

State of Oregon  
Department of Environmental Quality

Memorandum

Date: 7/5/2016

**To:** File/Gary Andes  
**From:** Mike Eisele

**Subject:** Source Test Review Report  
Hollingsworth and Vose  
Permit Number: 02-2173-ST-01

Test Date: March 8-14, 2016  
Report Received: May 2, 2016; Revised June 10, 2016  
Source Testers: Bison Engineering, Inc.  
DEQ Observed: Yes

**I) Source Description:** Glass fiber manufacturing.

**II) Process (es)/Emissions Unit(s) Tested:** Scrubber exhausts.

**III) Test Purpose:** To determine the emissions of particulate matter (PM), nitrogen oxides (NO<sub>x</sub>), carbon monoxide (CO), total fluorides (TF), hydrogen fluoride (HF), formaldehyde, and volatile organic compounds (VOCs).

**IV) Testing Location(s):**

**Glass Melt FSS Scrubber 10 Exhaust:**

Diameter: 32"  
Distance A (Method 1): 96" (3 Diameter)  
Distance B (Method 1): 246" (6.8 Diameters)  
Number traverse points utilized: 16

**Rotary Fine and Rotary Coarse L3S2 Exhaust:**

Diameter: 78"  
Distance A (Method 1): 40" (0.5 Diameter)  
Distance B (Method 1): 156" (2.0 Diameters)  
Number traverse points utilized: 24

**Flame Blown Plant 2 L4S1 Exhaust:**

Diameter: 70.5"  
Distance A (Method 1): 100" (1.4 Diameters)  
Distance B (Method 1): 3000" (4.3 Diameter)  
Number traverse points utilized: 24

**V) Testing Methodology:** The following testing methods were utilized during the testing program:

Flow Rate, O<sub>2</sub> & CO<sub>2</sub>, & Moisture Content: EPA Methods 1, 2, 3A & 4  
 Total Particulate: ODEQ Method 5  
 Nitrogen Oxides: EPA Method 7E  
 Carbon Monoxide: EPA Method 10  
 Total Fluorides: EPA Method 13B  
 Volatile Organic Compounds: EPA Method 25A & EPA Method 316  
 Hydrogen Fluoride: EPA Method 26A  
 Formaldehyde: EPA Method 316

**VI) Summary of Results:** The testing parameters, test results and operating parameters are summarized in Tables 1 - 15:

**TABLE 1: Glass Melt - PM**

TESTING PARAMETERS (PM)	Run 1	Run 2	Run 3	Average
Test Date	3/13/2016	3/14/2016	3/14/2016	--
Test Time	2035-2200	0945-1055	1106-1235	--
Exhaust Gas Temperature (°F)	86	87	87	87
Exhaust Gas Moisture (%)	4.3	4.3	4.1	4.3
Exhaust O <sub>2</sub> (% dry vol)	20.4	20.4	20.3	20.4
Exhaust CO <sub>2</sub> (% dry vol)	0.6	0.7	0.6	0.6
Exhaust Gas Flow Rate (dscfm)	12400	11700	12100	12100
PM Sample Volume (dscf)	36.5	46.06	47.66	43.41
Filterable Mass of PM Collected (mg)	7.7	6.2	6.4	6.8
Total Mass of PM Collected (mg)	12.2	13.7	13.4	13.1
Filterable Particulate (PM) Emissions:				
• gr/dscf	0.0033	0.0021	0.0021	0.0025
• lb/hr	0.35	0.21	0.21	0.26
• lb/ton of glass	0.16	0.10	0.10	0.12
Total Particulate (PM) Emissions:				
• gr/dscf	0.0052	0.0046	0.0043	0.0047
• lb/hr	0.55	0.46	0.45	0.49
• lb/ton of glass	0.25	0.21	0.21	0.22
Isokinetic Variation (%)	99	98	98	98
Scrubber Number	10	10	10	--
Scrubber Water Flow Rate (gal/min)	73.0	72.5	72.7	72.7
Scrubber Differential Pressure (inches of WC)	14.1	14.4	14.4	14.3

**TABLE 2: Glass Melt - TF&HF**

TESTING PARAMETERS (TF&HF)	Run 1	Run 2	Run 3	Average
Test Date	3/14/2016	3/14/2016	3/14/2016	--
Test Time	1248-1400	1445-1615	1740-1920	--
TF Exhaust Gas Temperature (°F)	90	89	88	89
HF Exhaust Gas Temperature (°F)	91	90	89	90
TF Exhaust Gas Moisture (%)	4.6	3.6	3.8	4.0
HF Exhaust Gas Moisture (%)	3.8	3.8	3.4	3.7
Exhaust O <sub>2</sub> (% dry vol)	20.4	20.4	20.3	20.4
Exhaust CO <sub>2</sub> (% dry vol)	0.6	0.7	0.6	0.6
TF Exhaust Gas Flow Rate (dscfm)	9900	11900	11400	11100
HF Exhaust Gas Flow Rate (dscfm)	11200	11400	11900	11500
<b>Total Fluoride (TF) Emissions:</b>				
• ppmvd	0.655	0.378	0.344	0.459
• lb/hr	0.019	0.013	0.012	0.015
• lb/ton of glass	0.009	0.006	0.005	0.007
<b>Hydrogen Fluoride (HF) Emissions:</b>	a	a	a	a
• ppmvd	0.258	0.245	0.289	0.264
• lb/hr	0.009	0.009	0.011	0.010
• lb/ton of glass	0.004	0.004	0.005	0.004
TF Isokinetic Variation (%)	101	98	99	99
HF Isokinetic Variation (%)	100	106	102	103
Scrubber Number	10	10	10	--
Scrubber Water Flow Rate (gal/min)	72.5	72.8	72.8	72.7
Scrubber Differential Pressure (inches of WC)	14.3	14.4	14.7	14.5

<sup>a</sup> Results are between the minimum detection level and the limit of quantification. Results are only an estimation.

**TABLE 3: Glass Melt - Formaldehyde, VOCs, CO, and NO<sub>x</sub>**

TESTING PARAMETERS (Formaldehyde, VOCs, CO, and NO <sub>x</sub> )	Run 1	Run 2	Run 3	Average
Test Date	3/13/2016	3/13/2016	3/13/2016	
Test Time	1523-1641	1712-1830	1845-1958	
Exhaust Gas Temperature (°F)	89	88	86	88
Exhaust Gas Moisture (%)	4.7	3.8	4.8	4.5
Exhaust O <sub>2</sub> (% dry vol)	20.4	20.4	20.3	20.4
Exhaust CO <sub>2</sub> (% dry vol)	0.6	0.7	0.6	0.6
Exhaust Gas Flow Rate (dscfm)	13900	13900	13500	13700
Formaldehyde Sample Volume (dscf)	41.4	40.4	39.9	40.5
Formaldehyde Emissions:				
• ug/dscm	9.82	<5.05	<4.81	<6.56
• lb/hr	0.0005	<0.0003	<0.0002	<0.0003
• lb/ton of glass	0.000236	<0.000122	<0.000112	<0.00016
• lb/MMscf natural gas	0.114	<0.060	<0.054	<0.076
VOC Emissions as Propane Including Formaldehyde:				
• ppmvd	Na	0.71	Na	0.71
• lb/hr	Na	0.067	Na	0.067
• lb/ton of glass	Na	0.031	Na	0.031
• lb/MMscf natural gas	Na	15	Na	15
Carbon Monoxide (CO) Emissions:				
• ppmvd	6.62	6.65	6.45	6.57
• lb/hr	0.40	0.40	0.38	0.39
• lb/ton of glass	0.19	0.19	0.18	0.18
• lb/MMSCF of Natural Gas <sup>a</sup>	91	91	86	89
Nitrogen Oxides (NO <sub>x</sub> ) Emissions:				
• ppmvd	0.62	0.54	Na	0.58
• lb/hr	0.06	0.05	Na	0.06
• lb/ton of glass	0.03	0.02	Na	0.03
• lb/MMSCF of Natural Gas <sup>a</sup>	14	12	Na	13
Isokinetic Variation (%)	100	98	100	99
Scrubber Number	10	10	10	--
Scrubber Water Flow Rate (gal/min)	72.9	72.9	72.9	72.9
Scrubber Differential Pressure (inches of WC)	13.9	14.0	14.1	14.0

**TABLE 4: Flame Blown - PM**

TESTING PARAMETERS (PM)	Run 1	Run 2	Run 3	Average
Test Date	3/8/2016	3/8/2016	3/9/2016	--
Test Time	1204-1334	2100-2222	1048-1208	--
Exhaust Gas Temperature (°F)	100	100	100	100
Exhaust Gas Moisture (%)	6.0	6.5	6.4	6.3
Exhaust O <sub>2</sub> (% dry vol)	19.9	19.7	19.9	19.8
Exhaust CO <sub>2</sub> (% dry vol)	0.5	0.5	0.5	0.5
Exhaust Gas Flow Rate (dscfm)	45600	47200	45000	45900
PM Sample Volume (dscf)	55.83	54.30	51.74	53.96
Filterable Mass of PM Collected (mg)	9.4	8.3	8.1	8.6
Total Mass of PM Collected (mg)	12.2	12.2	9.7	11.4
Filterable Particulate (PM) Emissions:				
• gr/dscf	0.0026	0.0024	0.0024	0.0025
• lb/hr	1.02	0.95	0.93	0.97
• lb/ton of glass	16.4	15.4	15.0	15.6
Total Particulate (PM) Emissions:				
• gr/dscf	0.0034	0.0035	0.0029	0.0032
• lb/hr	1.32	1.41	1.11	1.28
• lb/ton of glass	21.3	22.7	17.9	20.6
Isokinetic Variation (%)	100	101	101	101
Scrubber Number	11 & 12	11 & 12	11 & 12	--
Scrubber Water Flow Rate (gal/min)	292/255	291/242	292/246	292/248
Scrubber Differential Pressure (inches of WC)	12.9/8.7	12.8/8.5	12.2/8.6	12.6/8.6

**TABLE 5: Flame Blown - TF&HF**

TESTING PARAMETERS (TF&HF)	Run 1	Run 2	Run 3	Average
Test Date	3/8/2016	3/8&9/2016	3/9/2016	
Test Time	1757-1936	2324-0047	1256-1418	
TF Exhaust Gas Temperature (°F)	100	101	100	100
HF Exhaust Gas Temperature (°F)	101	100	101	101
TF Exhaust Gas Moisture (%)	6.0	6.1	7.0	6.3
HF Exhaust Gas Moisture (%)	5.0	4.5	6.3	5.3
Exhaust O <sub>2</sub> (% dry vol)	19.8	19.8	19.8	19.8
Exhaust CO <sub>2</sub> (% dry vol)	0.5	0.5	0.5	0.5
TF Exhaust Gas Flow Rate (dscfm)	45800	44700	44000	44800
HF Exhaust Gas Flow Rate (dscfm)	44900	47700	45400	46000
Total Fluoride (TF) Emissions:				
• ppm <sub>dv</sub>	0.381	0.447	0.584	0.471
• lb/hr	0.052	0.059	0.076	0.062
• lb/ton of fiber	0.83	0.95	1.23	1.00
Hydrogen Fluoride (HF) Emissions:				
• ppm <sub>dv</sub>	<0.036	<0.033	<0.034	<0.034
• lb/hr	<0.005	<0.005	<0.005	<0.005
• lb/ton of fiber	<0.080	<0.080	<0.078	<0.079
TF Isokinetic Variation (%)	100	101	100	100
HF Isokinetic Variation (%)	99	99	101	100
Scrubber Number	11 & 12	11 & 12	11 & 12	--
Scrubber Water Flow Rate (gal/min)	292/253	292/244	293/246	292/248
Scrubber Differential Pressure (inches of WC)	12.8/8.6	12.8/8.6	12.2/8.6	12.6/8.6

**TABLE 6: Flame Blown - Formaldehyde, VOCs, CO, and NO<sub>x</sub>**

TESTING PARAMETERS (Formaldehyde, VOCs, CO, and NO <sub>x</sub> )	Run 1	Run 2	Run 3	Average
Test Date	3/8/2016	3/8/2016	3/9/2016	--
Test Time	1204-1334	2100-2222	1048-1208	--
Exhaust Gas Temperature (°F)	100	100	100	100
Exhaust Gas Moisture (%)	6.6	6.2	6.4	6.4
Exhaust O <sub>2</sub> (% dry vol)	19.9	19.7	19.9	19.8
Exhaust CO <sub>2</sub> (% dry vol)	0.5	0.5	0.5	0.5
Exhaust Gas Flow Rate (dscfm)	45300	44900	44200	44800
Formaldehyde Sample Volume (dscf)	53.54	52.35	51.31	52.40
Formaldehyde Emissions:	<sup>a</sup>	<sup>a</sup>	<sup>a</sup>	<sup>a</sup>
• ug/dscm	65.0	26.4	69.5	53.6
• lb/hr	0.011	0.004	0.012	0.009
• lb/ton of glass	0.178	0.072	0.186	0.145
• lb/MMscf natural gas	0.89	0.37	0.90	0.72
VOC Emissions as Propane Including Formaldehyde:				
• ppmvd	2.28	3.37	2.40	2.68
• lb/hr	0.70	1.03	0.72	0.82
• lb/ton of glass	11.3	16.7	11.6	13.2
• lb/MMscf natural gas	57	87	57	67
Carbon Monoxide (CO) Emissions:				
• ppmvd	131	129	127	129
• lb/hr	26.0	25.3	24.6	25.3
• lb/ton of glass	419	408	397	408
• lb/MMSCF of Natural Gas <sup>a</sup>	2090	2130	1930	2050
Nitrogen Oxides (NO <sub>x</sub> ) Emissions:				
• ppmvd	6.64	6.60	5.84	6.36
• lb/hr	2.16	2.12	1.85	2.04
• lb/ton of glass	34.8	34.3	29.8	33.0
• lb/MMSCF of Natural Gas <sup>a</sup>	173	178	145	165
Isokinetic Variation (%)	101	99	99	100
Scrubber Number	11 & 12	11 & 12	11 & 12	--
Scrubber Water Flow Rate (gal/min)	292/255	290/244	292/246	291/249
Scrubber Differential Pressure (inches of WC)	12.9/8.7	12.8/8.6	12.2/8.6	12.6/8.6

<sup>a</sup> Results are between the minimum detection level and the limit of quantification. Results are only an estimation.

**TABLE 7: Rotary Coarse - PM**

TESTING PARAMETERS (PM)	Run 1	Run 2	Run 3	Average
Test Date	3/11/2016	3/11/2016	3/11&12/2016	--
Test Time	1410-1532	1841-2003	2303-0024	--
Exhaust Gas Temperature (°F)	96	96	94	95
Exhaust Gas Moisture (%)	5.9	5.9	6.0	5.9
Exhaust O <sub>2</sub> (% dry vol)	19.9	20.0	19.9	19.9
Exhaust CO <sub>2</sub> (% dry vol)	0.5	0.5	0.5	0.5
Exhaust Gas Flow Rate (dscfm)	18500	18900	19600	19000
PM Sample Volume (dscf)	46.41	47.71	49.73	47.95
Filterable Mass of PM Collected (mg)	20.7	22.8	23.1	22.2
Total Mass of PM Collected (mg)	24.1	25.1	24.4	24.5
Filterable Particulate (PM) Emissions:				
• gr/dscf	0.0069	0.0074	0.0072	0.0071
• lb/hr	1.09	1.20	1.21	1.17
• lb/ton of fiber	6.11	6.65	6.65	6.47
Total Particulate (PM) Emissions:				
• gr/dscf	0.0080	0.0081	0.0076	0.0079
• lb/hr	1.27	1.32	1.28	1.29
• lb/ton of fiber	7.10	7.33	7.03	7.15
Isokinetic Variation (%)	102	102	103	102
Scrubber Number	3	3	3	--
Scrubber Water Flow Rate (gal/min)	121	120	120	120
Scrubber Differential Pressure (inches of WC)	21.2	21.1	21.7	21.3



**TABLE 8: Rotary Coarse – TF & HF**

TESTING PARAMETERS (TF&HF)	Run 1	Run 2	Run 3	Average
Test Date	3/11/2016	3/11/2016	3/11/2016	
Test Time	1623-1742	2104-2227	0103-0222	
TF Exhaust Gas Temperature (°F)	96	97	95	96
HF Exhaust Gas Temperature (°F)	94	96	93	95
TF Exhaust Gas Moisture (%)	4.7	5.9	6.1	5.5
HF Exhaust Gas Moisture (%)	5.2	5.8	5.3	5.4
Exhaust O <sub>2</sub> (% dry vol)	19.9	20.0	19.9	19.9
Exhaust CO <sub>2</sub> (% dry vol)	0.5	0.5	0.5	0.5
TF Exhaust Gas Flow Rate (dscfm)	45.06	46.78	48.11	46.65
HF Exhaust Gas Flow Rate (dscfm)	48.00	50.18	48.95	49.04
Total Fluoride (TF) Emissions:				
• ppm <sub>dv</sub>	2.52	2.91	4.09	3.17
• lb/hr	0.138	0.160	0.234	0.177
• lb/ton of fiber	0.78	0.86	1.30	0.98
Hydrogen Fluoride (HF) Emissions:				
• ppm <sub>dv</sub>	0.21	0.28	0.25	0.25
• lb/hr	0.012	0.017	0.015	0.015
• lb/ton of fiber	0.070	0.092	0.084	0.082
TF Isokinetic Variation (%)	99	100	101	100
HF Isokinetic Variation (%)	102	101	101	101
Scrubber Numbers	3	3	3	3
Scrubber Water Flow Rate (gal/min)	121	120	120	120
Scrubber Differential Pressure (inches of WC)	21.3	21.4	21.0	21.2

<sup>a</sup> Results are between the minimum detection level and the limit of quantification. Results are only an estimation.

**TABLE 9: Rotary Coarse - Formaldehyde, VOCs, CO, and NO<sub>x</sub>**

TESTING PARAMETERS (Formaldehyde, VOCs, CO, and NO <sub>x</sub> )	Run 1	Run 2	Run 3	Average
Test Date	3/11/2016	3/11/2016	3/11/2016	--
Test Time	1410-1532	1841-2003	2303-0024	--
Exhaust Gas Temperature (°F)	95	96	95	95
Exhaust Gas Moisture (%)	5.9	7.4	5.1	6.1
Exhaust O <sub>2</sub> (% dry vol)	19.9	20.0	19.9	19.9
Exhaust CO <sub>2</sub> (% dry vol)	0.5	0.5	0.5	0.5
Exhaust Gas Flow Rate (dscfm)	18200	18600	19700	18800
Formaldehyde Sample Volume (dscf)	45.83	47.75	49.37	47.65
Formaldehyde Emissions:				
• ug/dscm	127	121	99	116
• lb/hr	0.009	0.008	0.007	0.008
• lb/ton of glass	0.049	0.047	0.040	0.045
• lb/MMscf natural gas	1.7	1.6	1.4	1.6
VOC Emissions as Propane Including Formaldehyde:				
• ppmvd	0.57	0.59	0.58	0.58
• lb/hr	0.081	0.084	0.085	0.083
• lb/ton of glass	0.45	0.47	0.47	0.46
• lb/MMscf natural gas	16	16	17	16
Carbon Monoxide (CO) Emissions:				
• ppmvd	116	117	116	116
• lb/hr	9.21	9.45	9.96	9.54
• lb/ton of glass	51.6	52.5	54.9	53.0
• lb/MMSCF of Natural Gas <sup>a</sup>	1800	1830	1930	1850
Nitrogen Oxides (NO <sub>x</sub> ) Emissions:				
• ppmvd	3.44	3.41	3.47	3.44
• lb/hr	0.45	0.45	0.49	0.46
• lb/ton of glass	2.52	2.52	2.69	2.58
• lb/MMSCF of Natural Gas <sup>a</sup>	88	88	95	90
Isokinetic Variation (%)	99	102	99	100
Scrubber Number	3	3	3	--
Scrubber Water Flow Rate (gal/min)	121	121	120	120
Scrubber Differential Pressure (inches of WC)	21.2	21.1	21.7	21.3

**TABLE 10: Rotary Fine Test 1 - PM**

<b>TESTING PARAMETERS (PM)</b>	<b>Run 1</b>	<b>Run 2</b>	<b>Run 3</b>	<b>Average</b>
<b>Test Date</b>	<b>3/10/2016</b>	<b>3/10/2016</b>	<b>3/11/2016</b>	<b>--</b>
<b>Test Time</b>	<b>1337-1536</b>	<b>1845-2015</b>	<b>0832-0958</b>	<b>--</b>
<b>Exhaust Gas Temperature (°F)</b>	<b>103</b>	<b>103</b>	<b>101</b>	<b>102</b>
<b>Exhaust Gas Moisture (%)</b>	<b>7.2</b>	<b>6.5</b>	<b>6.6</b>	<b>6.8</b>
<b>Exhaust O<sub>2</sub> (% dry vol)</b>	<b>19.9</b>	<b>19.9</b>	<b>19.7</b>	<b>19.8</b>
<b>Exhaust CO<sub>2</sub> (% dry vol)</b>	<b>0.6</b>	<b>0.6</b>	<b>0.6</b>	<b>0.6</b>
<b>Exhaust Gas Flow Rate (dscfm)</b>	<b>17600</b>	<b>18300</b>	<b>18300</b>	<b>18000</b>
<b>PM Sample Volume (dscf)</b>	<b>43.86</b>	<b>46.23</b>	<b>46.18</b>	<b>45.42</b>
<b>Filterable Mass of PM Collected (mg)</b>	<b>23.2</b>	<b>16.8</b>	<b>14.0</b>	<b>18.0</b>
<b>Total Mass of PM Collected (mg)</b>	<b>25.0</b>	<b>20.4</b>	<b>17.1</b>	<b>20.8</b>
<b>Filterable Particulate (PM) Emissions:</b>				
• <b>gr/dscf</b>	<b>0.0081</b>	<b>0.0056</b>	<b>0.0047</b>	<b>0.0061</b>
• <b>lb/hr</b>	<b>1.23</b>	<b>0.88</b>	<b>0.73</b>	<b>0.95</b>
• <b>lb/ton of fiber</b>	<b>21.9</b>	<b>15.9</b>	<b>13.0</b>	<b>16.9</b>
<b>Total Particulate (PM) Emissions:</b>				
• <b>gr/dscf</b>	<b>0.0088</b>	<b>0.0068</b>	<b>0.0057</b>	<b>0.0071</b>
• <b>lb/hr</b>	<b>1.32</b>	<b>1.07</b>	<b>0.89</b>	<b>1.09</b>
• <b>lb/ton of fiber</b>	<b>23.6</b>	<b>19.4</b>	<b>15.8</b>	<b>19.6</b>
<b>Isokinetic Variation (%)</b>	<b>101</b>	<b>102</b>	<b>102</b>	<b>102</b>
<b>Scrubber Number</b>	<b>4</b>	<b>4</b>	<b>4</b>	<b>--</b>
<b>Scrubber Water Flow Rate (gal/min)</b>	<b>144</b>	<b>144</b>	<b>144</b>	<b>144</b>
<b>Scrubber Differential Pressure (inches of WC)</b>	<b>15.1</b>	<b>15.1</b>	<b>15.4</b>	<b>15.2</b>

**TABLE 11: Rotary Fine Test 1 – TF & HF**

<b>TESTING PARAMETERS (TF&amp;HF)</b>	<b>Run 1</b>	<b>Run 2</b>	<b>Run 3</b>	<b>Average</b>
<b>Test Date</b>	<b>3/10/2016</b>	<b>3/10/2016</b>	<b>3/11/2016</b>	<b>--</b>
<b>Test Time</b>	<b>1639-1803</b>	<b>2056-2213</b>	<b>1039-1203</b>	<b>--</b>
<b>TF Exhaust Gas Temperature (°F)</b>	<b>104</b>	<b>102</b>	<b>101</b>	<b>102</b>
<b>HF Exhaust Gas Temperature (°F)</b>	<b>104</b>	<b>102</b>	<b>99</b>	<b>102</b>
<b>TF Exhaust Gas Moisture (%)</b>	<b>7.3</b>	<b>7.0</b>	<b>6.4</b>	<b>6.9</b>
<b>HF Exhaust Gas Moisture (%)</b>	<b>6.9</b>	<b>6.5</b>	<b>5.9</b>	<b>6.4</b>
<b>Exhaust O<sub>2</sub> (% dry vol)</b>	<b>19.9</b>	<b>19.9</b>	<b>19.7</b>	<b>19.8</b>
<b>Exhaust CO<sub>2</sub> (% dry vol)</b>	<b>0.6</b>	<b>0.6</b>	<b>0.6</b>	<b>0.6</b>
<b>TF Exhaust Gas Flow Rate (dscfm)</b>	<b>17400</b>	<b>17600</b>	<b>17800</b>	<b>17600</b>
<b>HF Exhaust Gas Flow Rate (dscfm)</b>	<b>18200</b>	<b>18300</b>	<b>18300</b>	<b>18300</b>
<b>Total Fluoride (TF) Emissions:</b>				
• <b>ppmdv</b>	<b>1.22</b>	<b>1.02</b>	<b>1.88</b>	<b>1.38</b>
• <b>lb/hr</b>	<b>0.063</b>	<b>0.053</b>	<b>0.099</b>	<b>0.072</b>
• <b>lb/ton of fiber</b>	<b>1.14</b>	<b>0.96</b>	<b>1.80</b>	<b>1.30</b>
<b>Hydrogen Fluoride (HF) Emissions:</b>				
• <b>ppmdv</b>	<b>&lt;0.049</b>	<b>&lt;0.035</b>	<b>&lt;0.039</b>	<b>&lt;0.041</b>
• <b>lb/hr</b>	<b>&lt;0.003</b>	<b>&lt;0.002</b>	<b>&lt;0.002</b>	<b>&lt;0.002</b>
• <b>lb/ton of fiber</b>	<b>&lt;0.051</b>	<b>&lt;0.036</b>	<b>&lt;0.040</b>	<b>&lt;0.048</b>
<b>TF Isokinetic Variation (%)</b>	<b>99</b>	<b>100</b>	<b>100</b>	<b>100</b>
<b>HF Isokinetic Variation (%)</b>	<b>98</b>	<b>102</b>	<b>103</b>	<b>101</b>
<b>Scrubber Numbers</b>	<b>4</b>	<b>4</b>	<b>4</b>	<b>--</b>
<b>Scrubber Water Flow Rate (gal/min)</b>	<b>144</b>	<b>144</b>	<b>145</b>	<b>144</b>
<b>Scrubber Differential Pressure (inches of WC)</b>	<b>15.3</b>	<b>15.1</b>	<b>15.4</b>	<b>15.3</b>

**TABLE 12: Rotary Fine Test 1 - Formaldehyde, VOCs, CO, and NO<sub>x</sub>**

TESTING PARAMETERS (Formaldehyde, VOCs, CO, and NO <sub>x</sub> )	Run 1	Run 2	Run 3	Average
Test Date	3/10/2016	3/10/2016	3/11/2016	--
Test Time	1337-1536	1845-2015	0832-0958	--
Exhaust Gas Temperature (°F)	103	102	102	102
Exhaust Gas Moisture (%)	7.8	7.0	6.3	7.0
Exhaust O <sub>2</sub> (% dry vol)	19.9	19.9	19.7	19.8
Exhaust CO <sub>2</sub> (% dry vol)	0.6	0.6	0.6	0.6
Exhaust Gas Flow Rate (dscfm)	16900	17200	17600	17200
Formaldehyde Sample Volume (dscf)	39.77	43.55	43.82	42.38
Formaldehyde Emissions:				
• ug/dscm	424	382	254	353
• lb/hr	0.027	0.025	0.017	0.023
• lb/ton of glass	0.48	0.45	0.30	0.41
• lb/MMscf natural gas	5	5	3	4
VOC Emissions as Propane Including Formaldehyde:				
• ppmvd	2.37	2.22	1.96	2.19
• lb/hr	0.26	0.25	0.23	0.25
• lb/ton of glass	4.71	4.55	4.05	4.44
• lb/MMscf natural gas	0.049	0.049	0.046	0.048
Carbon Monoxide (CO) Emissions:				
• ppmvd	200	188	186	191
• lb/hr	14.8	14.1	14.0	14.4
• lb/ton of glass	264	257	252	257
• lb/MMSCF of Natural Gas <sup>a</sup>	2750	2780	2860	2790
Nitrogen Oxides (NO <sub>x</sub> ) Emissions:				
• ppmvd	5.8	5.6	4.6	5.4
• lb/hr	0.70	0.70	0.58	0.66
• lb/ton of glass	12.5	12.6	10.3	11.8
• lb/MMSCF of Natural Gas <sup>a</sup>	131	137	117	128
Isokinetic Variation (%)	97	100	99	99
Scrubber Number	4	4	4	--
Scrubber Water Flow Rate (gal/min)	144	144	144	144
Scrubber Differential Pressure (inches of WC)	15.1	15.1	15.4	15.2

**TABLE 13: Rotary Fine Test 2 - PM**

<b>TESTING PARAMETERS (PM)</b>	<b>Run 1</b>	<b>Run 2</b>	<b>Run 3</b>	<b>Average</b>
<b>Test Date</b>	<b>3/12/2016</b>	<b>3/12/2016</b>	<b>3/12/2016</b>	<b>--</b>
<b>Test Time</b>	<b>1103-1224</b>	<b>1515-1646</b>	<b>1953-2124</b>	<b>--</b>
<b>Exhaust Gas Temperature (°F)</b>	<b>97</b>	<b>99</b>	<b>99</b>	<b>98</b>
<b>Exhaust Gas Moisture (%)</b>	<b>5.7</b>	<b>6.9</b>	<b>5.5</b>	<b>6.0</b>
<b>Exhaust O<sub>2</sub> (% dry vol)</b>	<b>19.6</b>	<b>19.6</b>	<b>19.8</b>	<b>19.7</b>
<b>Exhaust CO<sub>2</sub> (% dry vol)</b>	<b>0.5</b>	<b>0.5</b>	<b>0.5</b>	<b>0.5</b>
<b>Exhaust Gas Flow Rate (dscfm)</b>	<b>19700</b>	<b>19600</b>	<b>19600</b>	<b>19600</b>
<b>PM Sample Volume (dscf)</b>	<b>49.53</b>	<b>49.78</b>	<b>48.69</b>	<b>49.34</b>
<b>Filterable Mass of PM Collected (mg)</b>	<b>16.9</b>	<b>18.0</b>	<b>19.4</b>	<b>18.1</b>
<b>Total Mass of PM Collected (mg)</b>	<b>19.8</b>	<b>19.7</b>	<b>20.3</b>	<b>19.9</b>
<b>Filterable Particulate (PM) Emissions:</b>				
• <b>gr/dscf</b>	<b>0.0053</b>	<b>0.0056</b>	<b>0.0061</b>	<b>0.0057</b>
• <b>lb/hr</b>	<b>0.89</b>	<b>0.94</b>	<b>1.03</b>	<b>0.95</b>
• <b>lb/ton of fiber</b>	<b>16.4</b>	<b>17.0</b>	<b>18.6</b>	<b>17.4</b>
<b>Total Particulate (PM) Emissions:</b>				
• <b>gr/dscf</b>	<b>0.0062</b>	<b>0.0061</b>	<b>0.0064</b>	<b>0.0062</b>
• <b>lb/hr</b>	<b>1.04</b>	<b>1.03</b>	<b>1.08</b>	<b>1.05</b>
• <b>lb/ton of fiber</b>	<b>19.3</b>	<b>18.6</b>	<b>19.5</b>	<b>19.1</b>
<b>Isokinetic Variation (%)</b>	<b>102</b>	<b>103</b>	<b>101</b>	<b>102</b>
<b>Scrubber Number</b>	<b>4</b>	<b>4</b>	<b>4</b>	<b>--</b>
<b>Scrubber Water Flow Rate (gal/min)</b>	<b>143</b>	<b>143</b>	<b>144</b>	<b>143</b>
<b>Scrubber Differential Pressure (inches of WC)</b>	<b>14.9</b>	<b>15.0</b>	<b>16.0</b>	<b>15.3</b>

**TABLE 14: Rotary Fine Test 2 – TF & HF**

TESTING PARAMETERS (TF&HF)	Run 1	Run 2	Run 3	Average
Test Date	3/12/2016	3/12/2016	3/12/2016	--
Test Time	1307-1431	1736-1905	2205-2345	--
TF Exhaust Gas Temperature (°F)	99	97	97	98
HF Exhaust Gas Temperature (°F)	98	97	97	98
TF Exhaust Gas Moisture (%)	6.5	6.4	6.3	6.4
HF Exhaust Gas Moisture (%)	5.8	6.0	5.9	5.9
Exhaust O <sub>2</sub> (% dry vol)	19.6	19.6	19.8	19.7
Exhaust CO <sub>2</sub> (% dry vol)	0.5	0.5	0.5	0.5
TF Exhaust Gas Flow Rate (dscfm)	19200	19900	19600	19600
HF Exhaust Gas Flow Rate (dscfm)	19800	19600	19100	19500
Total Fluoride (TF) Emissions:				
• ppm <sub>dv</sub>	2.19	2.23	2.06	2.16
• lb/hr	0.124	0.131	0.120	0.125
• lb/ton of fiber	2.34	2.39	2.15	2.29
Hydrogen Fluoride (HF) Emissions:				
• ppm <sub>dv</sub>	<0.035	<0.033	<0.033	<0.033
• lb/hr	<0.002	<0.002	<0.002	<0.002
• lb/ton of fiber	<0.040	<0.036	<0.035	<0.035
TF Isokinetic Variation (%)	100	99	100	100
HF Isokinetic Variation (%)	102	102	100	101
Scrubber Numbers	4	4	4	--
Scrubber Water Flow Rate (gal/min)	143	143	144	144
Scrubber Differential Pressure (inches of WC)	15.0	15.9	15.9	15.6

**TABLE 15: Rotary Fine Test 2 - Formaldehyde, VOCs, CO, and NO<sub>x</sub>**

TESTING PARAMETERS (Formaldehyde, VOCs, CO, and NO <sub>x</sub> )	Run 1	Run 2	Run 3	Average
Test Date	3/12/2016	3/12/2016	3/12/2016	--
Test Time	1103-1224	1515-1646	1953-2124	--
Exhaust Gas Temperature (°F)	98	100	98	98
Exhaust Gas Moisture (%)	6.4	7.0	5.8	6.4
Exhaust O <sub>2</sub> (% dry vol)	19.6	19.6	19.8	19.7
Exhaust CO <sub>2</sub> (% dry vol)	0.5	0.5	0.5	0.5
Exhaust Gas Flow Rate (dscfm)	19200	19500	20000	19600
Formaldehyde Sample Volume (dscf)	48.44	49.69	49.57	49.23
Formaldehyde Emissions:				
• ug/dscm	314	309	286	303
• lb/hr	0.023	0.023	0.021	0.022
• lb/ton of glass	0.42	0.41	0.39	0.40
• lb/MMscf natural gas	0.0045	0.0045	0.0043	0.0045
VOC Emissions as Propane Including Formaldehyde:				
• ppmvd	0.90	0.91	0.85	0.89
• lb/hr	0.109	0.112	0.105	0.109
• lb/ton of glass	2.01	2.05	1.91	1.99
• lb/MMscf natural gas	22	22	21	22
Carbon Monoxide (CO) Emissions:				
• ppmvd	186	181	178	182
• lb/hr	15.6	15.4	15.6	15.5
• lb/ton of glass	289	283	280	284
• lb/MMSCF of Natural Gas <sup>a</sup>	3140	3090	3130	3120
Nitrogen Oxides (NO <sub>x</sub> ) Emissions:				
• ppmvd	5.11	4.80	4.31	4.74
• lb/hr	0.70	0.67	0.62	0.66
• lb/ton of glass	13.0	12.3	11.1	12.2
• lb/MMSCF of Natural Gas <sup>a</sup>	142	134	124	133
Isokinetic Variation (%)	100	101	98	100
Scrubber Number	4	4	4	--
Scrubber Water Flow Rate (gal/min)	143	143	144	144
Scrubber Differential Pressure (inches of WC)	14.9	15.1	16.0	15.3



**VII) Concerns & Comments:**

- 1) Some errors were found in the original report. A revised report was received electronically on June 10, 2016 that fixed these errors.
- 2) There were analyzer drift and bias checks that were above the maximum allowable during the glass melt testing. Therefore VOCs during runs 1 and 3; and NOx during run 3 were not included in the test averages.

**VIII) Overall Evaluation:** The test methods conducted and the data provided were sufficient to evaluate the emissions from the units tested.

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