


BWROG Report – GEH Class I

	BWROG ECCS Strainer Bypass Test Report		
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	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)	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

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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)	I 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	402.3	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

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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)	I 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

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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)	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

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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)	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	2042.1	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

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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)	I 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

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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)	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

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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)	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	1553.1	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

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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)	I 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

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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)	I 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

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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)	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

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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
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

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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)	I 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

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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)	I Pixel (µm)	Grid Adjusted Length (µm)	Length Category
sl_m01	10	235.2	131.6	160.2								527.0	2.049	1079.9	1000-1500
sl_m02	1	306.2	268.8									575.0	2.049	1178.3	1000-1500
sl_m02	2	536.1										536.1	2.049	1098.6	1000-1500
sl_m02	3	98.2										98.2	2.049	201.2	<500
sl_m02	4	248.1	266.7									514.8	2.049	1054.9	1000-1500
sl_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
sl_m02	6	192.9										192.9	2.049	395.3	<500
sl_m02	7	351.1	136	274.2								761.3	2.049	1560.1	1500-2000
sl_m02	8	349.2	99.3	30								478.5	2.049	980.5	500-1000
sl_m02	9	115.2	119.6									234.8	2.049	481.2	<500
sl_m03	10	65.8	121.5	105.5	64.8							357.6	2.049	732.8	500-1000
sl_m03	1	225.1	195.3	270.1	238.9	376.5	Off Page					1305.9	2.049	2676.1	>2500
sl_m03	2	100.3	28.4	35.7	36.8	63.7	71	87.3	10			433.2	2.049	887.7	500-1000
sl_m03	3	293.3	414.2	324	260.2	Off Page						1291.7	2.049	2647.0	>2500
sl_m03	4	524.4										524.4	2.049	1074.6	1000-1500
sl_m03	5	239.7	175.5	204.8								620.0	2.049	1270.5	1000-1500
sl_m03	6	143										143.0	2.049	293.0	<500
sl_m03	7	192.5	151.3	184.7	219	264.1	Off Page					1011.6	2.049	2073.0	2000-2500
sl_m03	8	346.3	280.9									627.2	2.049	1285.3	1000-1500
sl_m03	9	145.7										145.7	2.049	298.6	<500
sl_m03	10	215.7										215.7	2.049	442.0	<500
sl_m04	1	287.1	319.6									606.7	2.049	1243.2	1000-1500
sl_m04	2	118	228.8	473.3	180.9	413.2	Off Page					1414.2	2.049	2898.0	>2500

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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)	I 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

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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)	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

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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

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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)	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

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s3_m03	5	444.1	328.9	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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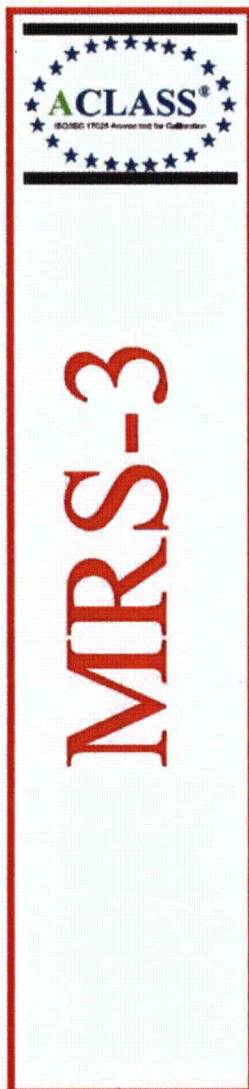
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Image #	#	Segment 1 Length (Pixels)	Segment 2 Length (Pixels)	Segment 3 Length (Pixels)	Segment 4 Length (Pixels)	Segment 5 Length (Pixels)	Segment 6 Length (Pixels)	Segment 7 Length (Pixels)	Segment 8 Length (Pixels)	Segment 9 Length (Pixels)	Segment 10 Length (Pixels)	Total Length (Pixels)	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

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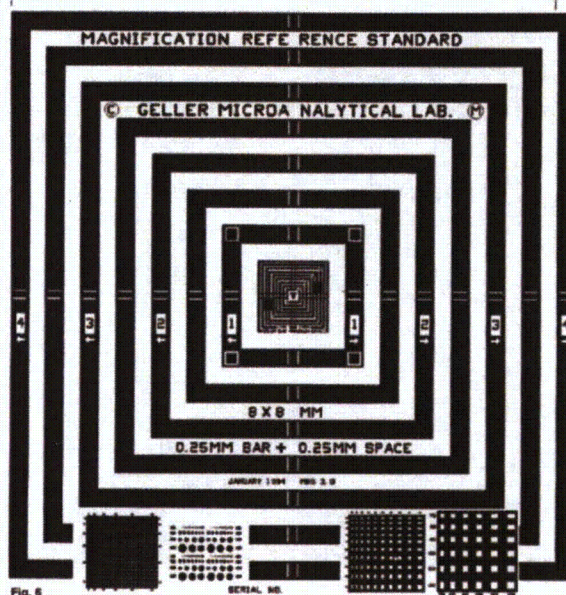
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Attachment E: Geller Microanalytical Laboratory MRS-3XY Resource Guide (March 2011)



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 -



Resource Guide

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





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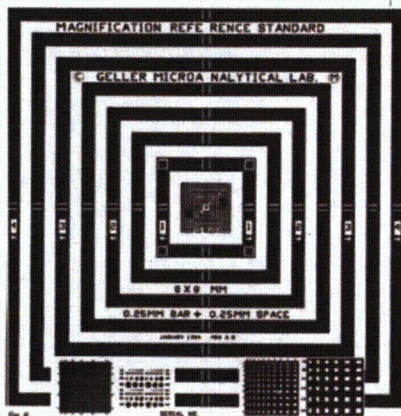
We are certified to ISO-9001 & 17025 - March 2011

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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 Ø 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 CrO₂ 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 4µm 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 CrO₂ over 70nm of Cr) over quartz. Imaging contrast in both secondary and backscattered electron mode is very high. The overall size is about 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 Ø X ½ mm thick – or another custom size. For applications requiring an electrically conductive sample (SEM at 10kV 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 Line-width Metrology in Optical Microscopy", Nystrom & Larabee, Journal of the Research of the National Bureau of Standards, Vol. 92, No. 3, 1987). Line-width 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, barrel, 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 (defining 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.

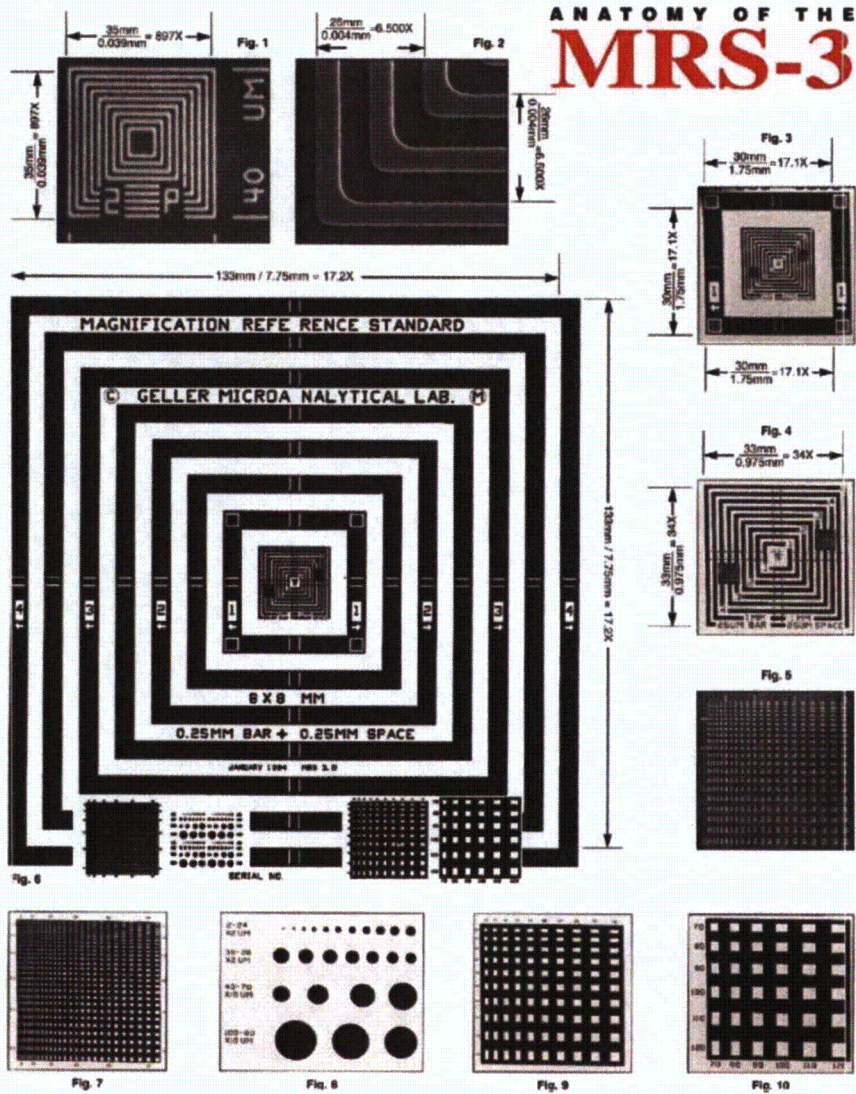
With the even numbered pitch patterns on the MRS-3 magnifications can usually be determined without the use of a calculator. For instance, if the length of five 2µm pitches are measured over a distance of 40µm on a micrograph or display screen the magnification would be 40µm ÷ 0.01mm = 4000X. **Please note:** our measurements are made by a special SEM where each individual pattern is measured. Other CRMs 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.

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Magnification Determination

- Magnification shall be determined using pitch measurements: the process of measuring repeating structures. Several examples are shown above. Since five 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 2 μm pitch. The pitch dimension of the largest box is 30 μm . 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 / 0.03mm = 897X (SEM, 1kV).

Fig. 2: At high magnification we image the line and space structure. Two cycles of the horizontal 2 μm pitch measures 20mm + 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 50 μm pitch the magnification is 35mm / 0.975mm = 34X.

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

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

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

Fig. 8: One of 4 identical circular patterns from 2 - 30 μm in 2 μm steps, and 40 - 100 μm in 10 μm 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 - 75 μm in 2 μm steps.

Fig. 10: Array of squares and rectangles from 70 - 125 μm in 16 μm 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 having us do the mounting on your holder to protect the standard. We can also do modify the MRS-3 to meet your needs. The following retainers and holders are available:

- StabMOR - 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 1/2" top surface.
- Others: Hitachi, VO PHE, 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 question the accuracy of our MRS. In every case it was determined their dimensions were not as represented or there was misoperation 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

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 relies greatly on 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-EL: Chemical standards for microanalysis
- Ion Sputtering Standards: for ion sputter rate
- SEM digital imaging
- Electron probe estimation
- Microtomed stage control
- Energy dispersive x-ray calibration (traceable)

ANALYTICAL SERVICES:

- Electron probe microanalysis (wavelength x ray), JEOL, JXA 8600
- Surface analysis (Auger), JEOL JAMP-7000
- Scanning electron microscopy, JEOL JSM-640
- Profilometry, Metallography, Microhardness
- Metallurgical failure analysis

observed and photographed. Magnifications can be measured directly on viewing CRTs in reticles mounted within the ocular, or directly on photomicrographs. For instruments with variable or electronic calipers distance measurements can be verified using a pitch pattern of appropriate size. For electron microscopes use any kV @ <10³ 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 3% 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-3 since there was no standard with 1 μm 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 in 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 its effect 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 analysis 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.

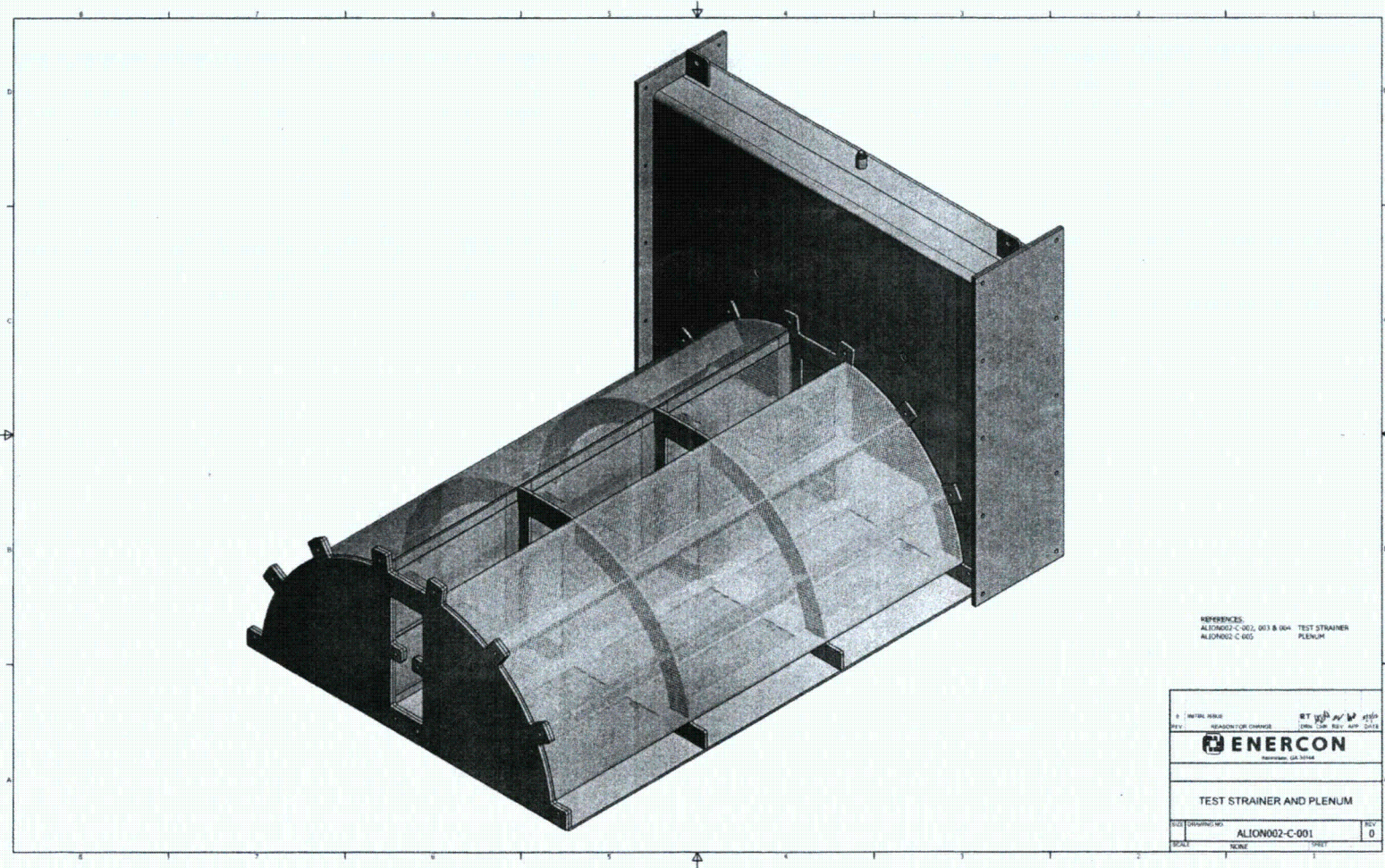
BWROG Report – GEH Class I

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ATTACHMENT P

Enercon Strainer Specifications

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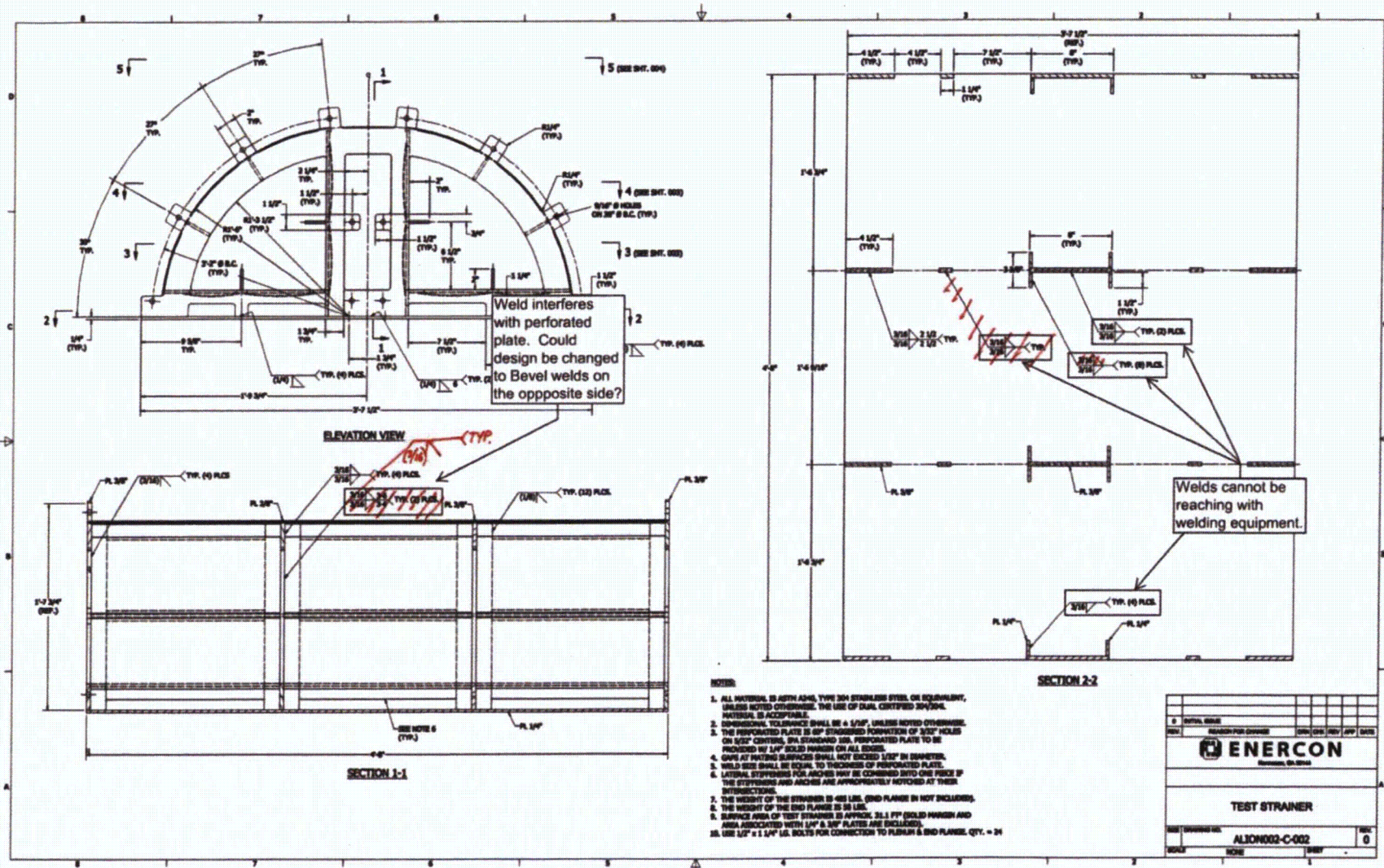



BWROG ECCS Strainer Bypass Test Report

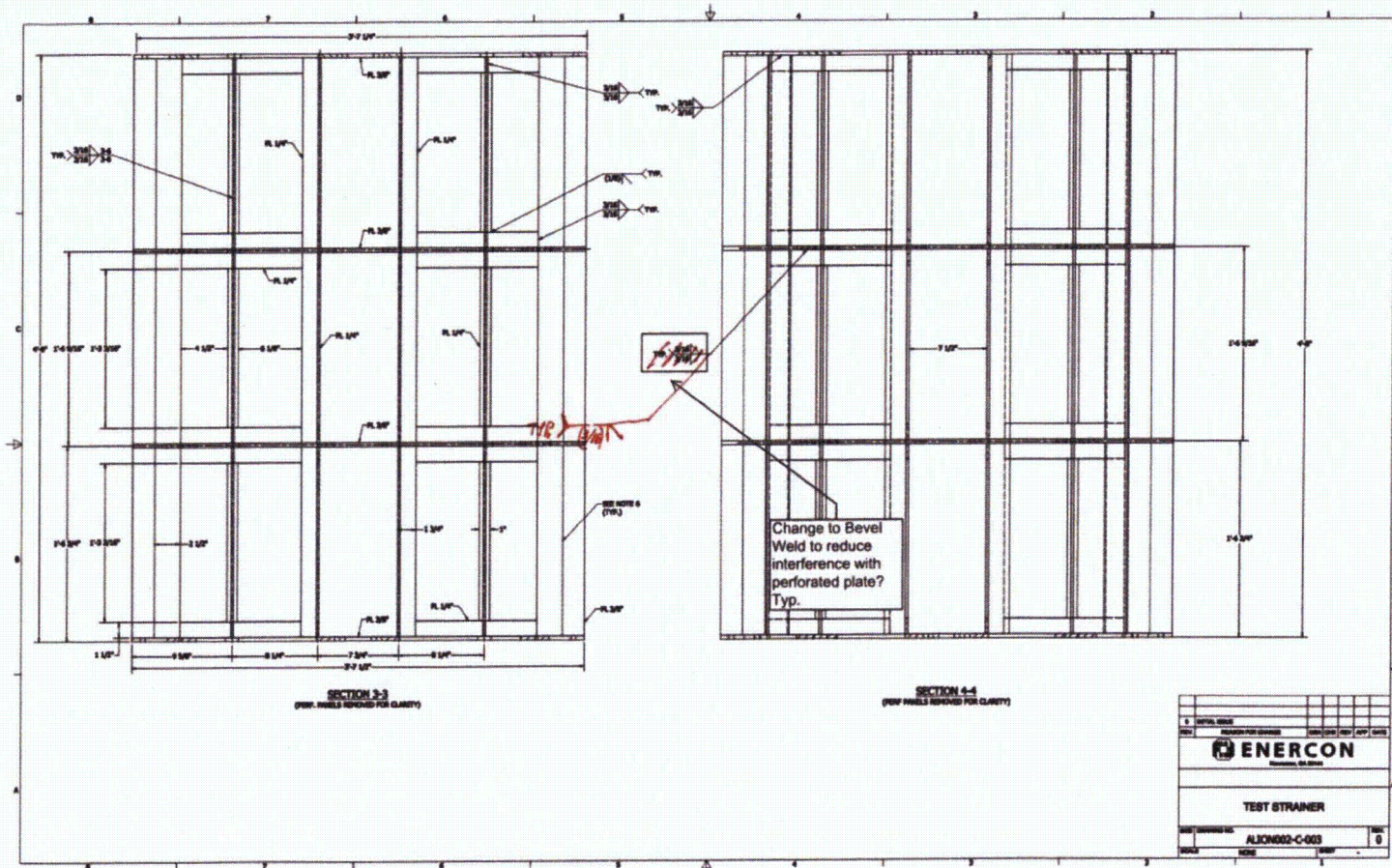
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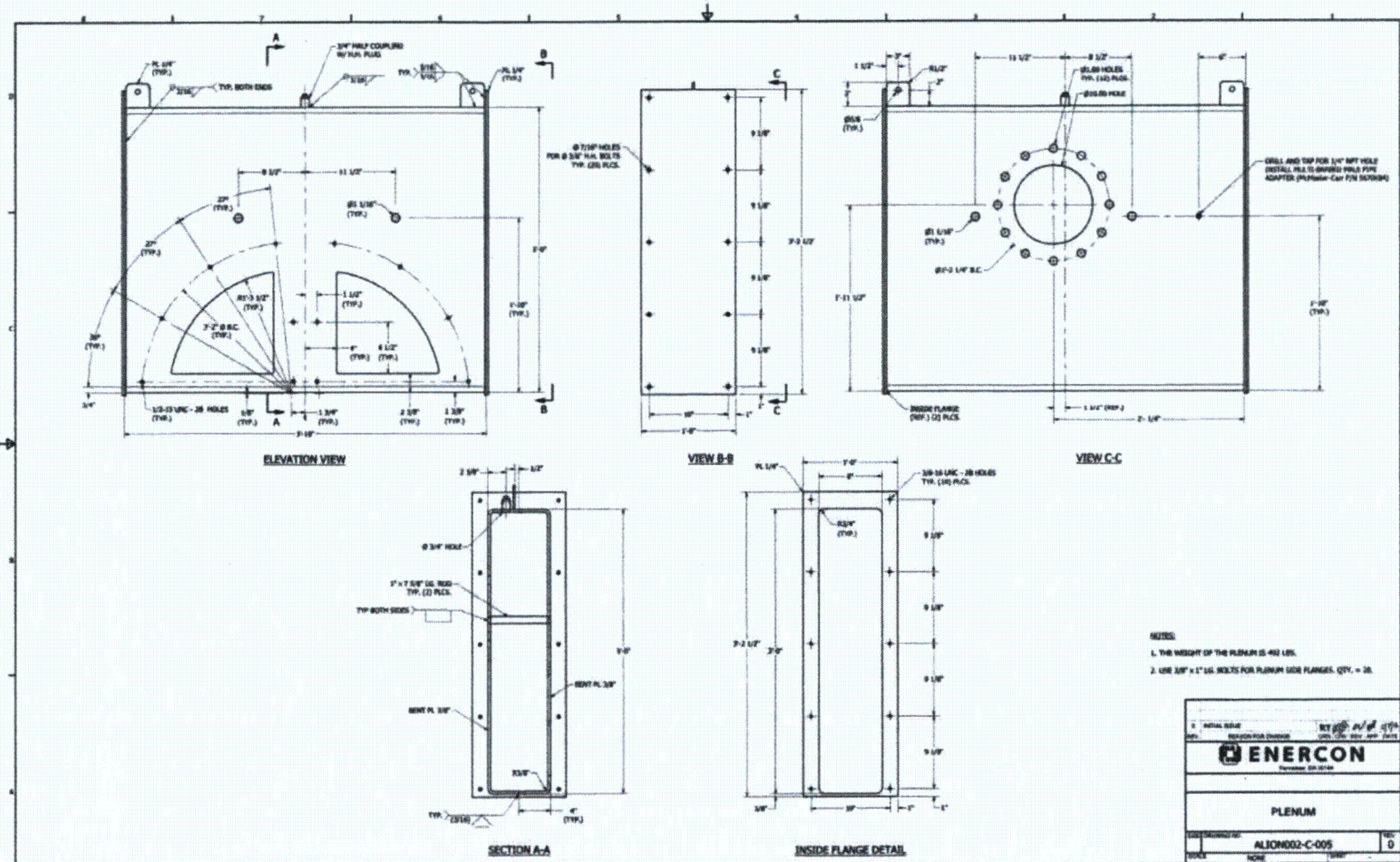
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ATTACHMENT Q

Scope Change Request and Emails Approval

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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, I 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

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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

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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

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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

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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 be 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.

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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.

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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

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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

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Poska, Jeffrey J

From: Whelan, Robert (GE Power & Water) <Robert.Whehan@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@peg.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@peg.com>, "Pat Coleman" <Pat.Coleman@peg.com>, "Eric Cox" <Eric.Cox@peg.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.

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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 ft³ 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 component'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.

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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


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
ATTACHMENT R

Testing Anomalies

BWROG Report – GEH Class I



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	CORRECTIVE ACTION REPORT	Number CAR # 2011-22
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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 <input checked="" type="checkbox"/> Reject <input type="checkbox"/>
Significant Condition Adverse to Quality:			
1. Potentially Reportable under 10CFR Part 21?		Yes <input type="checkbox"/> No <input checked="" type="checkbox"/>	
2. Significant degradation of or challenge to nuclear, plant or public safety?		Yes <input type="checkbox"/> No <input checked="" type="checkbox"/>	
3. Significant breakdown in quality program or adverse trend?		Yes <input type="checkbox"/> No <input checked="" type="checkbox"/>	
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

QA Review	QA Manager: <i>Kirit Parikh</i> Signature: <i>K.V. Parikh</i>	Date: <i>4/8/13</i>	Corrective Action Plan	To be completed by the individual assigned corrective action	All tasks shall have a scheduled completion date
10CFR21 Reportable? Yes <input type="checkbox"/> No <input checked="" type="checkbox"/>			Corrective Action Tasks:		
Justification: <i>* This CAR has been rejected by Kirit Parikh 4/8/13</i>			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

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	CORRECTIVE ACTION REPORT	Number CAR # 2011-22
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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.			
<table border="1"> <tr> <td>Corrective Action Complete:</td> <td>Signature:  Jeff Poska</td> <td>Date: 11-16-11</td> </tr> </table>	Corrective Action Complete:	Signature:  Jeff Poska	Date: 11-16-11
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.



4/8/13

	BWROG ECCS Strainer Bypass Test Report		
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	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 accidentally shut. This closed the flow path for an instant until they were opened again. Flow dropped to 200 gpm for a few seconds and head loss dropped to about 0.1 ft-H ₂ O. Flow and head loss returned to normal after the valves were reopened. A small 6" by 2" area on the screen also opened up during this event but this opening quickly filled again.			
<input type="checkbox"/> Photos or other documents attached? Name: Frank Biank Position: Test Engineer Signature: 			
Disposition: (refer to Section 3.2)			
Action(s):	<input checked="" type="checkbox"/> Continue Testing	<input type="checkbox"/> Hold Testing	<input type="checkbox"/> 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	<input checked="" type="checkbox"/> Resume Testing based on Justification above, with no additional requirements. Scheduled Completion Date		
	<input type="checkbox"/> Process ECR #		
	<input type="checkbox"/> Revise Test Plan/Procedure:		
	<input type="checkbox"/> Provide training/retraining before proceeding		
	<input type="checkbox"/> 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: 11/6/12
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):			
<input checked="" type="checkbox"/> Acceptable as is. SEE ATTACHED EVALUATION - "VALVE MANIPULATION TESTING DISCREPANCY"			
<input type="checkbox"/> Acceptable as discussed in			
<input type="checkbox"/> Other:			
Nonconformance Valid? <input type="checkbox"/> No <input checked="" type="checkbox"/> Yes NCR #: 2012-24 Scheduled Closure Date: 10/17/12			
CAR Required? <input checked="" type="checkbox"/> No <input type="checkbox"/> 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	

	BWROG ECCS Strainer Bypass Test Report		
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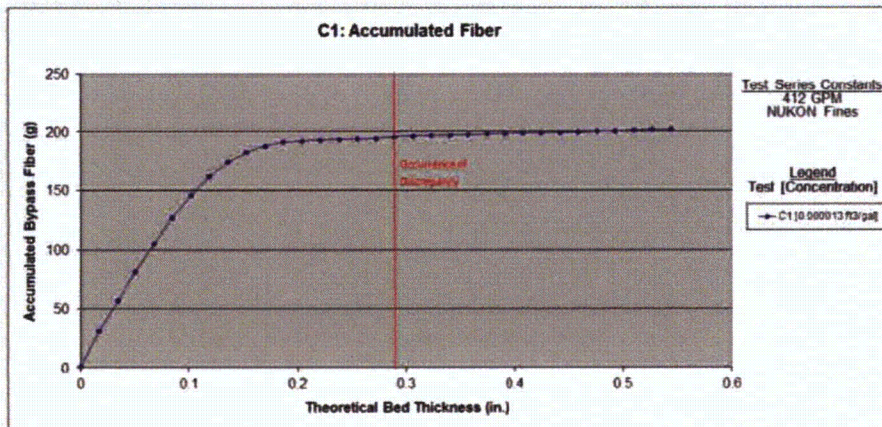
Valve Manipulation Testing Discrepancy

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-H₂O to 0.15 ft-H₂O. 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 I 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 I – Accumulated Fiber





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Table I - 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

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To summarize, the discrepancy did not significantly affect the results of the CI 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 CI Bypass Test are valid for use in evaluating the results of test CI.