049 | 204.5 | <500 |
| s1_m04 | 4 | 175.2 | | | | | | | | | | 175.2 | 2.049 | 359.0 | <500 |
| s1_m04 | 5 | 491.4 | | | | | | | | | | 491.4 | 2.049 | 1007.0 | 1000-1500 |
| s1_m04 | 6 | 177.6 | 155.6 | | | | | | | | | 333.2 | 2.049 | 682.8 | 500-1000 |
| s1_m04 | 7 | 26.9 | 21.4 | 33.2 | 31.1 | 107.8 | 40.6 | 79.1 | 26.2 | 42 | | 408.3 | 2.049 | 836.7 | 500-1000 |
| s1_m04 | 8 | 365.5 | | | | | | | | | | 365.5 | 2.049 | 749.0 | 500-1000 |
| s1_m04 | 9 | 179.9 | 270.2 | 229.9 | 196.6 | 197.7 | Off Page | | | | | 1074.3 | 2.049 | 2201.5 | 2000-2500 |
| s1_m04 | 10 | 82.3 | 102 | 65.9 | 109.1 | | | | | | | 359.3 | 2.049 | 736.3 | 500-1000 |
| s1_m05 | 1 | 164.5 | 144.5 | 90.6 | 38.5 | | | | | | | 438.1 | 4.107 | 1799.2 | 1500-2000 |
| s1_m05 | 2 | 128.1 | 134.1 | 254.5 | 81.7 | 201.8 | Off Page | | | | | 800.2 | 4.107 | 3286.3 | >2500 |
| s1_m05 | 3 | 183.4 | 162.8 | 47.1 | | | | | | | | 393.3 | 4.107 | 1615.2 | 1500-2000 |
| s1_m05 | 4 | 51.9 | | | | | | | | | | 51.9 | 4.107 | 213.1 | <500 |
| s1_m05 | 5 | 122.5 | | | | | | | | | | 122.5 | 4.107 | 503.1 | 500-1000 |
| s1_m05 | 6 | 42.4 | 42 | | | | | | | | | 84.4 | 4.107 | 346.6 | <500 |
| s1_m05 | 7 | 41.9 | 25.2 | 21.2 | 242.9 | | | | | | | 331.2 | 4.107 | 1360.2 | 1000-1500 |
| s1_m05 | 8 | 18 | 69.6 | 151.2 | | | | | | | | 238.8 | 4.107 | 980.7 | 500-1000 |
| s1_m05 | 9 | 154 | 218.2 | | | | | | | | | 372.2 | 4.107 | 1528.6 | 1500-2000 |
| s1_m05 | 10 | 261 | | | | | | | | | | 261.0 | 4.107 | 1071.9 | 1000-1500 |
| s2_m01 | 1 | 590.6 | | | | | | | | | | 590.6 | 2.049 | 1210.3 | 1000-1500 |
| s2_m01 | 2 | 248.2 | 170.8 | | | | | | | | | 419.0 | 2.049 | 858.6 | 500-1000 |
| s2_m01 | 3 | 965.7 | Off Page | | | | | | | | | 965.7 | 2.049 | 1978.9 | 1500-2000 |
| s2_m01 | 4 | 173 | | | | | | | | | | 173.0 | 2.049 | 354.5 | <500 |
| s2_m01 | 5 | 815.4 | | | | | | | | | | 815.4 | 2.049 | 1670.9 | 1500-2000 |

| Image # | # | Segment 1 Length (Pixels) | Segment 2 Length (Pixels) | Segment 3 Length (Pixels) | Segment 4 Length (Pixels) | Segment 5 Length (Pixels) | Segment 6 Length (Pixels) | Segment 7 Length (Pixels) | Segment 8 Length (Pixels) | Segment 9 Length (Pixels) | Segment 10 Length (Pixels) | Total Length (Pixels) | 1 Pixel (µm) | Grid Adjusted Length (µm) | Length Category |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| s2_m01 | 6 | 542.1 | | | | | | | | | | 542.1 | 2.049 | 1110.9 | 1000-1500 |
| s2_m01 | 7 | 13.9 | 102.9 | | | | | | | | | 116.8 | 2.049 | 239.3 | <500 |
| s2_m01 | 8 | 166 | 123.2 | | | | | | | | | 289.2 | 2.049 | 592.6 | 500-1000 |
| s2_m01 | 9 | 470.7 | 783.1 | Off Page | | | | | | | | 1253.8 | 2.049 | 2569.3 | >2500 |
| s2_m01 | 10 | 46.3 | 24 | 38.1 | 51.3 | 40.5 | 52.8 | 73.4 | 59.9 | 16.2 | | 402.5 | 2.049 | 824.8 | 500-1000 |
| s2_m02 | 1 | 453.8 | 274.4 | 107.1 | | | | | | | | 835.3 | 2.049 | 1711.7 | 1500-2000 |
| s2_m02 | 2 | 218.8 | 184.8 | 38.9 | 82.9 | | | | | | | 525.4 | 2.049 | 1076.6 | 1000-1500 |
| s2_m02 | 3 | 138.2 | 171.2 | 183.1 | 140.6 | 83.4 | | | | | | 716.5 | 2.049 | 1468.3 | 1000-1500 |
| s2_m02 | 4 | 758.1 | | | | | | | | | | 758.1 | 2.049 | 1553.5 | 1500-2000 |
| s2_m02 | 5 | 101.2 | | | | | | | | | | 101.2 | 2.049 | 207.4 | <500 |
| s2_m02 | 6 | 93 | 131.5 | 71.2 | | | | | | | | 295.7 | 2.049 | 605.9 | 500-1000 |
| s2_m02 | 7 | 202.9 | 152.3 | | | | | | | | | 355.2 | 2.049 | 727.9 | 500-1000 |
| s2_m02 | 8 | 140.4 | | | | | | | | | | 140.4 | 2.049 | 287.7 | <500 |
| s2_m02 | 9 | 407.6 | 163.8 | 128.4 | 162.8 | 122.8 | Off Page | | | | | 985.4 | 2.049 | 2019.3 | 2000-2500 |
| s2_m03 | 10 | 278.2 | 126.5 | | | | | | | | | 404.7 | 2.049 | 829.3 | 500-1000 |
| s2_m03 | 1 | 238.7 | 206.5 | | | | | | | | | 445.2 | 2.049 | 912.3 | 500-1000 |
| s2_m03 | 2 | 125.2 | 92.7 | 81.6 | 170.4 | 60.9 | 219.5 | | | | | 750.3 | 2.049 | 1537.5 | 1500-2000 |
| s2_m03 | 3 | 61.4 | 132.5 | 38.3 | | | | | | | | 232.2 | 2.049 | 475.8 | <500 |
| s2_m03 | 4 | 95 | | | | | | | | | | 95.0 | 2.049 | 194.7 | <500 |
| s2_m03 | 5 | 347.1 | 344 | | | | | | | | | 691.1 | 2.049 | 1416.2 | 1000-1500 |
| s2_m03 | 6 | 68 | 79.2 | 163.6 | 79.2 | 69.6 | 17 | 115.4 | 31 | 15 | 12.2 | 650.2 | 2.049 | 1332.4 | 1000-1500 |
| s2_m03 | 7 | 361.1 | 229 | 298.4 | 215.5 | Off Page | | | | | | 1104.0 | 2.049 | 2262.3 | 2000-2500 |
| s2_m03 | 8 | 403.3 | 457.3 | | | | | | | | | 860.6 | 2.049 | 1763.5 | 1500-2000 |

| Image # | # | Segment 1 Length (Pixels) | Segment 2 Length (Pixels) | Segment 3 Length (Pixels) | Segment 4 Length (Pixels) | Segment 5 Length (Pixels) | Segment 6 Length (Pixels) | Segment 7 Length (Pixels) | Segment 8 Length (Pixels) | Segment 9 Length (Pixels) | Segment 10 Length (Pixels) | Total Length (Pixels) | 1 Pixel (µm) | Grid Adjusted Length (µm) | Length Category |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| s2_m03 | 9 | 244.8 | 161 | 188.4 | | | | | | | | 594.2 | 2.049 | 1217.6 | 1000-1500 |
| s2_m03 | 10 | 170.1 | 171.7 | 54.6 | | | | | | | | 396.4 | 2.049 | 812.3 | 500-1000 |
| s2_m04 | 1 | 217.1 | 348.9 | 426.7 | 255.3 | 266.4 | Off Page | | | | | 1514.4 | 2.049 | 3103.3 | >2500 |
| s2_m04 | 2 | 101.5 | | | | | | | | | | 101.5 | 2.049 | 208.0 | <500 |
| s2_m04 | 3 | 105.2 | 68.5 | 52 | 16.4 | | | | | | | 242.1 | 2.049 | 496.1 | <500 |
| s2_m04 | 4 | 210.2 | | | | | | | | | | 210.2 | 2.049 | 430.7 | <500 |
| s2_m04 | 5 | 342.7 | 231.8 | 92.1 | | | | | | | | 666.6 | 2.049 | 1366.0 | 1000-1500 |
| s2_m04 | 6 | 204.6 | 144 | 82 | 24.8 | | | | | | | 455.4 | 2.049 | 933.2 | 500-1000 |
| s2_m04 | 7 | 180.9 | 132.7 | 90.4 | 78 | | | | | | | 482.0 | 2.049 | 987.7 | 500-1000 |
| s2_m04 | 8 | 75.7 | 329.2 | | | | | | | | | 404.9 | 2.049 | 829.7 | 500-1000 |
| s2_m04 | 9 | 618.5 | Off Page | | | | | | | | | 618.5 | 2.049 | 1267.4 | 1000-1500 |
| s2_m04 | 10 | 275.1 | | | | | | | | | | 275.1 | 2.049 | 563.7 | 500-1000 |
| s2_m05 | 1 | 155.2 | 188.1 | | | | | | | | | 343.3 | 4.107 | 1409.9 | 1000-1500 |
| s2_m05 | 2 | 79.6 | | | | | | | | | | 79.6 | 4.107 | 326.9 | <500 |
| s2_m05 | 3 | 111.9 | 87.1 | 79.5 | 133.8 | Off Page | | | | | | 412.3 | 4.107 | 1693.2 | 1500-2000 |
| s2_m05 | 4 | 191.4 | | | | | | | | | | 191.4 | 4.107 | 786.0 | 500-1000 |
| s2_m05 | 5 | 336.3 | | | | | | | | | | 336.3 | 4.107 | 1381.1 | 1000-1500 |
| s2_m05 | 6 | 505.7 | Off Page | | | | | | | | | 505.7 | 4.107 | 2076.8 | 2000-2500 |
| s2_m05 | 7 | 266.2 | | | | | | | | | | 266.2 | 4.107 | 1093.2 | 1000-1500 |
| s2_m05 | 8 | 266.5 | 222.1 | | | | | | | | | 488.6 | 4.107 | 2006.6 | 2000-2500 |
| s2_m05 | 9 | 228 | | | | | | | | | | 228.0 | 4.107 | 936.4 | 500-1000 |
| s2_m05 | 10 | 91.4 | | | | | | | | | | 91.4 | 4.107 | 375.4 | <500 |
| s3_m01 | 1 | 75.6 | | | | | | | | | | 75.6 | 2.049 | 154.9 | <500 |

| ALION SCIENCE AND TECHNOLOGY | BWROG Downstream Effects Scanning Electron Microscope Analysis | | |
|---|---|---|---|
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| Image # | # | Segment 1 Length (Pixels) | Segment 2 Length (Pixels) | Segment 3 Length (Pixels) | Segment 4 Length (Pixels) | Segment 5 Length (Pixels) | Segment 6 Length (Pixels) | Segment 7 Length (Pixels) | Segment 8 Length (Pixels) | Segment 9 Length (Pixels) | Segment 10 Length (Pixels) | Total Length (Pixels) | 1 Pixel (µm) | Grid Adjusted Length (µm) | Length Category |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| s3_m01 | 2 | 240.5 | 173.1 | 120.7 | 90.1 | 32.2 | | | | | | 656.6 | 2.049 | 1345.5 | 1000-1500 |
| s3_m01 | 3 | 353 | | | | | | | | | | 353.0 | 2.049 | 723.4 | 500-1000 |
| s3_m01 | 4 | 302 | 249.8 | 159.2 | Off Page | | | | | | | 711.0 | 2.049 | 1457.0 | 1000-1500 |
| s3_m01 | 5 | 641 | | | | | | | | | | 641.0 | 2.049 | 1313.5 | 1000-1500 |
| s3_m01 | 6 | 32.6 | | | | | | | | | | 32.6 | 2.049 | 66.8 | <500 |
| s3_m01 | 7 | 291.9 | | | | | | | | | | 291.9 | 2.049 | 598.2 | 500-1000 |
| s3_m01 | 8 | 197.2 | 123.3 | | | | | | | | | 320.5 | 2.049 | 656.8 | 500-1000 |
| s3_m01 | 9 | 245.4 | 279.3 | 138.9 | 91.4 | 53 | Off Page | | | | | 808.0 | 2.049 | 1655.8 | 1500-2000 |
| s3_m01 | 10 | 446.7 | | | | | | | | | | 446.7 | 2.049 | 915.4 | 500-1000 |
| s3_m02 | 1 | 1036.5 | 138.3 | 117.6 | 107.9 | 122 | 99.4 | 113.2 | 104.9 | 54.2 | Off Page | 1894.0 | 2.049 | 3881.2 | >2500 |
| s3_m02 | 2 | 85.8 | | | | | | | | | | 85.8 | 2.049 | 175.8 | <500 |
| s3_m02 | 3 | 239 | 146.5 | 165 | 135.1 | 110.4 | Off Page | | | | | 796.0 | 2.049 | 1631.2 | 1500-2000 |
| s3_m02 | 4 | 468.7 | | | | | | | | | | 468.7 | 2.049 | 960.5 | 500-1000 |
| s3_m02 | 5 | 302 | 251.9 | | | | | | | | | 553.9 | 2.049 | 1135.1 | 1000-1500 |
| s3_m02 | 6 | 273.2 | 105 | 52.5 | | | | | | | | 430.7 | 2.049 | 882.6 | 500-1000 |
| s3_m02 | 7 | 172.1 | | | | | | | | | | 172.1 | 2.049 | 352.7 | <500 |
| s3_m02 | 8 | 178.1 | 175.6 | 125.4 | 166.1 | 98 | | | | | | 743.2 | 2.049 | 1523.0 | 1500-2000 |
| s3_m02 | 9 | 175.9 | 168.5 | 66 | | | | | | | | 410.4 | 2.049 | 841.0 | 500-1000 |
| s3_m03 | 10 | 216.9 | 223.1 | | | | | | | | | 440.0 | 2.049 | 901.6 | 500-1000 |
| s3_m03 | 1 | 238.8 | 297.8 | 230.8 | | | | | | | | 767.4 | 2.049 | 1572.6 | 1500-2000 |
| s3_m03 | 2 | 73.2 | | | | | | | | | | 73.2 | 2.049 | 150.0 | <500 |
| s3_m03 | 3 | 502.7 | | | | | | | | | | 502.7 | 2.049 | 1030.1 | 1000-1500 |
| s3_m03 | 4 | 218.8 | 289.4 | | | | | | | | | 508.2 | 2.049 | 1041.4 | 1000-1500 |

| Image # | # | Segment 1 Length (Pixels) | Segment 2 Length (Pixels) | Segment 3 Length (Pixels) | Segment 4 Length (Pixels) | Segment 5 Length (Pixels) | Segment 6 Length (Pixels) | Segment 7 Length (Pixels) | Segment 8 Length (Pixels) | Segment 9 Length (Pixels) | Segment 10 Length (Pixels) | Total Length (Pixels) | 1 Pixel (µm) | Grid Adjusted Length (µm) | Length Category |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| s3_m03 | 5 | 444.1 | 320.9 | Off Page | | | | | | | | 765.0 | 2.049 | 1567.6 | 1500-2000 |
| s3_m03 | 6 | 101.8 | | | | | | | | | | 101.8 | 2.049 | 208.6 | <500 |
| s3_m03 | 7 | 320.1 | | | | | | | | | | 320.1 | 2.049 | 655.9 | 500-1000 |
| s3_m03 | 8 | 88.6 | 84.3 | | | | | | | | | 172.9 | 2.049 | 354.3 | <500 |
| s3_m03 | 9 | 236.2 | 229.5 | 198.2 | 159.8 | 159.7 | 62.8 | Off Page | | | | 1046.2 | 2.049 | 2143.9 | 2000-2500 |
| s3_m03 | 10 | 291.6 | 150.1 | 89.7 | | | | | | | | 531.4 | 2.049 | 1088.9 | 1000-1500 |
| s3_m04 | 1 | 535.4 | 173.6 | 166.2 | 156.7 | 102 | Off Page | | | | | 1133.9 | 2.049 | 2323.6 | 2000-2500 |
| s3_m04 | 2 | 201.7 | 137.4 | | | | | | | | | 339.1 | 2.049 | 694.9 | 500-1000 |
| s3_m04 | 3 | 103.9 | 102.6 | 95.1 | 115.7 | 104.7 | | | | | | 522.0 | 2.049 | 1069.7 | 1000-1500 |
| s3_m04 | 4 | 82.6 | 76.1 | | | | | | | | | 158.7 | 2.049 | 325.2 | <500 |
| s3_m04 | 5 | 629 | 172.1 | | | | | | | | | 801.1 | 2.049 | 1641.6 | 1500-2000 |
| s3_m04 | 6 | 224.6 | 190.7 | 270.1 | | | | | | | | 685.4 | 2.049 | 1404.5 | 1000-1500 |
| s3_m04 | 7 | 88.8 | 97.7 | 95.2 | 97.4 | 124 | 179.9 | 146.5 | Off Page | | | 829.5 | 2.049 | 1699.8 | 1500-2000 |
| s3_m04 | 8 | 332.3 | | | | | | | | | | 332.3 | 2.049 | 680.9 | 500-1000 |
| s3_m04 | 9 | 157.8 | | | | | | | | | | 157.8 | 2.049 | 323.4 | <500 |
| s3_m04 | 10 | 131.5 | 139.2 | 330.5 | 142.2 | 235.7 | Off Page | | | | | 979.1 | 2.049 | 2006.4 | 2000-2500 |
| s3_m05 | 1 | 118.8 | 159.1 | 90.2 | 67.1 | 155.7 | 52 | | | | | 642.9 | 4.107 | 2640.3 | >2500 |
| s3_m05 | 2 | 210.4 | 183.9 | | | | | | | | | 394.3 | 4.107 | 1619.3 | 1500-2000 |
| s3_m05 | 3 | 88.1 | 36.7 | | | | | | | | | 124.8 | 4.107 | 512.5 | 500-1000 |
| s3_m05 | 4 | 228.1 | 5 | | | | | | | | | 233.1 | 4.107 | 957.3 | 500-1000 |
| s3_m05 | 5 | 60 | | | | | | | | | | 60.0 | 4.107 | 246.4 | <500 |
| s3_m05 | 6 | 84 | | | | | | | | | | 84.0 | 4.107 | 345.0 | <500 |
| s3_m05 | 7 | 104.8 | 75.2 | | | | | | | | | 180.0 | 4.107 | 739.2 | 500-1000 |

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|---|---|---|---|
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| Image # | # | Segment 1 Length (Pixels) | Segment 2 Length (Pixels) | Segment 3 Length (Pixels) | Segment 4 Length (Pixels) | Segment 5 Length (Pixels) | Segment 6 Length (Pixels) | Segment 7 Length (Pixels) | Segment 8 Length (Pixels) | Segment 9 Length (Pixels) | Segment 10 Length (Pixels) | Total Length (Pixels) | 1 Pixel (µm) | Grid Adjusted Length (µm) | Length Category |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| s3_m05 | 8 | 70.1 | 82.2 | 74 | 72.5 | 65 | | | | | | 363.8 | 4.107 | 1494.1 | 1000-1500 |
| s3_m05 | 9 | 77 | 228.9 | 111.8 | 54 | 39.3 | | | | | | 511.0 | 4.107 | 2098.6 | 2000-2500 |
| s3_m05 | 10 | 153.1 | 112.5 | 122 | 104 | 32.6 | | | | | | 524.2 | 4.107 | 2152.8 | 2000-2500 |

**Attachment E: Geller Microanalytical Laboratory MRS-3XY Resource Guide (March 2011)**

ACLASS®

MRS-3

NIST and NPL (NIST counterpart in the U.K.) traceable - **Certified Reference Material**. A Magnification Reference Standard designed for Microscopy *by* Microscopists.

*"Do It Right... The first time"*

***- THE 10X TO 50,000X STANDARD -***

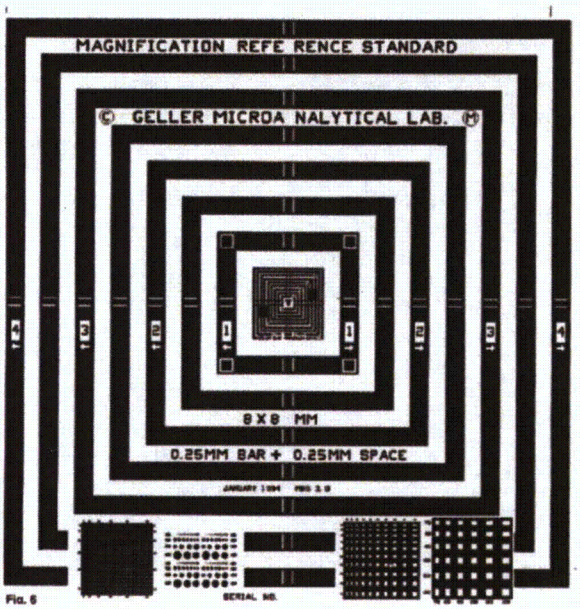



Fig. 6

***Resource Guide***

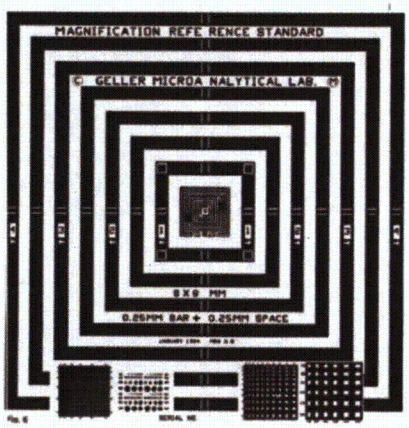
- **Product Design**
- **Magnification Measurement & Error Assessment**
- **Magnification Calibration Procedures for optical, video and scanning microscopies (following ASTM E766-98)**

**GELLER MICROANALYTICAL LABORATORY**
426e BOSTON ST., TOPSFIELD MA 01983-1216
TEL 978 887-7000 FAX 978-887-8671
sales@gellermicro.com http://www.gellermicro.com

*We are certified to ISO-9001 & 17025 - March 2011*

# MRS-3

This is our second generation, NIST and NPL (NIST counterpart in the U.K.) Traceable, Magnification Reference Standard & Stage Micrometer. For Instrument Calibration from 10X – 50,000A (2µm minimum pitch).




Applications:

- Electron Microscopy: SEM (secondary & backscattered electrons), TEM (for use with a bulk holder- the MRS-3 can be size altered to 3mm ∅ X ½ mm thick). Call for other sizes.
- Scanning Microscopies and Profilometry: STM, AFM, stylus and optical etc. The pattern height is 0.1µm.
- Optical Microscopy: transmitted, reflected, bright/dark field, differential contrast, and confocal.
- Chemical mapping: EDS, WDS, micro/macro XRF, XPS, Auger & others. The pattern is fabricated using 0.1µm $CrO_2$ over quartz.
- Particle Size Counting: series of circles, squares & rectangles for calibration confirmation.

## INTRODUCTION

Geller MicroAnalytical Laboratory introduces the MRS-3, our second generation magnification calibration standard (the MRS-4 with a ¼µm pitch is also available). Our MRS series of calibration standards are highly accepted pitch standards, with more than 1,000 delivered. We offer them as a certified reference material (a traceable standard) or, optionally, without traceability. We also offer a cleaning service and a recertification program, as required by international quality standards such as the ISO and QS-9000 and ISO 17025.

## PATTERN DESIGN

The MRS-3 is fabricated by using the highest accuracy electron direct write semiconductor manufacturing equipment available today. The pattern is anti reflective chromium (30nm of $CrO_2$ over 70nm of Cr) over quartz. Imaging contrast in both secondary and backscattered electron mode is very high. The overall size is 18mm X 9mm X 2.3 mm thick. The size can be modified for special applications (such as for a TEM bulk holder or mounting on a large wafer) to 3 mm ∅ X ½ mm thick – or another custom size. For applications requiring an electrically conductive sample (SEM at ≤1keV and higher), the MRS-3 is coated with a proprietary material which allows for image observation at any accelerating voltage. A distinct advantage of this coating is that electron beam tracks from contamination are removable by plasma etching. Applying a fresh coating restores the MRS-3 to like new condition.

The geometric design of the MRS-3 has groups of nested squares spanning several orders of magnitude with pitches of 2µm, 50µm and 500µm. We measure and certify pitch (the distance between repeating parallel lines using center-to-center or edge-to-edge spacing. This is the only type of measurement that can be used to relate measurements from different microscopy techniques (see "Submicrometer Linewidth Metrology in Optical Microscopy", Nyyssonen & Larrabee, Journal of the Research of the National Bureau of Standards, Vol. 92, No. 3, 1987). Linewidth measurements (the measurement of a single line or space width) can only be related if the same type of illumination is used as for the calibrating instrument since edge effects lead to uncertainty in the edge locations. Using pitch measurements, errors from edge-to-edge locations cancel as long as like positions are measured. Several examples are given on the illustrations and in the figure captions of this resource guide.

Square boxes are used for measuring magnification simultaneously in the X and Y directions. This gives a measure of image skew, barreling, pincushion and other non-linearities which can have various origins, such as from stray magnetic fields.

The largest pattern has an overall dimension of 8mm square. It contains lines and spaces that are nominally 250µm wide (totaling 500µm pitch). This can be used to check magnifications from 10X – 100X. The 50µm pitch patterns are useful from 100X – 1000X. The 2µm pitch patterns will allow calibrations up to 50,000X.

Included are squares and rectangles from 1 – 31µm in 1µm increments, 30 – 75µm in 5µm increments, and 70 to 120µm in 10µm increments. Also included is an array of 4 repeating patterns of circles with diameters ranging from 2 – 39µm in 2µm increments and 40 – 100µm in 10µm increments. These patterns are useful for checking the performance and setup of particle size counting systems. From our experience it is very difficult to get the proper size distribution knowing the correct answer. The patterns can also be used for determining imaging and chemical spatial resolution, and chemical mapping. Since the circles and rectangles are not pitch patterns, they cannot be made traceable.

## HOW ACCURATE ARE THE PITCH PATTERNS?

Several MRS-3's have been measured by the National Physical Laboratory in the U.K. (the NIST counterpart in the United Kingdom). The uncertainties we state for the 500 µm pitch pattern is ±0.25µm, for the 50µm pitch pattern it is 0.104 µm and for the 2µm pitch pattern it is 0.031µm. It goes without saying that these reported results from NPL combine with our uncertainties are highly conservative. Our customers have also sent MRS-3's to NIST. The NIST data shows better accuracy than NPL reports.

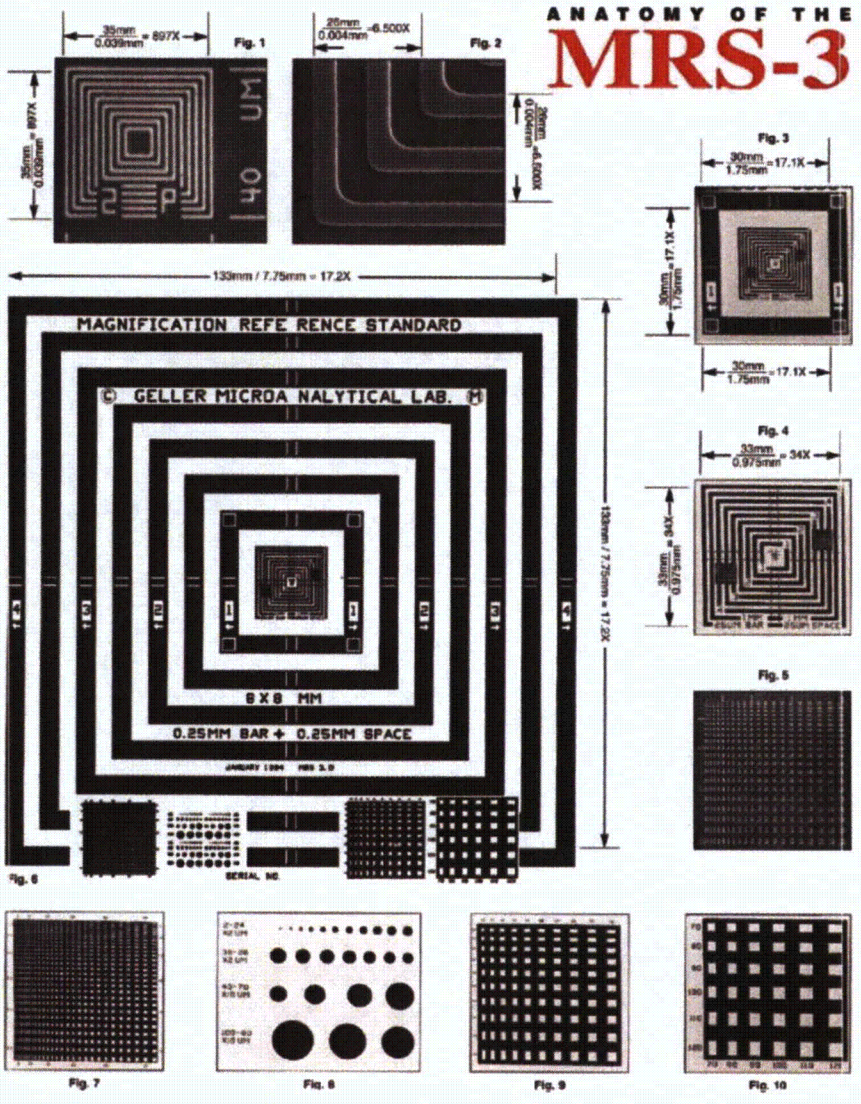
With the even numbered pitch patterns on the MRS-3 magnifications can usually be determined without the use of a calculator. For instance, if the length of five 2µm pitches are measured over a distance of 49mm on a micrograph or display screen the magnification would be 49mm ÷ 0.01mm = 4900X. **Please note:** our measurements are made by a special SEM where each individual pattern is measured. Other CEMs may calibrate using optical diffraction. This technique averages over large patterned areas, not individual pitches- like your microscope.

## WHAT IS INCLUDED THE CERTIFICATION REPORT?

We follow the ISO guidelines for certification and traceability. Included is the unique serial number engraved on the standard, certification date, recertification due date, operator, instrumentation used, and actual pattern measurements along with a measure of accuracy. This report has satisfied 100% of our customer audits.

| ALION SCIENCE AND TECHNOLOGY | BWROG ECCS Strainer Bypass Test Report | | |
|---|---|---|---|
| | Document No: BWROG-ECCS-TA13-004 | Revision: 1 | Page: O-153 of O-154 |

| ALION SCIENCE AND TECHNOLOGY | BWROG Downstream Effects Scanning Electron Microscope Analysis | | |
|---|---|---|---|
| | Document No: BWROG-ECCS-TA13-003 | Rev: 0 | Page: E-3 of E-4 |



## Magnification Determination

- Magnification shall be determined using pitch measurements- the process of measuring repeating structures. Several examples are shown above. Since the circles and squares cannot be measured using "pitch" their sizes cannot be made traceable (see ASTM E766-98)
- Magnification is simply defined as the ratio of the image size to object size (be careful to use the same units - µm, mm, nm, etc.). Please carefully note the locations of the above magnification measurements relative to the patterns in figure 4, 5, and 9. See examples below.

**Fig. 1**: The smallest pattern has a 2µm pitch. The pitch dimension of the largest box is 30µm. Starting at the left side with a light-to-dark transition we measure across to the last light-to-dark transition. Our magnification is 35mm ÷ 0.039mm = 897X (SEM, 1kV).

**Fig. 2**: At high magnification we image the line and space structure. Two cycles of the horizontal 2µm pitch measures 26mm ÷ 0.004mm = 6,500X. (SEM, 10kV).

**Fig. 3**: The 6 CRT measurement patterns are visible (see arrows). The magnification of this image is 30mm ÷ 1.75mm = 17.1X.

**Fig. 4**: Using the 50µm pitch the magnification is 35mm ÷ 0.975mm = 36X.

**Fig. 5**: This is one of the 6 CRT measurement patterns. Squares (going from top left to bottom right) ranging from 1 to 5µm in 0.2µm steps.

**Fig. 6**: Magnification of the whole pattern width 135mm ÷ 7.75mm = 17.2X

**Fig. 7**: Array of squares and rectangles from 1 - 31µm in 1µm steps.

**Fig. 8**: One of 4 identical circular patterns from 2 - 38µ in 2µm steps, and 40 - 100µm in 10µm steps. A particle size distribution should show a flat distribution of either 1 or 4 particles (depending upon the number of patterns).

**Fig. 9**: Array of squares and rectangles from 30 - 75µm in 5µm steps.

**Fig. 10**: Array of squares and rectangles from 70 - 120µm in 10µm steps.

## RETAINERS

The MRS-3 pattern sits on highly stressed quartz, which is easily chipped. We strongly suggest ordering the standard with one of our retainers, or letting us do the mounting on your holder to protect the standard. We can also also modify the MRS-3 to meet your needs. The following retainers and holders are available:

- StMR – 25mm ϕ X 3mm thick with a central hole. Can be used for optical transmitted light and SEM applications. This is our most popular retainer. The MRS-3 is secured with ultra high vacuum compatible silver epoxy.
- 3mm ϕ - modify the MRS-3 to 3mm ϕ X 0.5 mm thick.
- Pin Stub – commonly used StM stubs have a 1/8" pin and ½" top surface.
- Others: Hitachi, VG PHI, special sizes, etc. Please call for your special needs.

## TRACEABILITY

Why should you consider a traceable standard? Beyond the requirements of national and international quality standards, purchasing a CRM (certified reference material) from a national laboratory or a traceable standard from a certifying body (such as Geller MicroAnalytical Laboratory) guarantees dimensions. Most commercially available standards have unknown accuracies. The use of these standards, such as grids and spheres (which may change size under vacuum or are distorted), have called into questions the accuracy of our MRS. In every case it was determined their dimensions were not as represented or there was mis-operation by the user or service engineer calibrating the instrument. The MRS-3 is offered with or without traceability. The non-traceable standard differs only in documentation and cost. Traceability in the X and Y dimensions is established from "masters" that have been directly measured by NPL (National Physics Laboratory), the NIST counterpart in the U.K. and is traceable to NIST. The "Z" dimension (100nm) has been established on MRS "masters" by NIST.

## RECERTIFICATION PROGRAM

We are often asked why the MRS needs re-certification. Under ISO-17025 guidelines your quality department should determine the re-certification interval. They are most familiar with the company's quality requirements as it relates to ISO-9000, QS-9000 or ISO-17025. Re-certification is a common practice for devices such as gage blocks and electronic instruments. Over the years we have found several standards which could not be recertified due to physical damage and excessive contamination. The physical damage is most often caused by optical microscope objectives being drawn across the pattern surface or abuse. In a few cases we have seen electron beam damage and corrosion from storage in a hostile environment. Re-certification insures your standard will perform its proper task and that you will be meeting your quality system guidelines.

## OPERATING PARAMETERS

Optical microscopes can use the MRS-3 in all imaging modes. The antireflective coating greatly reduces scattered light enabling high contrast images to be observed and photographed. Magnifications can be measured directly on viewing CRTs, in reticles mounted within the ocular, or directly on photomicrographs. For instruments with verniers or electronic calipers distance measurements can be verified using a pitch pattern of appropriate size. For electron microscopes use any kV @ <$10^{-7}$A current.

## ASTM E766–98: STANDARD PRACTICE FOR CALIBRATING THE MAG. OF A SCANNING ELECTRON MICROSCOPE

The American Society for Testing and Materials has published the above standard. The copyrighted text is available from ASTM. A convenient way of obtaining E766-98 (or a later version) is online from the ASTM web site at: http://www.astm.org. This excellent standard offers terms, definitions and guidance to calibrate your instrument's magnification. Using the standard you should be able to calibrate to better than 5% precision in the magnification range from 10X to 50,000X. In our opinion, it is reasonable to extend the range to 200,000X using the MRS-4 since there was no standard with 1µm pitch when it was updated in 1998. Another SEM magnification standard is also under preparation by ISO Technical Committee 202 on microbeam analysis. The scope of E766-98 states "This practice covers general procedures necessary for the calibration of magnification of scanning electron microscopes. The relationship between the magnification and indicated magnification is a complicated function of operation conditions. Therefore, this practice must be applied to each set of standard operating conditions to be used." ASTM E766-98 describes several factors for successful calibration. These include what one should consider as a calibration specimen, a procedure for adjusting the SEM settings, how to calculate the magnification accuracy (on the "master" marker, display CRT, digital image and final print) *and* how often it should be calculated, measurement of precision and bias, application of magnification to the measurement of sample detail and an annex on parameters that influence the resultant magnification.

## E1951-98 STANDARD GUIDE FOR CALIBRATING RETICLES AND LIGHT MICROSCOPE MAGNIFICATIONS

This guide covers methods for calculating and calibrating light microscope magnifications, photographic magnifications, video monitor magnifications, grain size comparison reticles, and other measuring reticles. Reflected light microscopes are used to characterize material microstructures. Many materials engineering decisions may be based on qualitative and quantitative analyses of a microstructure. It is essential that microscope magnifications and reticle dimensions be accurate. The calibration using these methods is only as precise as the measuring devices used. It is recommended that the stage micrometer or scale used in the calibration be traceable to the National Institute of Standards and Technology (NIST) or a similar organization.

## ABOUT GELLER MICROANALYTICAL LABORATORY

Geller MicroAnalytical Laboratory, certified to ISO-9001 and 17025, offers several unique products and services to the technical community. We have developed products out of the need to support our analytical services. Our staff takes pride in performing state-of-the-art analyses on difficult specimens and we do our utmost to go beyond just offering analytical data. We interpret the information. As our satisfied repeat clients and publications reveal, we have developed several unique techniques for problem solving. Rest assured we will maintain your confidentiality with the utmost care as our small, but capable company, concentrates on providing you with answers. Call us.

**PRODUCTS:**

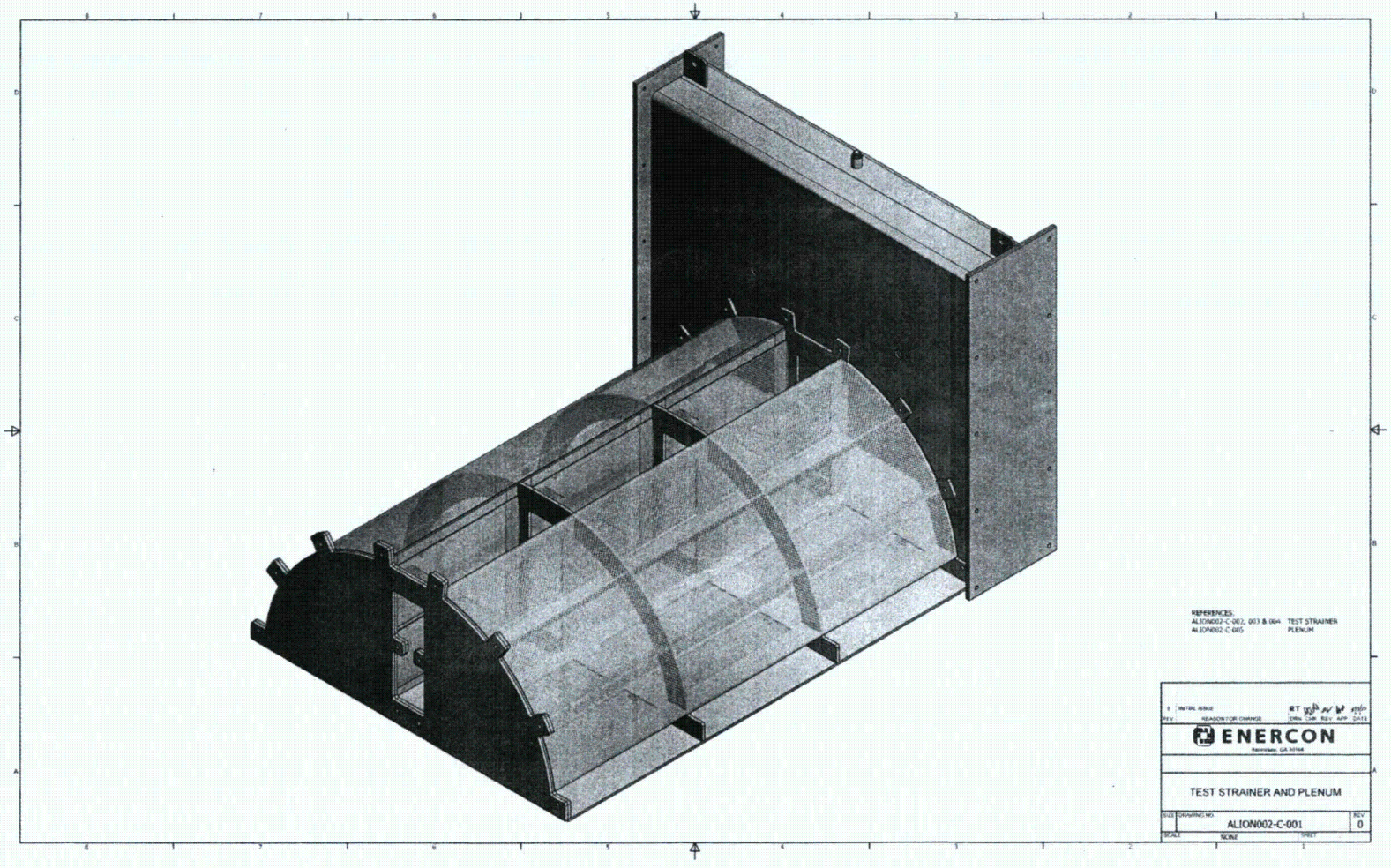
- UHV-RL: Chemical standards for microanalysis
- Ion Sputtering Standards: for ion sputter rate
- SEM digital imaging
- Electron probe automation
- Motorized stage control
- Energy dispersive x-ray calibration (traceable)

**ANALYTICAL SERVICES:**

- Electron probe microanalysis (wavelength x ray), JEOL JXA 8600
- Surface analysis (Auger), JEOL JAMP-7800
- Scanning electron microscopy, JEOL JSM-840
- Profilometry, Metallography, Microhardness
- Metallurgical failure analysis

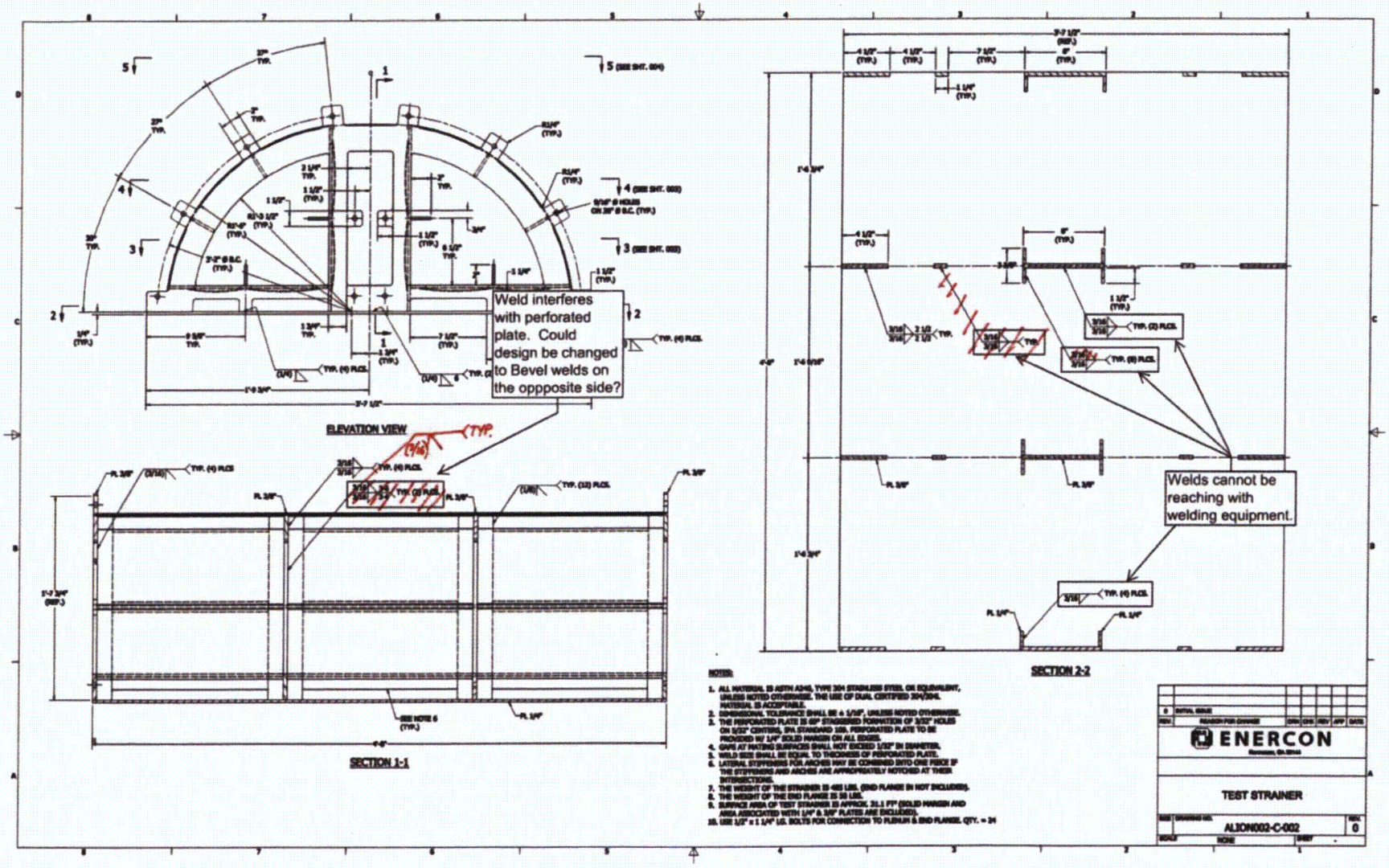
# ATTACHMENT P

## Enercon Strainer Specifications



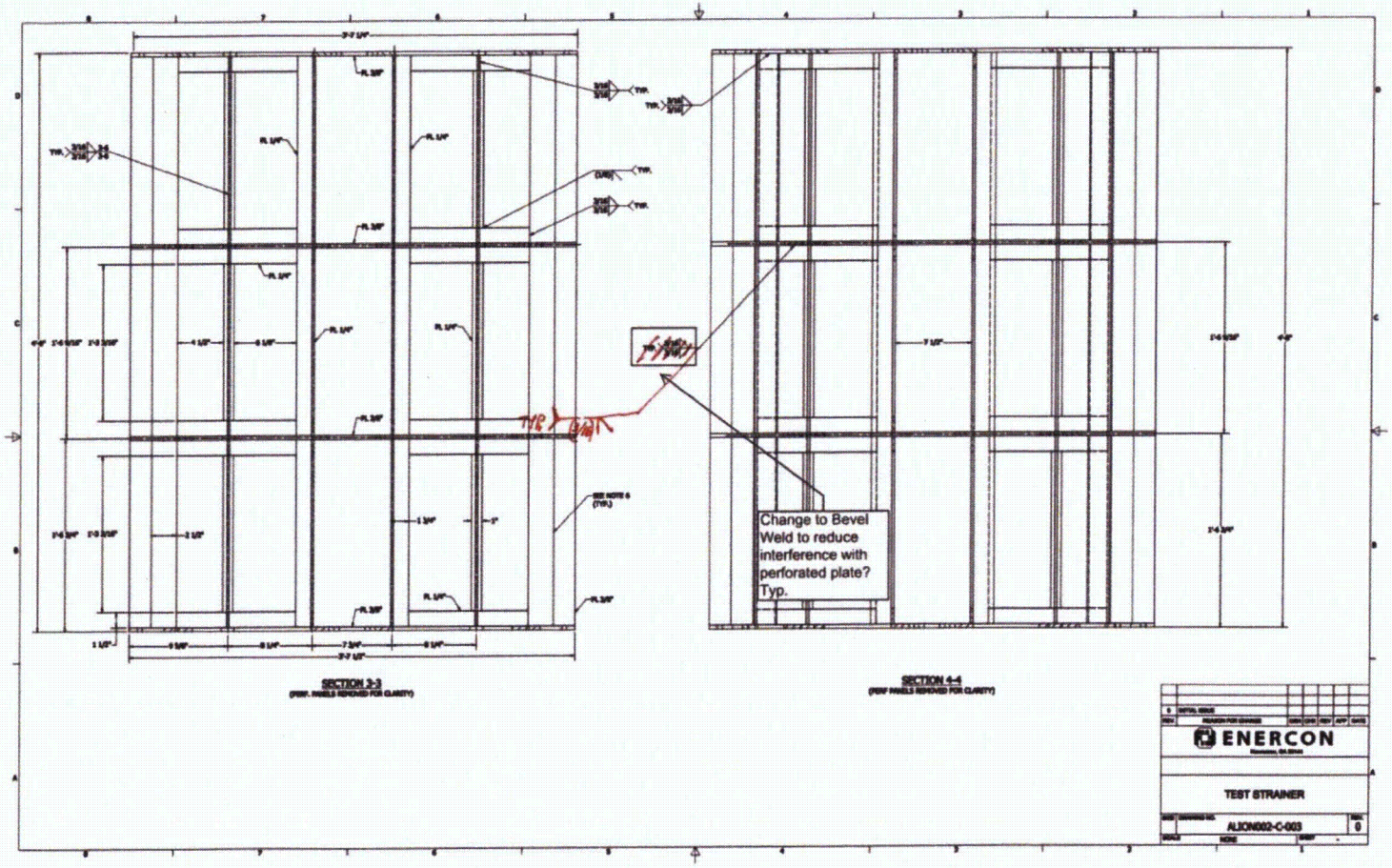

BWROG Report – GEH Class I

| ALION SCIENCE AND TECHNOLOGY | BWROG ECCS Strainer Bypass Test Report | | |
|---|---|---|---|
| | Document No: BWROG-ECCS-TA13-004 | Revision: 1 | Page: P-3 of P-6 |



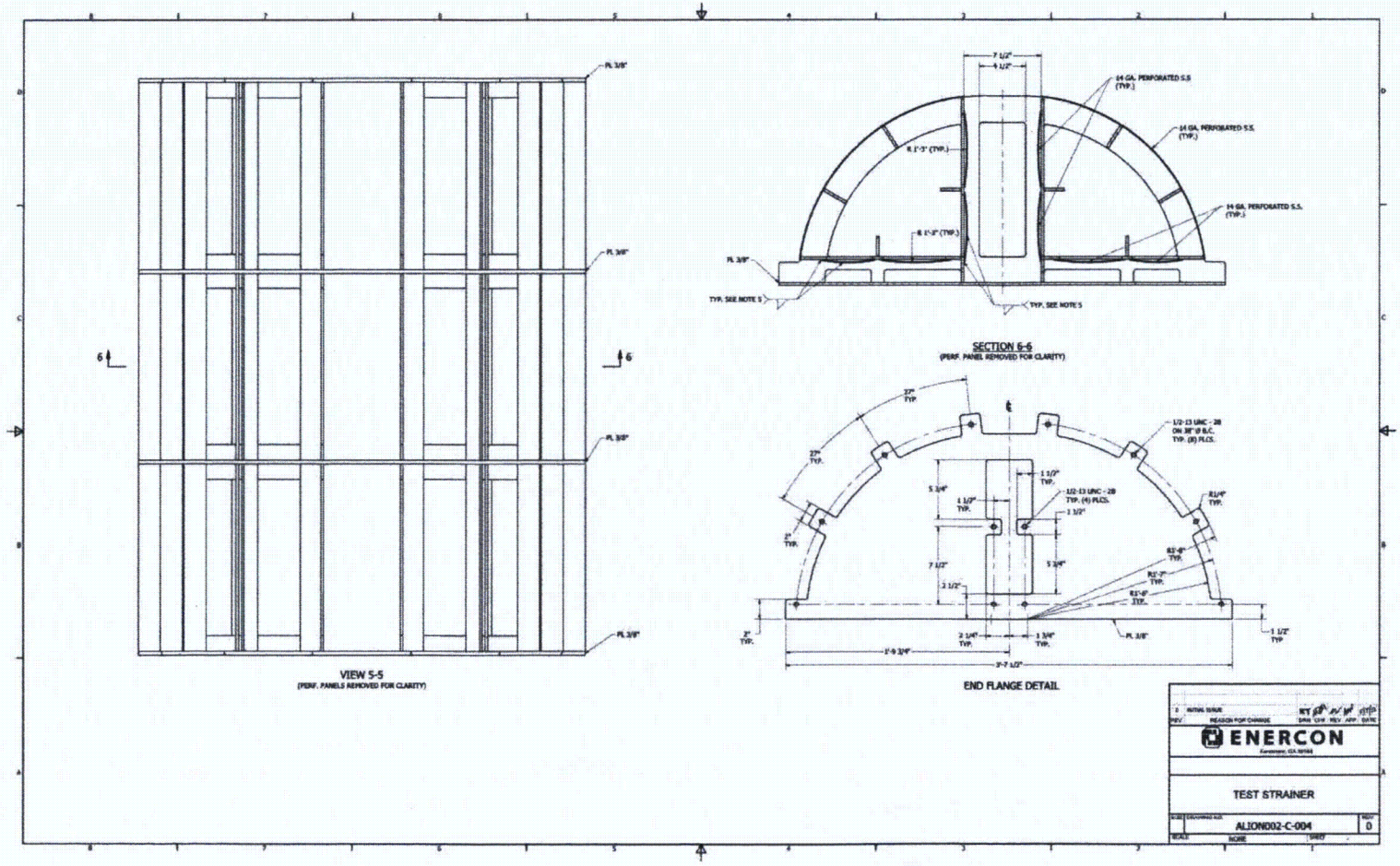

BWROG Report – GEH Class I

| ALION SCIENCE AND TECHNOLOGY | BWROG ECCS Strainer Bypass Test Report | | |
|---|---|---|---|
| | Document No: BWROG-ECCS-TA13-004 | Revision: 1 | Page: P-4 of P-6 |



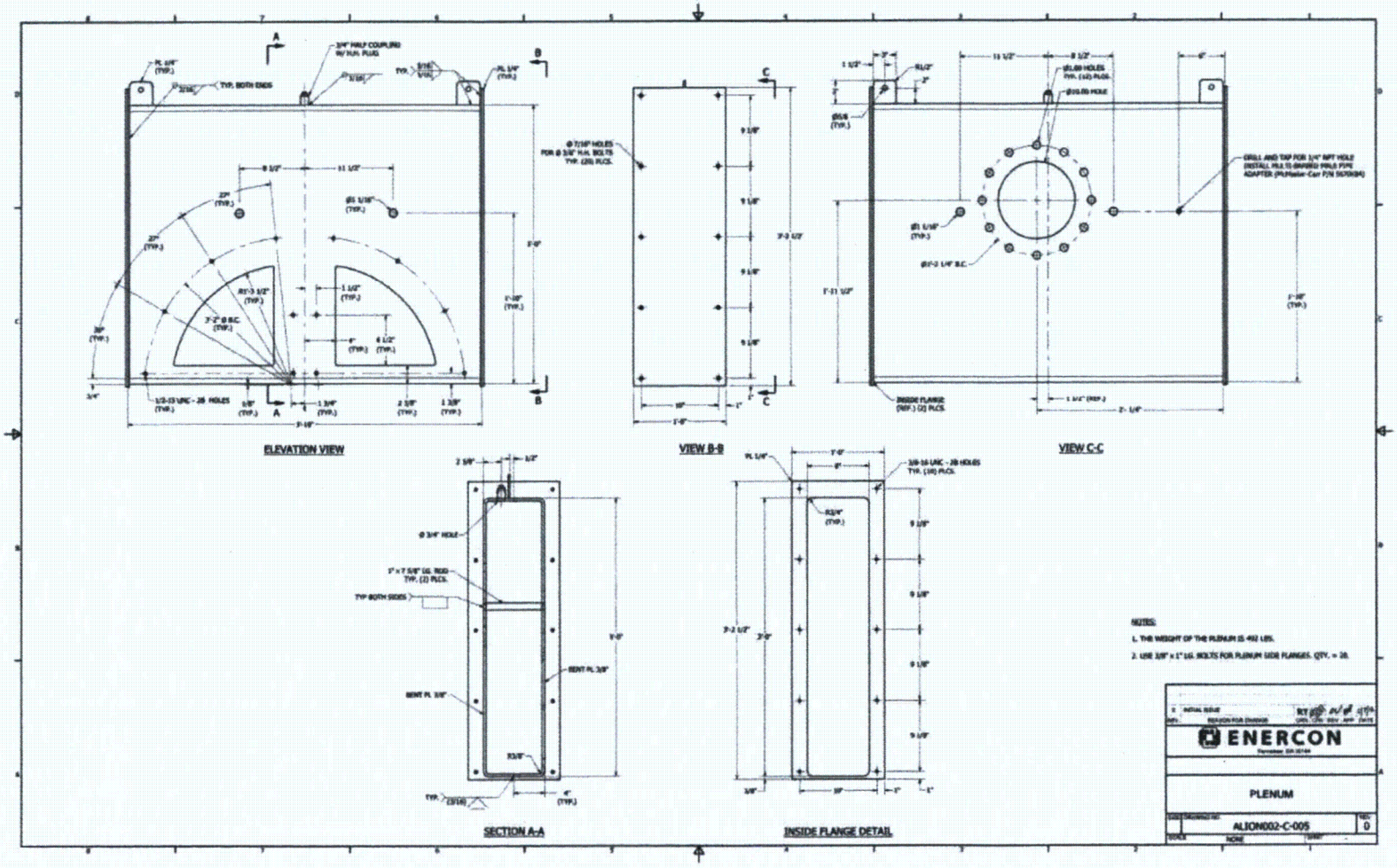

BWROG Report – GEH Class I

| ALION SCIENCE AND TECHNOLOGY | BWROG ECCS Strainer Bypass Test Report | | |
|---|---|---|---|
| | Document No: BWROG-ECCS-TA13-004 | Revision: 1 | Page: P-5 of P-6 |




BWROG Report – GEH Class I

| ALION SCIENCE AND TECHNOLOGY | BWROG ECCS Strainer Bypass Test Report | | |
|---|---|---|---|
| | Document No: BWROG-ECCS-TA13-004 | Revision: 1 | Page: P-6 of P-6 |




BWROG Report – GEH Class I

# ATTACHMENT Q

## Scope Change Request and Emails Approval

ALION
SCIENCE AND TECHNOLOGY

Aligned with your needs.

August 19, 2011

Robert Whelan
BWROG Project Manager
GE Hitachi Nuclear Energy
3901 Castle Hayne Road
M/C F-12
Wilmington, NC 28402

Subject: Engineering Services for BWROG ECCS Suction Strainer Committee
Scope Change Request - Strainer Source Term Bypass Testing Proposal

Reference:
1) GEH Purchase Order 437053311, 1 dated March 22, 2011.
2) BWROG-ECCS-TA13-001, *BWROG ECCS Strainer Bypass Testing Specification*, Revision 0.
3) BWROG-ECCS-TA13-002, *BWROG ECCS Strainer Bypass Test Plan*, Revision 2

Dear Mr. Whelan:

Alion Science and Technology Corporation (Alion) is pleased to submit this scope change to GEH to provide assistance with developing the debris loading downstream of the ECCS strainers for fuel blockage testing and downstream effects on components evaluation. The current scope of work under the reference (1) purchase order allowed for the completion of a Bypass Test Specification (2) and Test Plan (3) and stopped short of test implementation until the detailed requirements of the program were adequately defined. At this time Alion is requesting a scope change to include the implementation of the reference (3) test plan, including the bypass testing and test reporting.

As part of the current BWROG investigation into BWR ECCS strainer post-LOCA operation, it is necessary to characterize and quantify the debris that is able to pass through the ECCS strainer and possibly affect downstream component operation. Due to the complex nature of LOCA-generated debris migration through the structure of an ECCS strainer, the quantity and composition of downstream debris is best developed experimentally with BWR-specific debris bypass testing.

For PWR downstream analysis, bypassed debris has been grouped into two categories: fibrous insulation and particulate debris. Due to the small particle size assumed for most PWR coating debris (10 micron), and the requirement that all possible debris combinations must be considered for each accident scenario including one of insufficient fiber to cover the screen, PWR bypass evaluations assume 100% particulate bypass. This assumption may not apply to the larger particle

sizes present in a BWR suppression pool, and this will be taken into account when determining BWR particulate bypass.

PWR fibrous insulation bypass has typically been measured using two different fiber collection methodologies: 100% downstream capture using filter bags in the recirculation loop and flow stream sampling. Due to the characteristic initial burst of bypassed material that occurs within moments of the first debris reaching the strainer, 100% downstream capture is the preferred method to ensure that bypass is measured accurately and conservatively, since downstream liquid sampling can miss transient high-bypass periods and result in non-conservative bypass prediction.

When measuring debris bypass, it is important that the conditions of the debris bypass test are controlled to conservatively maximize debris migration through the strainer within the parameters of strainer operation. It's important to note that test conditions that maximize debris bypass can be different than the conditions required to maximize strainer head loss, so the use of debris bypass data obtained during head loss testing is potentially non-conservative and not useful for bypass evaluation.

Using a carefully designed matrix of test parameters to represent the entire population of BWR ECCS strainers, a single test program would be able to generate the data needed to accurately and conservatively predict the fibrous debris bypass for the entire BWR fleet. This approach is highly desirable as compared to the multi-vendor approach taken for US PWRs, because it will allow a well thought out, uniform solution with no variation between test methodologies, debris preparation, assumptions, or analysis between vendors. Perhaps most importantly, a unified approach is the preferred method to quickly gain regulatory acceptance.

## ***SCOPE OF WORK***

The scope of work presented in this scope change proposal is to implement the test specification (2) and test plan (3). The results of the bypass testing will be documented in a test report.

### *Task 1- Selection of Prototype Strainer Test Articles*

The test specification and test plan identify the requirements of the prototype test strainers to be used for the bypass testing. These test strainers will be obtained or procured from the original equipment manufacturers (OEMs). Alion will attempt to obtain existing prototype strainers to keep costs as low as possible and meet the testing schedule; however, should prototypes not be currently available, the vendors may need to fabricate prototypes for this testing program. The lead time for these strainers could impact the cost and schedule.

### *Task 2 - Fiber Bypass Testing*

Alion will perform the bypass testing in accordance with the test specification (2) and test plan (3). Specifically, Alion will implement the series of test called out in the test plan. It should be noted that the test plan assumes that bypass is not dependent on several variables and has proposed tests to confirm this assumption. Should we find that bypass is dependent on any one

of these variables and additional tests are required, Alion will submit a project change request and additional budget/scope/schedule may be needed.

**Test Description**

The test objective is to quantify and characterize the fibrous insulation debris that would bypass the BWROG plants' ECCS suction strainers during the ECCS response timeline. A series of eleven (11) tests will be structured to obtain data that can be used to determine the quantity of expected bypass fibrous debris with respect to known plant design and operating parameters. The proposed tests are intended to provide plots of bypass fiber quantity relative to the quantity of fiber added to each test. The results can be used to establish and trend relationships between bypass quantity and the variable conditions of pool concentration, approach velocity, fiber type and strainer design (including hole size). Actual plant conditions can be used in conjunction with the available plots to determine a prototypical or conservative bypass quantity.

The technical approach requires that fibrous debris be added into the test tank and allowed to transport to a prototypical test strainer. For each test, debris additions will be cumulative to facilitate the formation of a debris bed on the strainer. Each incremental addition will contribute to the debris bed thickness. Any fiber that bypasses the strainer (bypass fiber) shall be collected in a downstream filter system. Throughout the testing, filters must be changed after debris additions to determine the incremental effect of debris loading on bypass quantity. The filter system is configured with multiple elements in parallel to allow undisturbed flow through the strainer as flow is diverted between the filters. The filter bags shall be processed and analyzed to measure and characterize the fiber bypass.

**Test Plan**

The BWROG has provided specific inputs relevant to their individual strainer designs and ECCS operation. Using this information, Alion has prepared a test plan (3) to detail the test conditions. Alion will follow the currently approved test plan for the performance of the test.

**Test Apparatus Layout**

The testing will be performed at Alion's facilities in Warrenville, IL. Our test tank allows the measurement and control of flow rate. Differential pressure across the strainer, differential pressure across the filter bags, and downstream water turbidity can be measured in real-time. The data acquisition system is comprised of National Instruments FieldPoint hardware and LabVIEW software. The water downstream of the strainer is passed through the filters before being injected into the tank via a sparger system, which aids in debris suspension. Mixing motors provide the turbulence to simulate blowdown, condensation oscillations and chugging, and to keep the debris suspended in the pool after the high energy phase.

**Test Sequence**

The test tank shall be thoroughly cleaned prior to each test. The appropriate hardware (suction strainer prototype, plenum, sparger, etc.) shall be installed, and the tank shall be filled with potable tap water to the specified level for a nominal 2500 gallons. This volume is selected to facilitate laboratory equipment capacity and provide the desired relationships between debris volume and test pool volume.

At the appropriate flow rate and turbulence, a measured amount of fiber debris shall be added at a specific introduction rate per the test matrix. The debris will be allowed to reach the strainer via turbulence and approach velocities for a given amount of time as defined by the number of pool turnovers at the specified flow rate. All water passing through the strainer shall be filtered by filter bags that have been pre-dried to ensure accurate weights are obtained.

After all debris has been added in accordance with the test matrix and the required number of pool turnovers has been achieved, the filters are valved out and the filter bags are removed. (Note that this step may occur on occasions earlier than the test end for sake of capturing filter bypass trends vs. time.) The used filter bags are put into an oven and allowed to dry. Each is weighed multiple times until the weight remains stable at the baseline oven temperature.

***Task 3 - Downstream Debris Characterization***

Under this task, Alion will characterize the sizes of the bypass debris from the filters obtained from the Task 2 testing using optical magnification, and/or Scanning Electron Microscopy (SEM), as necessary, to measure the length of the fibrous debris that was collected.

Fiber will be collected from filter bags used in 4 of the tests, representing each of the two holes sizes, and multiple types of fiber. From each test, fiber samples will be collected from the filter bags used to collect the bypassed material. A characterization report will be prepared to determine lengths of fiber that bypass the screens.

## ***DELIVERABLES***

***Bypass Test Report***

The deliverable for scope of work is a safety-related bypass quantity test report documenting the test objectives, test plan, procedures, test data and results. The test report will provide graphical representations of the bypass fiber quantities measured with respect to the incremental fiber quantities added to the test under each set of conditions identified in the test plan. The test will report will also document the size distribution of the fiber collected from each of four tests selected to represent bypass fiber characteristics (See Assumption 2 below).

## ***SCHEDULE***

Currently, the design requirements of the test prototypes are being discussed with multiple vendors to obtain the required test articles. It is anticipated that the actual testing will require nine weeks after receipt of the prototypes. The draft bypass quantity test report will be issued two (2) weeks after the termination of the testing. The final reports will be provided one (1) week after formal comments have been received.

The schedule is proposed as follows:

| Activity | Start Date | Finish date |
|---|---|---|
| Procurement of Strainer Prototypes | 8/14/2011 | 9/21/2011 |
| Alion to install hardware in test tank | 9/5/2011 | 9/28/2011 |
| Alion to perform 11 Bypass Tests as described in BWROG-ECCS-RA13-002, BWROG Downstream Effects Bypass Test Plan | 9/22/2011 | 11/28/2011 |
| Alion to prepare draft bypass quantity test report and submit to BWROG for comments | 11/15/2011 | 12/12/2011 |
| BWROG to review draft bypass quantity test report and submit comments to Alion | 12/13/2011 | 12/26/2011 |
| Alion to incorporate BWROG comments on draft bypass quantity test report and submit final bypass quantity test report (deliverable). | 12/27/2011 | 1/02/2012 |

***ASSUMPTIONS/CLARIFICATIONS***

1. This scope includes 11 tests performed to collect bypass test data as provided in the test plan.

2. This scope includes a maximum of four (4) bypass characterization examinations. Bypass fiber will collected and examined from one Nukon test with a 1/8" hole strainer, one Temp-Mat test with a 1/8" hole strainer, one Rockwool test with a 1/8" hole strainer, and one Nukon test with a 3/32" hole strainer.

3. The bypass testing will be performed using prototype test strainers specified in the test plan. The test series assumes that three strainers will be provided to Alion. Two GE (or equivalent complex geometry) strainers will be provided, one with 1/8" holes and one with 3/32" holes. Additionally, one Enercon (or equivalent simple geometry) strainer will be provided with 3/32" holes.

4. The tests are designed to measure bypass quantity over a representative range of conditions. All plant conditions and all strainer designs are not being tested. The measurements will illustrate the specific attributes such as hole size, pool concentration, strainer design, etc., that have an impact on bypass quantity. It should be recognized that if results show that multiple attributes each have a significant effect on the bypass quantity, then additional tests will be required. The number of additional tests will be dependent upon the number of individual attributes that are shown to impact bypass quantity. Additional tests are out of scope.

5. All testing is performed with commercially available insulation utilizing standard debris preparation practices, (e.g. shredding, soaking, boiling, etc) as outlined in the Test Plan. Vendor MSDS or specs will be provided and attached to the test report for future identification.

6. Alion will incorporate a single round of comments on each deliverable from the BWROG ECCS Strainer Committee. Alion requests that the comments on each deliverable are to be provided within 2 weeks of issuance of the draft document. All comments shall be formally transmitted. Addressing of such comments and submission of final deliverables shall constitute acceptance by the BWROG ECCS Strainer Committee.

***QUALITY ASSURANCE***

The scope of work defined in this proposal will be accomplished in accordance with the Alion-ITS Operation Quality Assurance Program Manual and Quality Assurance Procedures, which meets the requirements of 10 CFR 50 Appendix B, 10 CFR Part 21 and ASME NQA-1 1989.

***PRICING***

***TERMS AND CONDITIONS***

This work will be governed by the MSA (US MSA Template 6.30.08) between GE Hitachi and Alion Science and Technology with an effective date of January 1st 2009.

We look forward to getting started as soon as possible and supporting the BWROG. If you have any questions or require additional information please contact me at (630) 846-6787 any time.

Sincerely,

Robert Choromokos
Project Manager

cc: J. Nuehoff
C. Garves

**SECTION 2 – COST AND COMMERCIAL TERMS**

**2.1 OFFER**

**2.1.1 PRICING, INVOICING, AND PAYMENT TERMS**

Alion proposes performing this work for the firm fixed price of $KKK

Alion proposes the following invoicing and payment schedule:

| Milestone | |
|---|---|
| 20% | Notification of Award |
| 20% | Draft Submittal of Test Plan |
| 30% | Completion of Bypass Testing |
| 20% | Draft Submittal of Test Report and Debris Characterization Report |
| 10% | Final Submittal of Deliverables |

**Poska, Jeffrey J**

**From:** Whelan, Robert (GE Power & Water) <Robert.Whelan@ge.com>
**Sent:** Friday, August 26, 2011 9:24 AM
**To:** Rob Choromokos
**Cc:** Poska, Jeffrey J; Ed.Asbury@ge.com
**Subject:** RE: BWR Bypass Test Strainer Proposal Rev 0

Rob—I agree with this procurement. Thanks for making this happen. Rob

**From:** Rob Choromokos [mailto:rchoromokos@live.com]
**Sent:** Thursday, August 25, 2011 6:21 PM
**To:** Whelan, Robert (GE Power & Water)
**Cc:** 'Poska, Jeffrey J'
**Subject:** FW: BWR Bypass Test Strainer Proposal Rev 0

Rob,

Attached is a proposal for 2 strainers from PCI for the Bypass Testing. The price is very reasonable and they are committed to the schedule. I know it was not essential that we obtain PCI strainers given that we have a GEH stacked disk strainer available for testing. However, given the reluctance on GEH's part to participate in this testing program I would like to move forward with the purchase of the PCI strainers as 1) a contingency plan to ensure schedule and any technical issues GEH may have and 2) provide a larger data set for our correlation.

I would like to authorize Jim to proceed. Can you confirm that you agree with this procurement for our bypass testing program?

Thanks,

Robc

**From:** "Jim Bleigh" <Jim.Bleigh@pcg.com>
**Date:** August 25, 2011 7:56:59 AM GMT+08:00
**To:** "Poska, Jeffrey J" <jposka@alionscience.com>
**Cc:** "Choromokos, Robert " <rchoromokos@alionscience.com>, "Bockewitz, Luke D" <lbockewitz@alionscience.com>, "Patrick Reyes" <Patrick.Reyes@pcg.com>, "Pat Coleman" <Pat.Coleman@pcg.com>, "Eric Cox" <Eric.Cox@pcg.com>
**Subject: BWR Bypass Test Strainer Proposal Rev 0**

Jeff.

Please find below our proposal to supply Alion Sure-Flow Strainer test strainer(s) for your use in tests planned for the BWROG.

Pricing: Pricing is $[redacted]; plus any applicable sales taxes. UPS Air Freight is allowed. Payment is due 30 days following shipment of the components.

Schedule: Our pricing is based on shipping the test strainers on September 9 for delivery on or before Sept 12.

Scope of Work: The ~23 $ft^2$ test strainer components are defined herein as follows:

- One 10" NPS pipe flange welded to one core tube body that can receive either the 3/32" Φ disks and gaps, or, the 1/8" Φ disks and gaps
- 3 disks at 2" wide and 2 gap rims at 2" wide; using perforated plate with 3/32" Φ holes
- 3 disks at 2" wide and 2 gap rims at 2" wide; using perforated plate with 1/8" Φ holes
- Accessories as required to assemble the test strainer multiple times
- Disks are a nominal 26" Φ; gap rims are a nominal 12.5" Φ
- A drawing will be provided to confirm all test strainer comonent's configuration. Our intent is to have all disks and gaps be removable for cleaning and change outs. Regarding multiple core tubes for different flow rates: our hydraulic engineer does not believe different core tubes will be required for a 3 disk configuration; however, please confirm the range of flow rates you anticipate to subject this test strainer to so we can confirm this is the case.

QA: To meet this schedule deadline, not all materials are in stock and received under our QA program; so, some materials will be procured non QA to expedite the order. The "configuration" of the strainer will be inspected to meet all dimensions; and, the perf plate will be inspected to confirm its configuration. As a test strainer, this should be adequate for your use in QA tests; but, I wanted to be clear on this issue. If you need the test strainer and all materials of construction to be in accord with our QA program; tell me now as it will affect the price and schedule. Also note, we are proposing herein to use carbon steel fittings to lessen the likelihood of galling the threads in the multiple assembly and dis-assembly of components anticipated.

One last request, is, I would like P.J. Reyes to witness some if not all of this testing so we know how our strainer is performing, and how it was tested. There is no charge for this witness; we simply feel we need to understand how our product is being tested and how well it performed.

If you have questions or issues with this proposal; please let me know.

**Best regards,**

*James M. Bleigh*

Engineered Systems Manager

Performance Contracting, Inc.

16047 West 110th Street

Lenexa, KS 66219

Phone: 913-928-2801 / Fax 913 928-2901

Cell: 913-707-5407

# ATTACHMENT R

## Testing Anomalies

| ALION SCIENCE AND TECHNOLOGY | **CORRECTIVE ACTION REPORT** | Number CAR # 2011-22 |
|---|---|---|

| **INITIATOR** | Name: J. Poska | Signature: Jeff Poska | Date: 11-16-11 |
|---|---|---|---|

**Requirement:** Strainers used for testing shall meet requirements of test procedure.

**Statement of Problem:** Contrary to the above requirement, after tank cleaning was performed as required by ALION-SPP-BWROG-7337-0C2, it was observed that the strainer installed had the incorrect perforation size for performing the prescribed test. ALION-SPP-BWROG-7337-0C2 requires the test to be performed using a test article with 1/8" perforations. The installed test article had 3/32" perforations.

| **Division Manager** | Name: Bill Closser | Signature: | Accept ☒ | Reject ☐ |
|---|---|---|---|---|

**Significant Condition Adverse to Quality:**

1. Potentially Reportable under 10CFR Part 21? Yes ☐ No ☒
2. Significant degradation of or challenge to nuclear, plant or public safety? Yes ☐ No ☒
3. Significant breakdown in quality program or adverse trend? Yes ☐ No ☒

**Comment:**
During this pre-test cleaning it was noticed that the wrong screen was installed for the test. The only distinguishing characteristics of the screen differences are 1/8" diameter vs. 3/32" diameter holes. This does not represent any safety concern or procedural non-compliance and if left unnoticed would have invalidated the results. It's fortunate that it was caught and in light of this, a step will be added to the procedure requiring the validation of the hole size to ensure the correct strainer is installed for the test.

| **Corrective Action Assigned To:** | Name: Jeff Poska | Date: 11-16-11 |
|---|---|---|

Kirit Parikh TKP 4/8/13

| **QA Review** | QA Manager: ~~R. William Scier~~ Signature: K. Vijeniel | Date: 4/8/13 |
|---|---|---|
| **10CFR21 Reportable?** | Yes ☐ | No ☐ |
| **Justification:** * This CAR has been rejected by Kirit Parikh 4/8/13 | | |

| **Corrective Action Plan** | *To be completed by the individual assigned corrective action* | *All tasks **shall** have a scheduled completion date* |
|---|---|---|
| Corrective Action Tasks: | | **Date** |
| 1. Remove and install correct strainer | | 11/16/2011 |
| 2. Revise procedure to add verification step | | 11/16/2011 |
| 3. | | |

| **Division Manager Approval** | Signature: | Date: |
|---|---|---|
| **QA Manager Approval** | Signature: | Date: |

**Status of Corrective Actions Taken and Completion Dates:** *(Should correlate with the above Plan)*

Strainer removed and correct strainer installed — Jeff Poska / 11-16-11

Procedure revised to add verification step. — Jeff Poska / 11-16-11

| ALION SCIENCE AND TECHNOLOGY | **CORRECTIVE ACTION REPORT** | Number CAR # 2011-22 |
|---|---|---|

**Root Cause Analysis/Cause of Condition**

Not Required.

**Actions to Prevent Recurrence**

ALION-SPP-BWROG-7337-0C2 has been revised to include a signature step to physically measure the size of the perforation on the installed test article prior to testing.

| **Corrective Action Complete:** | Signature: Jeff Poska | Date: 11-16-11 |
|---|---|---|

| **CONCURRENCE AND CLOSURE** | | | |
|---|---|---|---|
| **Division Manager's Concurrence** | Name: Bill Closser | Signature: | Date: |
| **QA Manager's Concurrence & Closure** | Name: R. William Seier | Signature: | Date: |
| **Client Notification (if required)** | Name: | Signature: | Date: |

**Failure Code** *(To be completed by the QA Manager using the Failure Codes in QAP 18.1)*

Justification :- This car should not have been initiated. Correction was performed on the same day. Project specific procedure was updated to make sure this situation does not happen in future.

K. V. Smith
4/8/13

| ALION SCIENCE AND TECHNOLOGY | Testing Discrepancies | | |
|---|---|---|---|
| | Document No.: ALION SPP-LAB-2352-14 | Revision: 3 | Page A1 of A1 |

**ATTACHMENT A**
**TESTING DISCREPANCY FORM**
**(QA Form 15.1.1—Nonconformance—for Lab use)**

**Initiation: (refer to Section 3.1)**

| | | |
|---|---|---|
| Date: 12-22-2011 | Time: 17:30 | Test #/Designator: C1 |
| Test SPP #/Rev: ALION-SPP-BWROG-7337-0C1 | | Title: Bypass Test C1 Procedure |
| Test Plan #/Rev: BWROG-ECCS-TA13-002 | | Title: BWROG Downstream Effects Bypass Test Plan |
| Project #: 7337-007 | | Project Name: GEH: BWROG ECCS Suction Strainer Committee Project Technical Support |

Description of Discrepancy:
During a valve change for step C1.17 the valves for the filter housing were accidently shut. This closed the flow path for an istant until they were opened again. Flow dropped to 200 gpm for a few seconds and head loss dropped to about 0.1 ft-$H_2O$. Flow and head loss returned to normal after the vavles were reopened. A small 6" by 2" area on the screen also opened up during this event but this opening quickly filled again.

☐ Photos or other documents attached?

| Name: Frank Biank | Position: Test Engineer | Signature: Frank Biank |
|---|---|---|

**Disposition: (refer to Section 3.2)**

Action(s): ☒ Continue Testing ☐ Hold Testing ☐ Stop Testing

Justification:
Flow and Head loss returned to normal. The time the flow path was shut only occurred for a few seconds. The open screen area was relatively small and quickly filled with a thin bed. Any changes in bypass can be measure by the change in bypass trend between the filter bags as seen before and after the event.

Additional Actions:

| | | Scheduled Completion Date |
|---|---|---|
| ☒ | Resume Testing based on justification above, with no additional requirements. | |
| ☐ | Process ECR # | |
| ☐ | Revise Test Plan/Procedure: | |
| ☐ | Provide training/retraining before proceeding | |
| ☐ | Other: | |

The information provided above is complete/satisfactory, and concurrence is granted for the Action(s) indicated:

| Name: JEFF POSKA | Position: LAB MGR. | Signature: | Date: 1/6/12 |
|---|---|---|---|

If Concurrence is provided by phone or other means, record the following information:

| Concurrence: | | |
|---|---|---|
| | Provided By (print name): | Jeff Poska |
| | Time/Date: | 18:00 |
| | Recorded By (print name): | Frank Biank |

**PM Acceptance: (prior to formal release of test data, refer to Section 3.3)**

Action(s):

☒ Acceptable as is. SEE ATTACHED EVALUATION - "VALVE MANIPULATION / TESTING DISCREPANCY"
☐ Acceptable as discussed in
☐ Other:

Scheduled Closure Date

Nonconformance Valid? ☐ No ☒ Yes **NCR #:** 2012-24 — 10/17/12

CAR Required? ☒ No ☐ Yes **CAR #:**

| Name: JEFF POSKA (ACTING PM) | Signature: | Date: 10/17/12 |
|---|---|---|

**QA Manager Closeout: (prior to formal release of test data, refer to Section 3.3)**

| Name: R C CUTSHAW | Signature: | Date: 10/17/12 |
|---|---|---|

Valve Manipulation Testing Discrepancy

While changing valves to bring filter housings online, the flow path was momentarily restricted. This happened during Step 294 of procedure ALION-SPP-BWROG-7337-0C1. The flow was observed to drop to approximately 200 gpm, down from the 412 gpm nominal test flow rate. During this time, the test engineer did note that strainer head loss dropped from approximately 0.28 ft-$H_2O$ to 0.15 ft-$H_2O$. Immediately upon recognizing the filter housing valve's settings, the valves were set to their correct positions and the flow rate and head loss returned to their previous levels. The test engineer noted that a section of bed approximately 6" x 2" in area opened up but quickly reformed once the valve positions were corrected.

The below figure displays the accumulation of fiber for each debris addition with the discrepancy noted. Table 1 shows an excerpt of the bypass fiber results. The discrepancy occurred at the 0.289 inch theoretical bed thickness and caused a slight increase in fiber bypass (1.46 grams) as compared to the preceding (0.52 grams) and proceeding (0.68 grams) fiber quantities. This increase is expected to have occurred as a result of the momentary 6" x 2" opening in the fiber bed. It should be noted that the increase in fiber bypass is less than 1% of the total accumulated fiber up to that point (195.74 grams), and would yield a slightly conservative result.

Per 'Section 5.0 – Discrepancies during Testing' of the Bypass Test C1 Procedure, a test coordinator was notified of the discrepancy and the test proceeded upon their approval.

**Figure 1 – Accumulated Fiber**

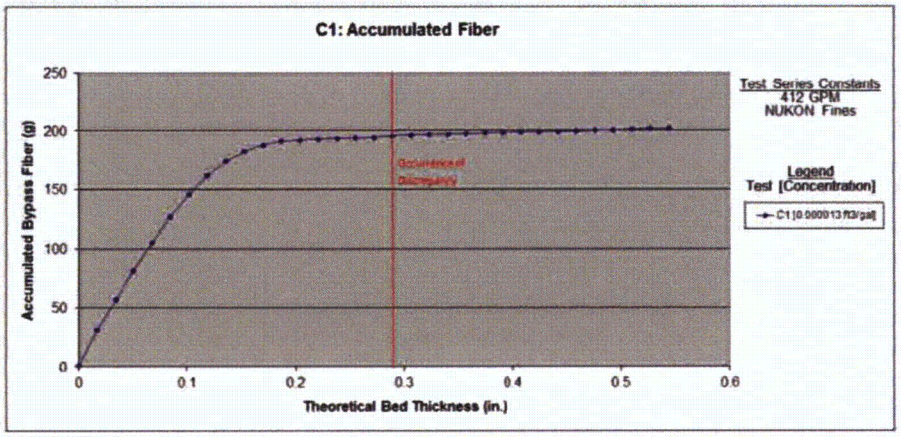


**Table 1 - Bypass Results**

| Test C1 | | |
|---|---|---|
| Theoretical Bed Thickness (in) | Recovered Fiber (g) | Accumulated Fiber (g) |
| 0.017 | 30.08 | 30.87 |
| 0.034 | 25.30 | 56.17 |
| 0.05 | 25.08 | 81.25 |
| 0.07 | 23.67 | 104.92 |
| 0.09 | 22.26 | 127.18 |
| 0.10 | 18.63 | 145.81 |
| 0.12 | 16.17 | 161.98 |
| 0.136 | 11.96 | 173.94 |
| 0.153 | 8.46 | 182.4 |
| 0.17 | 5.32 | 187.72 |
| 0.187 | 3.12 | 190.84 |
| 0.204 | 1.18 | 192.02 |
| 0.221 | 0.80 | 192.82 |
| 0.238 | 0.57 | 193.39 |
| 0.255 | 0.37 | 193.76 |
| 0.272 | 0.52 | 194.28 |
| 0.289 | 1.46 | 195.74 |
| 0.306 | 0.68 | 196.42 |
| 0.323 | 0.19 | 196.61 |
| 0.34 | 0.50 | 197.11 |
| 0.357 | 0.56 | 197.67 |
| 0.374 | 0.54 | 198.21 |
| 0.391 | 0.38 | 198.59 |
| 0.408 | 0.19 | 198.78 |
| 0.425 | 0.33 | 199.11 |
| 0.442 | 0.12 | 199.23 |
| 0.459 | 0.54 | 199.77 |
| 0.476 | 0.48 | 200.25 |
| 0.493 | 0.38 | 200.63 |
| 0.51 | 0.52 | 201.15 |
| 0.527 | 0.44 | 201.59 |
| 0.544 | 0.08 | 201.67 |

To summarize, the discrepancy did not significantly affect the results of the C1 Bypass test for the following reasons:

- Flow rate and head loss returned to previous levels after correcting the valve positions.
- The increase in fiber bypass corresponding to the valve misalignment was less than 1% of the total accumulated fiber.
- The slight increase in fiber associated with the fiber addition is conservative.

Because of these points, the results for the BWROG C1 Bypass Test are valid for use in evaluating the results of test C1.