State of Oregon
Department of Environmental Quality Memorandum

Date: 7/20/2016

To: File/Dave Kauth
From: Mike Eisele

Subject: Source Test Review Report
Bullseye Glass Company
Permit Number: 26-3135-ST-01

Test Dates: April 26-29, 2016
Date Initial Report Received: June 10, 2016
Date Final Report Revision Received: est. July 22, 2016
Source Testers: Horizon Engineering
DEQ Observed: Yes

Test Results Summary:

This review report provides a comprehensive analysis of the source test performed by Horizon Engineering on behalf of Bullseye Glass. Testing was performed on April 26-29, 2016 on a single baghouse attached to Furnace 7 within the facility. The purpose of the testing was to verify the particulate removal efficiency of the baghouse, to ensure it is meeting the 99 percent particulate removal standard specified in DEQ rule. Further tests were performed to analyze the conversion rate of trivalent chromium (which is added as a feedstock in glass making) to hexavalent chromium leaving the furnace during the melting and refining phases.

The tests conducted and the subsequent validated data collected allowed DEQ to complete these evaluations. Test results show that the baghouse is effectively controlling particulate emissions, with an average removal efficiency of 99.8%. This capture rate is consistent with manufacturer's specifications and indicate that the device was installed and being operated properly.

Test data regarding chromium conversion rates indicate an average conversion rate of trivalent chromium to hexavalent chromium for the portion of chromium escaping the furnace is 98.4 percent. While there is some margin of error associated with this calculation, overall, DEQ concludes that the vast majority of chromium leaving the furnace during the melting and refining phases is, or converts to hexavalent chromium. Certain factors unique to the melting and exhausting process may be encouraging this conversion, including the amount of oxygen used in the processes, and the addition of additional oxygen in the cooling process prior to flowing into the baghouse.

Lastly, the single chromium test run at the outlet of the baghouse indicates the chromium control efficiency is not equal to the particulate collection efficiency. To verify the chromium control efficiency more testing would need to be completed.

The final report will be submitted when remaining questions are resolved. DEQ has noticed several issues that have required resubmission of calculations to date. DEQ does not predict changes to the substantive conclusions presented above.

I) Source Description: Glass melting furnace

II) Process (es)/Emissions Unit(s) Tested: The exhaust of the baghouse controlled Glass Furnace No. 7 was tested.

III) Test Purpose: To determine the particulate matter (PM) removal efficiency of the baghouse, to determine the conversion rate of trivalent chrome to hexavalent chrome, and to develop an emission factor for total and hexavalent chromium.

IV) Testing Location(s):

Furnace No. 7 Baghouse Inlet:

Diameter:	12.0”
Number traverse points utilized:	24

Furnace No. 7 Baghouse Outlet:

Diameter:	12.3”
Number traverse points utilized:	24

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

Flow Rate, O_2 & CO_2, & Moisture Content: EPA Methods 1, 2, 3C & 4
Filterable Particulate: EPA Method 5
Total Particulate: ODEQ Method 5
Total and Hexavalent Chrome: EPA SW-846 Method 0061

VI) Summary of Results: The testing parameters, test results, emission factors and operating parameters are summarized in Tables 1 - 4:

TABLE 1: Furnace No. 7 Baghouse Inlet Particulate Matter

TESTING PARAMETERS (Inlet PM)	Run 1	Run 2	Run 3	Average
Test Date	4/26-27/2016	4/27-28/2016	4/28-29/2016	--
Test Time	1730-0930	1730-0930	1700-0900	--
Exhaust Gas Temperature (^{o}F)	148	161	179	163
Exhaust Gas Moisture (%)	3	3	4	3
Exhaust O_2 (% dry vol)	20.5	20.5	20.6	20.5
Exhaust CO_2 (% dry vol)	2.0	2.0	1.5	1.8
Exhaust Gas Flow Rate (dscfm)	455	397	378	410
PM Sample Volume (dscf)	241	240	223	234
Filterable Mass of PM Collected (mg)	1192	1289	1369	1283
Total Mass of PM Collected (mg)	1199	1295	1377	1290
Filterable Particulate (PM) Emissions:				
• gr/dscf	0.077	0.083	0.095	0.085
• lb/hr	0.30	0.28	0.31	0.30
• lb/ton of glass produced	8.58	8.12	8.84	8.51
Total Particulate (PM) Emissions:				
• gr/dscf	0.077	0.083	0.096	0.085
• lb/hr	0.30	0.28	0.31	0.30
• lb/ton of glass produced	8.63	8.16	8.89	8.56
Isokinetic Variation (%)	97	102	101	100
Baghouse Pressure Drop (inches of water column)	5.5	5.3	5.7	5.5
Furnace Temperature (^{o}F)	2415	2410	2443	2423
Duration of Melting/Charging Period (hrs)	8	8	8	8
Duration of Refining Period (hrs)	8	8	8	8
Product Type	1445	1445	1445	--
Production (tons/hr)	0.0347	0.0347	0.0347	0.0347

TABLE 2: Furnace No. 7 Baghouse Outlet Particulate Matter

TESTING PARAMETERS (Outlet PM)	Run 1	Run 2	Run 3	Average
Test Date	**4/26-27/2016**	**4/27-28/2016**	**4/28-29/2016**	**--**
Test Time	**1730-0930**	**1730-0930**	**1700-0900**	**--**
Exhaust Gas Temperature (^{0}F)	**143**	**142**	**147**	**142**
Exhaust Gas Moisture (%)	**3**	**3**	**3**	**3**
Exhaust O_2 (% dry vol)	**20.6**	**20.6**	**20.7**	**20.6**
Exhaust CO_2 (% dry vol)	**1.4**	**1.5**	**1.0**	**1.4**
Exhaust Gas Flow Rate (dscfm)	**651**	**559**	**572**	**605**
PM Sample Volume (dscf)	**534**	**488**	**482**	**511**
Filterable Mass of PM Collected (mg)	**1.5**	**0.3**	**na**	**0.9**
Filterable Mass of PM at the MDL (mg)	**3**	**3**	**3**	**--**
Total Mass of PM Collected (mg)	**13.2**	**8.3**	***8.5***[a]	**10**
Filterable Particulate (PM) Emissions:				
• **gr/dscf**	**0.00004**	**0.00001**	**Na**	**0.00003**
• **lb/hr**	**0.00024**	**0.00005**	**Na**	**0.00014**
• **lb/ton of glass produced**	**0.0070**	**0.0013**	**Na**	**0.0041**
Filterable Particulate (PM) Emissions at the Method Detection Limit (MDL):				
• **gr/dscf**	**0.00009**	**0.00009**	**Na**	**0.00009**
• **lb/hr**	**0.00048**	**0.00045**	**Na**	**0.00047**
• **lb/ton of glass produced**	**0.0139**	**0.0131**	**Na**	**0.0135**
Total Particulate (PM) Emissions:			[a]	
• **gr/dscf**	**0.00038**	**0.00026**	***0.00027***	**0.00032**
• **lb/hr**	**0.0021**	**0.0013**	***0.0013***	**0.0017**
• **lb/ton of glass produced**	**0.0543**	**0.0362**	***0.0384***	**0.0453**
Isokinetic Variation (%)	**96**	**101**	**100**	**99**
Baghouse Filterable PM Removal Efficiency (%)	**99.8**	**99.8**	**na**	**99.8**
Baghouse Pressure Drop (inches of water column)	**5.5**	**5.3**	**5.7**	**5.5**
Furnace Temperature (^{0}F)	**2415**	**2410**	**2443**	**2423**
Duration of Melting/Charging Period (hrs)	**8**	**8**	**8**	**8**
Duration of Refining Period (hrs)	**8**	**8**	**8**	**8**
Product Type	**1445**	**1445**	**1445**	**--**
Production (tons/hr)	**0.0347**	**0.0347**	**0.0347**	**0.0347**

[a] During the third run the particulate filter used to collect filterable particulate ripped. Therefore, the filterable fraction of the third run could not be determined. The total particulate emission rate for the third run is an approximation and should be used with caution. If particulate passed by the ripped filter it would have likely been collected in the impingers portion (condensable portion) of the sampling system. This run was not included in the average in above, but it was included in the average of the test report.

TABLE 3: Furnace No. 7 Baghouse Inlet Chromium

TESTING PARAMETERS (Inlet Chromium)	Run 1	Run 2	Run 3	Average
Test Date	4/26-27/2016	4/27-28/2016	4/28-29/2016	--
Test Time	1730-0930	1730-0930	1700-0900	--
Exhaust Gas Temperature (^{o}F)	167	163	181	171
Exhaust Gas Moisture (%)	1	2	3	2
Exhaust O_2 (% dry vol)	20.5	20.5	20.6	20.5
Exhaust CO_2 (% dry vol)	2.0	2.0	1.5	1.8
Exhaust Gas Flow Rate (dscfm)	430	390	370	400
Chromium Sample Volume (dscf)	202	148	144	165
Mass of Total Chromium Collected (mg)	1.81-1.88[b]	0.98-1.02[b]	0.44-0.48[b]	1.08-1.12[b]
Mass of Hexavalent Chromium Collected (mg)	1.77-1.84[b]	1.03-1.06[b]	0.43-0.47[b]	1.08-1.12[b]
Total Chromium Emissions:[b]				
• ng/dscm	316,700-328,700	234,400-242,200	108,200-117,900	219,800-229,600
• lb/hr	0.00051-0.00053	0.00034-0.00035	0.00015-0.00017	0.00034-0.00035
• lb/ton of Glass Produced	0.015-0.015	0.010-0.010	0.004-0.005	0.010-0.010
• lb/ton of Chromium Used	2.03-2.11	1.35-1.39	0.60-0.66	1.33-1.39
Hexavalent Chrome Emissions:[b]				
• ng/dscm	309,400-321,200	245,800-254,000	105,700-115,400	220,300-230,200
• lb/hr	0.00050-0.00052	0.00036-0.00037	0.00015-0.00016	0.00034-0.00035
• lb/ton of Glass Produced	0.014-0.015	0.010-0.011	0.004-0.005	0.010-0.010
• lb/ton of Chromium Used	1.98-2.06	1.41-1.46	0.59-0.64	1.33-1.39
Isokinetic Variation (%)	93	95	95	94
Conversion of Trivalent to Hexavalent Chrome (%)	97.5	*100*[c]	97.7	98.4
Baghouse Pressure Drop (inches of water column)	5.5	5.3	5.7	5.5
Furnace Temperature (^{o}F)	2415	2410	2443	2423
Duration of Melting/Charging Period (hrs)	8	8	8	8
Duration of Refining Period (hrs)	8	8	8	8
Product Type	1445	1445	1445	--
Trivalent Chromium Usage in the Batch (lbs)	8.1	8.1	8.1	8.1
Production (tons/hr)	0.0347	0.0347	0.0347	0.0347

[b] The values are given as a range because a portion of the sample was used to measure the pH of the chrome absorbing solution, but that portion of the absorbing solution was not sent to the laboratory. The lower end of the range is the amount of chromium measured and assumes the absorbing solution contained no chromium. The higher end of the range is the amount of chromium measured plus it adds the amount of chromium that was not measured with the assumption that it contained as much chromium at the time of the pH measurement as at the end of the test.

[c] The data shows the conversion rate to be over 100%. Since it is not possible to have more than 100% conversion, the conversion rate shown is 100%.

TABLE 4: Furnace No. 7 Baghouse Oulet Chromium

TESTING PARAMETERS (Outlet Chromium)	Run 1	Run 2	Run 3
Test Date	**Not Tested**	**Note Tested**	**4/28-29/2016**
Test Time	**Not Tested**	**Note Tested**	**1700-0900**
Exhaust Gas Temperature (^oF)	**Not Tested**	**Note Tested**	**140**
Exhaust Gas Moisture (%)	**Not Tested**	**Note Tested**	**1**
Exhaust O_2 (% dry vol)	**Not Tested**	**Note Tested**	**20.74**
Exhaust CO_2 (% dry vol)	**Not Tested**	**Note Tested**	**1.01**
Exhaust Gas Flow Rate (dscfm)	**Not Tested**	**Note Tested**	**500**
Chromium Sample Volume (dscf)	**Not Tested**	**Note Tested**	**124**
Mass of Total Chromium Collected (mg)	**Not Tested**	**Note Tested**	**0.102-0.104[b]**
Mass of Hexavalent Chromium Collected (mg)	**Not Tested**	**Note Tested**	**0.099-0.100[b]**
Total Chromium Emissions: • **ng/dscm** • **lb/hr** • **lb/ton of Glass Produced** • **lb/ton of Chromium Used**	**Not Tested**	**Note Tested**	**[b]** **29,200-29,500** **0.000055-0.000055** **0.0016-0.0016** **0.217-0.219**
Hexavalent Chromium Emissions: • **ng/dscm** • **lb/hr** • **lb/ton of Glass Produced** • **lb/ton of Chromium Used**	**Not Tested**	**Note Tested**	**[b]** **28,300-28,600** **0.000053-0.000054** **0.0015-0.0015** **0.210-0.212**
Isokinetic Variation (%)	**Not Tested**	**Note Tested**	**95**
Conversion of Trivalent to Hexavalent Chromium (%)	**Not Tested**	**Note Tested**	**96.9**
Removal Efficiency of Hexavalent Chromium (%)	**Not Tested**	**Note Tested**	**62.9-67.2[b]**
Baghouse Pressure Drop (inches of water column)	**Not Tested**	**Note Tested**	**5.7**
Furnace Temperature (^oF)	**Not Tested**	**Note Tested**	**2443**
Duration of Melting/Charging Period (hrs)	**Not Tested**	**Note Tested**	**8**
Duration of Refining Period (hrs)	**Not Tested**	**Note Tested**	**8**
Product Type	**Not Tested**	**Note Tested**	**1445**
Trivalent Chromium Usage in the Batch (lbs)	**Not Tested**	**Note Tested**	**8.1**
Production (tons/hr)	**Not Tested**	**Note Tested**	**0.0347**

[b] The values are given as a range because a portion of the sample was used to measure the pH of the chrome absorbing solution, but that portion of the absorbing solution was not sent to the laboratory. The lower end of the range is the amount of chromium measured and assumes the absorbing solution contained no chromium. The higher end of the range is the amount of chromium measured plus it adds the amount of chromium that was not measured with the assumption that it contained as much chromium at the time of the pH measurement as at the end of the test.

VII) Concerns & Comments:

1) During the third run the particulate filter ripped. Therefore, the filterable fraction of the third run could not be determined. The total particulate emission rate for the third run is an approximation and should be used with caution. If particulate made it passed the ripped filter it should have been collected in the impingers portion of the sampling system. This run was not included in the average in Table 2 of this memo, but it was included in the average of the test report.

2) The first run's inlet filter appeared to have had a drop of liquid fall on it after the sample was collected. This would have had little to no affect on the results. Therefore, this run was used in the averages found in Table 1 of this memo.

3) The furnace appears to have been operated in an oxidizing environment. This is evident by the lack of methane at the exhaust of the furnace. Had the furnace been operating with an oxygen to fuel ratio as described in the test report excess fuel (methane) would have been present in the exhaust. Almost no methane was detected, what methane was detected can be found in concentration in the ambient air which most of the exhaust from the baghouse was.

4) A portion of the sample was used to measure the pH of the chrome absorbing solution, but that portion of the absorbing solution was not sent to the laboratory. Therefore, the exact results of this test are not known. Tables 3 and 4 give a range of possible results.

5) On page 15 of the test report, in the second paragraph of the discussion section, it is noted that some sample concentrations for hexavalent chrome are higher than the total chrome and that there is significant variation in chrome emissions. However, it is not uncommon to see this amount of variation in test results, which is why we require multiple test runs. Staff from the laboratory that measured the concentrations of total and hexavalent chromium stated that the margin of error for their continuous calibration was +/- 10%. The difference in total and hexavalent chromium was only +/- 5%. Therefore, variations in the hexavalent chromium concentrations are well within the margins of error for the test, and should not be disregarded for these reasons.

6) Further into the discussion section of the test report it states that the levels of hexavalent chrome were likely to have increased due to the hot (750 ^{o}F) furnace exhaust coming into contact with ambient (cool) air and associated oxygen. According to literature read and consultations with DEQ laboratory staff, it is not likely much trivalent chromium would convert to hexavalent chromium. Also the residence time from when the furnace exhaust mixed with the ambient air until it was sampled was less than a second, not giving the reaction much time to convert trivalent chromium to hexavalent chromium. Evidence shows that the furnace was in an oxidizing state therefore it is likely that the majority or all the trivalent chrome converted to hexavalent chrome in the furnace, and not at the much cooler temperature (750^{o}F) of the cooling air mixing zone.

VIII) Overall Evaluation: The test methods conducted and the data provided were sufficient to evaluate the particulate emissions for the unit tested. The test methods conducted and the data provided are sufficient to show the conversion rate of trivalent chromium to hexavalent chromium given the furnace operating conditions and the baghouse configuration during the testing. The chromium test completed at the inlet to the baghouse gave us a range of emission rates from this furnace with these operating conditions of an uncontrolled furnace. The single chromium test run at the outlet of the baghouse indicates the particulate collection efficiency is not equal to the chromium control efficiency. To verify the chromium control efficiency more testing would need to be completed.

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Acronym List

PM = Particulate Matter
^{o}F = Degrees Fahrenheit
mg = Millagrams
lbs = Pounds
hrs = Hours
est. = estimated
% = Percent
% dry vol = Percent on a Dry Volume Basis
O_2 = Oxygen
CO_2 = Carbon Dioxide
dscfm = Dry Standard Cubic Feet per Minute
dscf = Dry Standard Cubic Feet
gr/dscf = Grains per Dry Standard Cubic Foot
ng/dscm = Nanograms per Dry Standard Cubic Meter
lb/hr = Pounds per Hour
lb/ton of glass produced = Pounds per Ton of Glass Produced
lb/ton of chromium used = Pounds per Ton of Chromium Used
tons/hr = Tons per Hour