Best Available Mercury Reduction Technology Analysis and Proposed Alternative Mercury Emissions Reduction Plan

Prepared for
ArcelorMittal Minorca Mine Inc.

December 2018

Appendix B (B-5)

Historical Mercury Reduction Research Reports

Appendix B

Historical Mercury Reduction Research Reports

Appendix B-5

Site-Specific Evaluations

Contents

Appendix B-5-1

ArcelorMittal Minorca Mine Inc. Activated Carbon Injection Testing to Control Mercury Air Emissions: Results of Extended Testing

September 2018

BARR

Activated Carbon Injection Testing To Control Mercury Air Emissions

Results of Extended Testing

Prepared for
ArcelorMittal Minorca Mine Inc.

ArcelorMittal

September 2018

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Activated Carbon Injection Testing To Control Mercury Air Emissions

September 2018

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Acronyms and Abbreviations

Acronym	**Description**
ACI	Activated Carbon Injection
Barr	Barr Engineering Co.
BPAC	Brominated Powdered Activated Carbon
EPA	U.S. Environmental Protection Agency
Hg	Mercury
HgG	Vapor Phase Mercury
HgP	Mercury Adsorbed to Particulates
HgT	Total Mercury
Hg^0	Elemental Mercury
Hg^{++}	Oxidized Mercury
HPAC	High Temperature Brominated Powdered Activated Carbon
Minorca	ArcelorMittal Minorca Mine Inc.
lb/mmacf	Pound Per Million Actual Cubic Feet
MPCA	Minnesota Pollution Control Agency
NTS	Northeast Technical Services
PAC	Powdered Activated Carbon
PM	Particulate Matter
TMDL	Total Maximum Daily Load

1.0 Executive Summary

ArcelorMittal's Minorca Mine Inc. (Minorca) conducted extended testing of activated carbon injection (ACI) to determine its feasibility to reduce mercury (Hg) air emissions from the indurating furnace. This effort is a continuation of the study of Hg reduction technologies for the taconite industry in order to comply with Minnesota Hg rules (Minn. R. 7007-0502) by 2025. Previous ACI testing at Minorca suggested that the technology has the potential to reduce Hg air emissions. However, the results from previous ACI testing identified areas that warranted additional testing in order to determine if ACI is technically and economically feasible for a full-scale installation. In addition to ACI, previous research indicated re-routing the scrubber solids to the tailings thickener provides an opportunity for additional Hg reduction. This correlation was also evaluated along with ACI testing.

Minorca followed a test plan developed by Barr Engineering Co. (Barr). Previous testing indicated that two commercially available powdered activated carbons (PACs), HPAC and BPAC, yielded the highest likelihood of reducing Hg emissions. Baseline and PAC screening tests were conducted to establish normal operating conditions to determine the best PAC for extended testing. Screening tests identified HPAC as the best candidate for extended testing because it showed the highest potential reduction in Hg emissions.

Extended ACI testing was conducted starting on January 20, 2017 and ended on April 7, 2017 at an injection rate of 1 pound per million actual cubic feet (lb/mmacf) of flue gas into the windbox exhaust duct work prior to the multiclones. Extensive process sampling and stack testing were conducted during the extended testing to study process impacts and determine the technology's ability to reduce Hg air emissions. Additional process sampling and stack testing were conducted when Minorca had re-routed the scrubber solids to discharge to the tailings thickener to determine its impact on Hg emissions.

ACI at an injection rate of 1 lb/mmacf did not result in a reduction of total Hg (HgT) emissions when accounting for the change in stack emissions and the amount of Hg entering the furnace with the greenball feed. Any change in the Hg emission rate was a result of the varying Hg content of the greenballs being fed to the furnace. Therefore, ACI at an injection rate of 1 lb/mmacf is not considered to be a potential control technology for a full-scale implementation. Re-routing scrubber solids to the tailings thickener reduced HgT emissions by 22% or 21% depending on the calculation methodology.

2.0 Introduction

2.1 Project Purpose and Scope

2.1.1 Background

The Minnesota Pollution Control Agency (MPCA) developed a state-wide Hg Total Maximum Daily Load (TMDL) to address Hg concentrations in Minnesota's lakes and streams, which was approved by the U.S. Environmental Protection Agency (EPA) in March 2007. The TMDL addresses impaired waters by evaluating the sources of Hg pollution, pollutant reduction necessary to meet water quality standards, and the allowable levels of future pollution. In Minnesota, mercury is primarily introduced to surface waters through atmospheric deposition. The TMDL recognized that a majority of the mercury deposited in the state originates from emission sources outside of the state; only 10% of total deposition within Minnesota is from sources within the state.

The TMDL specifies that in order to meet water quality standards, a 93% reduction from 1990 human-caused, air-deposited mercury levels is required. In accordance with the TMDL, the taconite processing sector has committed to a 75% reduction of mercury emissions by 2025.

The TMDL Implementation Plan notes that "mercury-reduction technology does not currently exist for use on taconite pellet furnaces. Therefore, achieving the 75% mercury reduction target will incorporate the concept of adaptive management by focusing on research to develop the technology in the near term and installation of mercury emission control equipment thereafter." The adaptive management criteria states that the control technology must be technically and economically feasible, it must not impair pellet quality, and it must not cause excessive corrosion to pellet furnaces and associated ducting and emission-control equipment.

Minorca previously conducted ACI testing in order to determine the technology's ability to reduce Hg air emissions and if it is technically and economically feasible. In 2013, in what was known as Phase II, five taconite companies tested ACI along with Minorca. Phase II testing indicated that ACI cannot reduce Hg emissions enough to meet the goal of the Hg TMDL. Vapor phase mercury (HgG) reductions from the five facilities ranged from 48% - 82% (81% for Minorca), but total mercury reductions, the combination of HgG and particulate bound mercury (HgP) ranged from 25% - 61% (54% for Minorca). Results varied from site to site due to intrinsic differences in furnace design, configuration, and operation. None of the facilities demonstrated non-compliance during particulate matter (PM) stack testing, but significantly higher PM flow weighted averages were noted during ACI. Phase II testing also failed to adequately determine all possible plant impacts. Refer to Attachment A for a complete copy of the Phase II test report. In addition, the MPCA identified concerns with the methods employed during the testing to measure mercury air emissions (Attachment B). Therefore, additional testing of ACI was warranted.

Since the Phase II testing, Minnesota has finalized state regulations (Minn. R. 7007.0502) that require Minorca to reduce Hg emissions by January 1, 2025 to no more than 28% of the Hg emitted in 2008 or 2010, whichever is greater. The state regulations also require Minorca to submit a Hg emissions reduction plan by December 30, 2018 to show how Minorca will achieve the 72% reduction, or propose an alternate plan if Minorca concludes that a 72% reduction is not technically achievable.

Minorca has chosen to use an approach similar to EPA's five-step top down Best Available Retrofit Technology analysis to determine whether a given Hg control technology is technologically and economically feasible. Minorca will also evaluate technologies against the adaptive management criteria outlined in the TMDL. The new rules (Minn. R. 7007.0502) do not formally incorporate all four of the adaptive management criteria for consideration when evaluating mercury reduction technologies for feasibility. However, in the response to comments and discussions with the agency, the MPCA has indicated that any evaluation of potential mercury reduction technologies may consider all four adaptive management criteria to determine if a potential mercury reduction technology is suitable for application. In order to assess the feasibility of ACI for the Hg emissions reduction plan, Minorca determined that additional evaluation was required. This round of ACI testing was used to provide a better estimate of ACI's ability to reduce Hg emissions and address other questions or concerns identified during Phase II testing:

- The original test plan was too short of duration to determine process impacts.
- The MPCA did not approve the use of a modified EPA Method 30B stack test method to estimate HgT emissions during Phase II testing. Also, when utilizing ACI, HgP is present and cannot be measured by EPA Method 30A (Hg CEMS).
- Higher particulate emission rates from varying ACI rates posed the concern of compliance with existing PM emission limits for the indurating furnace.
- Re-routing scrubber solids to the tailings thickener provides an additional opportunity for Hg reduction. Minorca also studied the impact of this process change with and without ACI to observe its effect on Hg emissions.

Minorca followed a test plan developed by Barr (Refer to Attachment C). The test plan sought to determine several important aspects of the technology and address any MPCA comments from Phase II (Refer to Attachment B). The key question to be answered was what amount of Hg capture is possible with ACI at a lower injection rate in order to ensure compliance with particulate limits while also monitoring other aspects of the process to determine the technical and economic feasibility for implementation of a full-scale ACI system? The testing was performed while the process was operated under two different conditions: recycling vs. removing scrubber solids from the process. Current operations at Minorca recycle scrubber solids back to the concentrate thickener. This allows for the Hg captured by the wet scrubbers to be recycled back to the process and potentially emitted again out the stack. Removing scrubber solids from the process means that the scrubber solids are redirected to the tailings thickener. This would route Hg contained in the scrubber solids to the tailings basin. According to a report by the Coleraine Minerals Research Laboratory (Attachment D), Hg contained in the scrubber solids would not leach from the tailings basin. Therefore, the tailings basin acts as a "sink" for Hg disposal.

2.1.2 Goals of Testing

Testing sought to answer several questions regarding the feasibility of ACI for Hg control. These include:

- Determine percentage reduction in HgT (HgP and HgG combined) emissions using ACI at an injection rate of 1 lb/mmacf of flue gas.
- Determine final destination of Hg following capture by ACI.
- Evaluate scrubber performance with additional ACI loading via particulate stack testing.
- Determine the amount of Hg emitted through the stack without ACI and with ACI.
- Evaluate all forms of Hg stack emissions such as vapor and particulate as well as elemental Hg (Hg^0)/oxidized Hg (Hg^{++}) (conducting stack tests during ACI testing).
- Quantify operating and maintenance cost at a specified injection rate.
- Determine if ACI is a technically feasible control technology to reduce Hg emissions.
- Determine if the selected ACI is an economically feasible control technology to reduce Hg emissions.
- Measure and analyze the impact of ACI on pellet quality.
- Measure and analyze maintenance and equipment issues associated with ACI.
- Document abnormal erosion/corrosion issues with plant equipment and ductwork during post shutdown visual inspections.
- Identify safety/hygiene issues with ACI.
- Identify any non-air quality environmental impacts.

Testing also served the purpose of determining the impact of removing scrubber solids from the process on Hg emissions.

2.2 Facility Description

Minorca mines taconite ore (magnetite) and produces iron pellets that are shipped to the company’s blast furnace in Indiana.

Concentrate slurry flows to a storage tank where limestone is added to make flux pellets. The concentrate is dewatered by vacuum disk filters, mixed with bentonite and conveyed to balling disks. Greenballs produced on the balling disks are transferred to a roll conveyor for additional removal of over- and undersize material.

The greenballs are distributed evenly across pallet cars, prior to entry into the pellet furnace. The pallet cars have a layer of fired pellets, called the hearth layer, on the bottom and sides of the car. The hearth layer acts as a buffer between the pallet car and the heat generated through the exothermic conversion of magnetite to hematite.

There is one natural gas fired furnace at Minorca’s taconite plant. The straight grate furnace has several distinct zones. The first two stages are updraft and downdraft drying zones. The next zones are the preheat zone and firing zone. The temperature increases as the pellets pass through each zone, reaching a peak in the firing zone. The pellets enter the after-firing zone, where the conversion of magnetite to hematite is completed. The last two zones are cooling zones that allow the pellets to be discharged at a temperature of around 120 degrees Fahrenheit.

Heated air discharged from the two cooling zones is recirculated to the drying, preheat and firing zones. Off-gases from the furnaces are vented primarily through two ducts, the hood exhaust that handles the drying and recirculated cooling gases, and the windbox exhaust, which handles the preheat, firing, and after-firing gases. The windbox exhaust flows through a multiclone dust collector, which protects the downstream fan, and then enters a common header shared with the hood exhaust stream. The exhaust gases are subsequently divided into four streams which lead to four venturi rod scrubbers and exhaust from individual stacks (Furnace Stacks A-D). Under normal operations, the captured scrubber solids from each of the four scrubbers are routed back to the concentrate thickener. Figure 2-1 provides a simple sketch of this process.

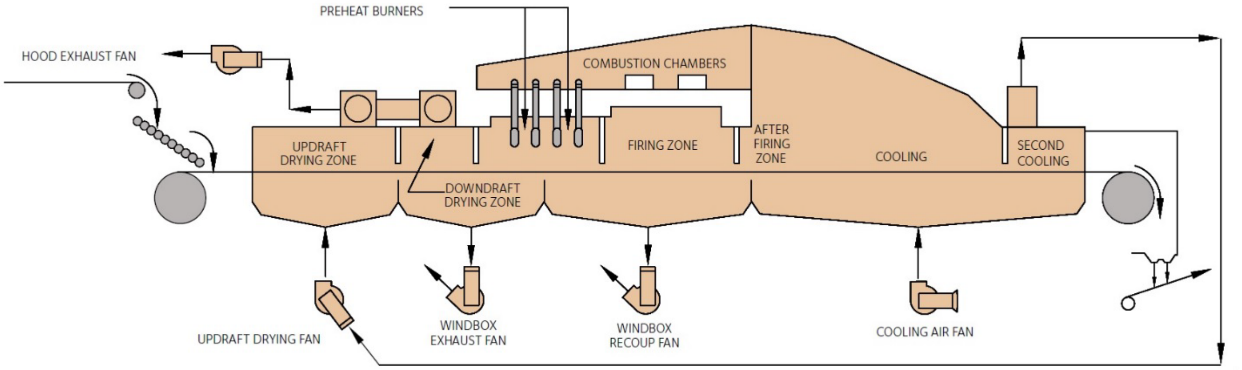

Figure 2-1 **Schematic of Minorca’s Indurating Furnace**

The majority of Hg entering the process comes from the ore. Hg is rejected from the process in tailings streams or stack emissions from the indurating furnace. Stack emissions are dependent on the Hg content of the greenballs and the rate that the greenballs are fed to the furnace. Hg is emitted to the atmosphere through each of the exhaust stacks mentioned above as Hg is liberated from the greenballs during the induration process. The hood exhaust contains lesser amounts of Hg compared to the windbox exhaust. Some mixing between the hood and windbox occurs in the common scrubber header, but the majority of the windbox exhaust exits through Stacks C and D along with the majority of the Hg from the furnace. Hg emissions out the stack can be in several different forms: HgG (in the form of Hg^0 or Hg^{++}) or HgP.

3.0 Equipment Details, Data Acquisition, Sampling Methods, and Stack Test Methods

3.1 ACI Details

Nol-Tec was awarded the contract to be the ACI equipment supplier and operator. The Nol-Tec report provided in Attachment E contains details of the testing equipment (Note: Appendix C of the Nol-Tec report is available upon request, but is not included due to file size constraints). Nol-Tec was responsible for operating the testing skid and ensuring that the injection rate was maintained at 1 lb/mmacf. This injection rate was selected because during Phase II pre-screen testing it achieved up to a 63% reduction in HgG emissions in Stack D. Also, Minorca wanted to minimize the risk of not complying with PM limits as well as reduce the amount of HgP being emitted out of the stacks. In addition, particulate emission increases were a concern as a full-scale installation may require additional air quality permitting.

To maintain consistency, PAC was injected in the same location as the previous Phase II ACI testing. Therefore, differences in Hg reduction compared to prior testing would not be due to a change in the distribution of PAC in the waste gas. PAC was injected into each of the three windbox exhaust ducts prior to the multiclones. See Figure 3-1 for a schematic of the injection pattern.

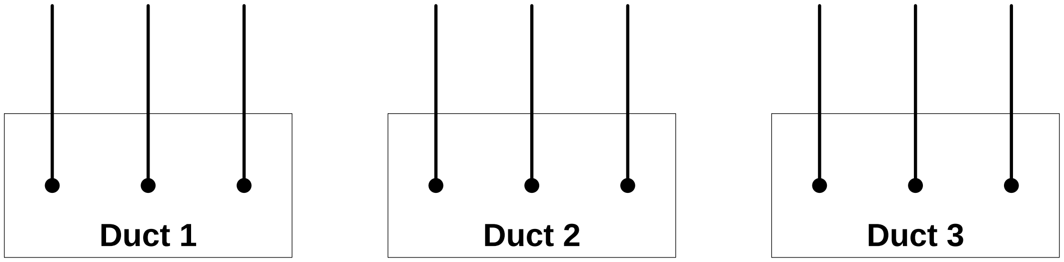

Figure 3-1 ACI Lance Arrangements in the Windbox Exhaust Ducts

It was decided to inject PAC only into the windbox exhaust because Phase II testing showed that the hood exhaust contains small amounts of Hg compared to the windbox. The majority of the windbox exhaust is emitted out of Stacks C and D. Also, the hood exhaust has a significantly reduced residence time in the duct leading to the scrubber because it lacks a multiclone collector.

3.2 Re-routing of Scrubber Solids

Current operations at Minorca recycle scrubber solids back to the concentrate thickener. This allows for the Hg captured by the wet scrubbers to be recycled back to the process and potentially emitted out the stack unless captured again by the wet scrubbers. Removing scrubber solids from the process means that the scrubber solids are redirected to the tailings thickener. This would route Hg contained in the scrubber solids to the tailings basin. Scrubber solids were removed from the process during a portion of ACI and during a baseline test following ACI.

3.3 Mercury Stack Testing

3.3.1 Discussion of Available Test Methods

The following test methods were considered for each phase of ACI testing:

3.3.1.1 Ontario-Hydro Method or ASTM Method D6784-02

The Ontario-Hydro Method was developed to provide the speciation of Hg constituents from gaseous emissions. The test is used to estimate HgT, HgP, Hg^0, and Hg^{++} emission rates. Sampling is a batch method, performed isokinetically. The gas sample is drawn into a heated sample probe, through a heated glass filter. After the filtration, the gas phase passes through impingers submerged in an ice bath with potassium chloride solution where Hg^{++} mercury is captured. Hg^0 is captured in the remaining solutions of acidified peroxide and acidified potassium permanganate. Refer to Figure 3-2 for a schematic.

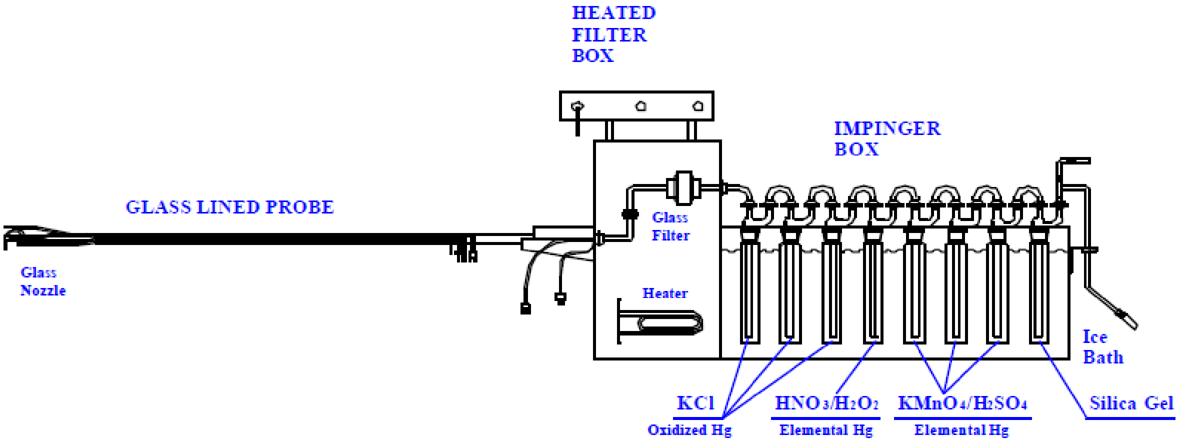

Figure 3-2 Ontario-Hydro Sampling Apparatus

The Ontario-Hydro Method is a very complex sampling method with many steps and the laboratory analysis can take 1-4 weeks to complete. This testing requires skilled testing staff for equipment and reagent preparations, test execution, sample recovery, DOT shipping qualified personnel and access to a qualified laboratory to analyze samples. Table 3-1 provides a summary of the benefits and drawbacks associated with the Ontario-Hydro Method.

Table 3-1 Considerations of Ontario-Hydro Method

Pros	Con
• Gives an accurate measure of HgT • Gives an estimate for HgP and HgG • Speciates Hg • Isokinetic sampling to collect a representative sample of particulate emissions in order to accurately quantify HgP • Is applicable to use in measuring emissions from taconite induration furnaces during ACI for Hg control	• Relatively difficult procedure to perform involving multiple steps • Requires special equipment and specially trained stack test personnel and a qualified laboratory • Produces an average of the Hg emission over the selected sample duration • Turnaround time is typically one to four weeks for lab analysis and data processing

3.3.1.2 EPA Method 29

EPA Method 29 was developed to measure metal emissions from gaseous emissions. The test is identical to the Ontario-Hydro Method with the exception that it cannot speciate HgG emissions into Hg^0 and Hg^{++} fractions. The only difference from Figure 3-2 is that EPA Method 29 does not have a glass impinger filled with potassium chloride. This testing requires skilled testing staff for equipment and reagent preparations, test execution, sample recovery, DOT shipping qualified personnel and access to a qualified laboratory to analyze samples. Table 3-2 provides a summary of the benefits and drawbacks associated with EPA Method 29.

Table 3-2 Considerations of EPA Method 29

Pros	Cons
• Gives an accurate measure of HgT • Gives an estimate for HgP and HgG • Isokinetic sampling to collect a representative sample of particulate emissions in order to accurately quantify HgP • Is applicable to use in measuring emissions from taconite induration furnaces during ACI for Hg control	• Relatively difficult procedure to perform involving multiple steps • Requires special equipment and specially trained stack test personnel and a qualified laboratory • Cannot speciate Hg • Produces an average of the Hg emission over the selected sample duration • Turnaround time is typically one to four weeks

3.3.1.3 EPA Method 30B

EPA Method 30B is a simple sampling method relative to EPA Method 29 or the Ontario-Hydro Method. EPA Method 30B should only be used in low-particulate gas streams with little or no HgP because the method is intended to measure HgG emissions. HgG can be assumed to be equal to HgT if HgP is negligible. The gas sample is pulled through carbon sorbent traps, which captures HgG. The sorbent traps contain two separate carbon beds with a wool plug prior to the beds to prevent any residual particulate from reaching the carbon. The first carbon bed is called the analytical bed that should contain most of the Hg captured during the test. The second carbon bed is called the breakthrough bed to capture any of the

Hg that might have broken through the analytical section. Refer to Figure 3-3 for a schematic. Both carbon beds and the wool plug are analyzed for Hg content and can be analyzed onsite shortly after testing to provide near real-time results. The wool plug is analyzed with the carbon beds for Hg content.

EPA Method 30B sampling is not performed isokinetically, which is why the test cannot be used to measure particulate Hg.

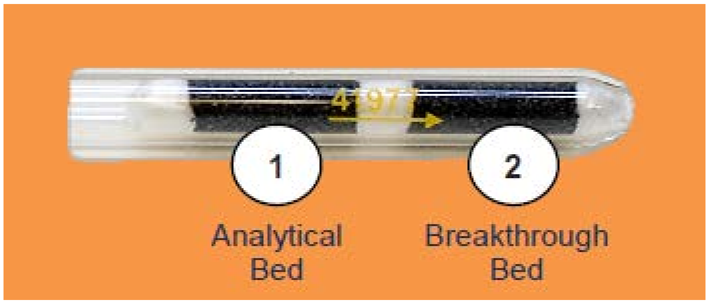

Figure 3-3 EPA Method 30B Sorbent Trap

EPA Method 30B is the least expensive testing option and is the best choice for any screening tests. Table 3-3 provides a summary of the benefits and drawbacks associated with EPA Method 30B.

Table 3-3 Considerations of EPA Method 30B

Pros	Cons
• Gives an accurate value for HgG at low detection limits in low particulate gas streams • Relatively inexpensive and easy to perform • Sample times can be set from 30 minutes to longer durations making it ideal for screening tests • Can be adapted to a continuous long-term measurement of Hg	• Designed to give HgG only in low particulate gas streams because sampling is not isokinetic • Cannot appropriately quantify HgP emissions. • Does not speciate • Produces an average of the Hg emission over the selected sample duration • Turnaround time is typically one to two weeks, unless an analyzer system is also purchased and personnel trained in its use for onsite analysis

During the Phase II testing, ADA-ES, Inc. used a modified version of EPA Method 30B in order to provide an estimate of HgP in the stacks, which allowed them to estimate HgT. Following the Phase II testing, the MPCA reviewed the initial results of the Phase II testing, including the modified EPA Method 30B results. MPCA identified concerns with the modified EPA Method 30B because the sampling does not occur isokinetically. Therefore, it cannot provide a proper estimate of HgP. This method was not used during ACI due to the presence of more HgP.

3.3.1.4 Hg Analyzers or Hg Continuous Emissions Monitoring Systems (Hg-CEMS)

Hg-CEMS were developed to provide real-time measurements of speciated HgG. Hg-CEMS cannot be used to measure HgP because it uses spectroscopy. This method would only be appropriate for low-particulate conditions or where minimal HgT is in the form of HgP. Atomic absorption and atomic fluorescence are susceptible to interference from typical source gas emission constituents (i.e. SO_2, NO_x, & water vapor). High dilution rates of source gas with nitrogen reduce the interferences but can impact reliability of low-level Hg concentrations (1 µg per cubic meter Hg). Significant particulate matter concentrations in the gas stream may require specific sample extraction probes to prevent potential Hg scrubbing from the filtration apparatus and additional maintenance during operations. To produce reliable results, Hg CEMS would require stable conditions, significant space (i.e. CEMS shelter), and may have line length limitations to the sampling tube from the probe to the analyzer.

Hg-CEMS require a significant capital investment and commitment to extensive maintenance and training. Therefore, this method is avoided due to its expense, complexity, and presence of particulates in the flue gas. Table 3-4 provides a summary of the benefits and drawbacks associated with Hg-CEMS.

Table 3-4 Considerations of Hg-CEMS

Pros	Cons
• Gives continuous, real time measurement of HgG • Speciates Hg	• Cannot measure particulate phase Hg • High capital cost • Requires a large commitment to training, operating and maintenance

3.3.1.5 Comparison of Available Test Methods

A summary of the available testing methods is provided in Table 3-5 below.

Table 3-5 Mercury Measurement Comparison

Method	Measurement Type	Measured Values	Speciating (Hg^{2+} and Hg^0)	Relative Ease of Method	Relative Cost	Turnaround Time
Ontario-Hydro	Average over selected duration	HgT, (HgG+HgP)	Yes	Difficult	Medium	1-4 weeks
EPA Method 29	Average over selected duration	HgT, (HgG+HgP)	No	Difficult	Medium	1-4 weeks
EPA Method 30B	Average over selected duration	HgG	No	Easy	Low	Onsite analysis to 2 weeks
Hg-CEMS	Real time Continuous	HgG	Yes	Difficult	High	Continuous

3.3.2 Test Method Selection

3.3.2.1 Baseline Testing Pre-ACI

Minorca has demonstrated that the majority of Hg emissions are emitted in the form of HgG (approximately 91%) and not HgP based on an EPA Method 29 stack test from 2015 (Refer to Attachment F for a summary of these results). Furthermore, EPA Method 30B was tested on Stack D at the same time and yielded a very similar emission rate. This validates the assumption that most of the Hg emitted at Minorca is in the form of HgG under the operating scenario which was captured during the 2015 EPA Method 29 test.

Utilizing the data from the 2015 stack test, limited HgP was identified. Therefore, Method 30B was utilized to establish a baseline. Hg-CEMS were not used because they must be operated under very close tolerances and as such, are difficult to maintain reliability in the taconite furnace environment.

3.3.2.2 PAC Screening Testing

In order to determine the most effective PAC for extended testing, only the reduction in gas phase Hg was monitored. Therefore, EPA Method 30B was used for this phase of testing. This is an appropriate method for analysis of Hg concentration in the stack exhaust because the reduction in HgG would be an indicator of a shift in Hg being adsorbed to the PAC. In addition, EPA Method 30B can provide relatively quick results compared to other test methods. Hg-CEMS were not chosen because of the high capital cost and the short duration of testing.

3.3.2.3 Extended ACI Testing

Due to the expected increase in HgP from the PAC, EPA Method 30B and Hg-CEMS were not recommended for analysis of Hg concentration in the stack exhaust during ACI testing. The Ontario Hydro Method was used for the extended ACI stack test events because the method provides an estimate of HgT and can speciate Hg between Hg^{++} and Hg^0.

3.3.2.4 Post ACI While Re-Routing Scrubber Solids

Without ACI, the EPA Method 29 test from 2015 demonstrates that the majority of Hg emitted out the stack is in the form of HgG. Therefore, EPA Method 30B was used for this baseline sampling event while scrubber solids were re-routed to the tailings thickener.

3.3.2.5 Hg Stack Test Selection Summary

Table 3-6 summarizes the selected Hg stack test method for each phase of testing.

Table 3-6 Selected Hg Stack Test Methods

Testing Phase	Stacks Tested	Hg Stack Test Method Utilized
Baseline #1 – Pre-ACI	A, B, C, and D	EPA Method 30B
PAC Screening	C and D	EPA Method 30B
Long Term #1	A, B, C, and D	Ontario-Hydro
Long Term #2	A, B, C, and D	Ontario-Hydro
Baseline #2 – Post-ACI	A, B, C, and D	EPA Method 30B

3.4 Particulate Stack Testing

During Phase II ACI testing, increased flow weighted filterable particulate emission rates were measured. Therefore, EPA Method 5 stack testing was performed for each phase of ACI (PAC screening and extended testing (Long Term #1 and #2 tests)) to compare against Minorca's PM limits and inform potential air quality permitting implications from a full-scale ACI system installation.

3.5 Process Sampling

All solid and slurry process samples were analyzed by Legend Technical Services, Inc. Solids were analyzed using EPA Method 7473 while slurries were analyzed using EPA Method 200.8. Liquid samples were sent to North Shore Analytical and were analyzed using EPA Method 1631E. Sampling was carried out by Minorca staff and Northeast Technical Services (NTS) in accordance with the clean hands/dirty hands procedure. Refer to Attachment G for details. Sampling results were sent by the laboratories to Barr for data analysis.

Minorca measured mass flow rates of the process were needed to study the mass balance of Hg before and after ACI. If the information was unavailable, historical operating data was used to supplement the analysis.

3.6 Process Parameter Monitoring

Minorca agreed to monitor several process parameters during extended testing to determine any secondary impacts from ACI. The list of monitored process variables is included in Attachment H.

4.0 Test Plan

4.1 Project Team

Barr was contracted by Minorca to perform stack testing, assist with process sampling, and analyze all data obtained from testing.

Nol-Tec was chosen as the ACI vendor and equipment supplier. Nol-Tec used Facilities Performance Group as a sub-contractor to operate the testing skid.

Process sampling was conducted by Minorca staff and NTS. Barr coordinated sampling events and materials for sample collection, and analysis of samples with a third party laboratory.

4.2 Schedule

The extended ACI test started with mobilization of the ACI equipment on January 4, 2017. Screening tests commenced on January 17, 2017 and extended testing started on January 20, 2017 and ended on April 7, 2017 for a total of 77 days prior to the April shutdown of the furnace. Minorca conducted baseline stack testing the week of December 12, 2016 prior to any ACI and the week of April 10, 2017 after ACI. Scrubber solids were re-routed to the tailings thickener for the April baseline stack test.

A detailed schedule outlining process sampling and stack testing is provided in Attachment I.

4.3 Testing Phases

ACI testing was separated into four phases. Each phase is summarized below.

4.3.1 Baseline Stack Testing Prior to ACI Testing and Process Sampling While Recycling Scrubber Solids

In order to determine any reduction in Hg emissions following ACI, it was necessary to establish a baseline. This emission rate was normalized with an average greenball feed rate of 350 dry long tons per hour to account for variations in the amount of Hg entering the process as it relates to stack emissions.

4.3.1.1 Stack Testing

Hg emissions were measured on all four stacks. As previously discussed, the 2015 EPA Method 29 test showed that the majority of Hg emitted out the stack is in the form of HgG. Therefore, the baseline Hg emission rate prior to ACI was determined by using EPA Method 30B. Three separate one-hour test runs were conducted.

4.3.1.2 Process Sampling

Following the Phase II testing, Minorca identified several processing locations that should be sampled for Hg concentrations to determine where Hg is present in the process and in what quantities to inform where Hg is moving throughout the process. This helped to compare the Hg mass flow rates and its ultimate fate before and after ACI. During baseline testing, the locations listed below were sampled during the stack testing event on December 13, 2017. Refer to Attachment J for details.

1. Rod Mill Discharge
2. Sands of Spiral Classifier to Tails Bin (cobber tails)
3. Spiral Classifier (overflow)
4. Tails Thickener (underflow) (fine tails)
5. Tails Thickener (overflow)
6. Finishers Concentrate Discharge to Concentrate Thickener/FMS Sump
7. Flotation Reject Product to Tailings Thickener
8. Concentrate Thickener Feed
9. Concentrate Thickener (underflow)
10. Concentrate Thickener (overflow)
11. Fluxstone Feed (from Fluxstone Slurry Storage Tank)
12. Binder Supply (feed to bin)
13. Repulper Tank (Concentrate Reclaim Feed to Acid Concentrate – Slurry Tank/Fluxed Concentrate – Slurry Tank)
14. Greenball (balling disc discharge)
15. Multiclones (windboxes recycle to concentrate thickener)
16. Scrubber Blowdown/Scrubber Sump
17. Final Pellet Sample
18. Make-up water sample from plant head tank/raw water feed to plant

In order to complete a mass balance, flow measurements were obtained from each sample location if possible, otherwise historical performance data was used.

4.3.2 PAC Screening

Phase II testing in 2013 indicated that two PAC types showed the greatest Hg reduction potential: high temperature brominated powdered activated carbon (HPAC) and brominated powdered activated carbon (BPAC). During Phase II, HPAC and BPAC achieved HgG reductions of 60% and 63%, respectively, with a 1 lb/mmacf injection rate as measured on Stack D. Therefore, Minorca performed screening tests to determine which PAC would be the best option for a long-term ACI test. Screening tests were conducted at an injection rate of 1 lb/mmacf on January 17, 2017 and January 18, 2017.

4.3.2.1 Stack Testing

Hg emissions were monitored using EPA Method 30B on Stacks C and D. Three test runs were conducted using each PAC type lasting a minimum of 30 minutes. In addition, Stacks C and D were tested using EPA Method 5 for filterable particulate matter emissions to compare with Minorca's PM limits. The PAC with the highest reduction in HgG emissions was used for the long-term ACI test. Comparing the reduction in HgG is appropriate for a screening test because this would indicate that the HgG is adsorbing to the PAC and thus becoming HgP to be captured more effectively by the wet scrubber.

HPAC was selected for long-term testing because it provided a lower HgG emission rate during the screening test even though it is more expensive and yielded higher particulate emission rates compared to BPAC. Refer to Table 4-1 for details.

Table 4-1 PAC Performance During Screening Tests

Carbon	Screening Results HgG, lb/yr, Stack C	Screening Results HgG, lb/yr, Stack D
BPAC	11.4	12.9
HPAC	9.7	10.6

4.3.2.2 Process Sampling

No process samples were taking during the PAC screening phase.

4.3.3 Extended ACI Testing with Performance Tests and Process Sampling

As a result of the screening ACI test, HPAC was chosen for extended testing. Injection started on January 20, 2017 and ended on April 7, 2017. Scrubber solids were recycled back to the concentrate thickener through February 13, 2017, consistent with normal operating conditions. Recycling scrubber solids can allow for Hg in the scrubber solids to be recycled back to the greenballs. After February 13, 2017, the scrubber blowdown stream (approximately 1,550 gpm) was routed to the tailings thickener (discharged to the tailings basin) for the remainder of ACI testing. This prevents Hg in the scrubber solids from recycling back to the process and ending up in the greenball feed.

4.3.3.1 Stack Testing

On February 7, 2017 through February 9, 2017, the Long Term #1 test during ACI was conducted using the Ontario Hydro Method to measure HgT emissions and EPA Method 5 to measure particulate emissions on all four stacks. Each stack was tested with three separate runs, each lasting two hours. The total Hg reduction was determined by comparing the HgT emissions to the baseline testing emission rate normalized with the average greenball feed rate of 350 dry long tons per hour.

On March 28, 2017 and March 29, 2017, the Long Term #2 test was conducted using the same methods as the Long Term #1 test. This was to determine the Hg emission rate with ACI while scrubber solids were routed to the tailings thickener for disposal into the tailings basin.

4.3.3.2 Process Sampling

During the stack test events, process sampling was conducted in the same manner as described in Section 4.3.1.2 above.

In addition to the process sampling that occurred during the Long Term #1 and #2 tests, specific locations in the process were sampled weekly throughout the ACI extended test. The weekly process sampling was used to monitor changes in Hg concentrations throughout the process. These locations are listed below. Refer to Attachment K for details.

1. Tails Thickener (underflow) (fine tails)
2. Tails Thickener (overflow)
3. Concentrate Thickener (underflow)
4. Concentrate Thickener (overflow)
5. Greenball (balling disc discharge)
6. Scrubber Blowdown/Scrubber Sump
7. Final Pellet Sample

Flow measurements were obtained from each sample location if possible, otherwise historical performance data were used.

4.3.4 Baseline Stack Testing After ACI Testing and Process Sampling While Scrubber Solids Routed to Tailings Thickener

After ACI ceased, baseline stack testing was conducted on April 11, 2017 and April 12, 2017 while scrubber solids were routed to the tailings thickener. This baseline stack testing event was conducted to determine if routing scrubber solids to the tailings thickener reduced Hg concentrations of the stack exhaust.

4.3.4.1 Stack Testing

Test methods used during this baseline stack testing event were the same as those described in Section 4.3.1.1 (i.e., Method 30B, measuring HgG only).

4.3.4.2 Process Sampling

During the stack test event, process sampling was conducted in the same manner as described in Section 4.3.1.2.

5.0 Results and Discussion

5.1 Stack Testing and Process Sampling Results

Only the process sampling data that provides insight on the performance or process impacts of ACI is discussed in this section. All other remaining process data collected is included in Attachment L. It is unclear if fluctuations in the Hg content of the process samples included in Attachment L is a result of ACI or is normal variability linked to the chemical make-up of the ore body being processed. A complete report of the stack test data from Barr is included in Attachment M.

Figure 5-1 below provides a summary of the stack testing results from each phase of testing along with the greenball feed rate and Hg content. The Hg inputs and outputs presented in the figure have been normalized to a greenball feed rate of 350 LT/hr. Hg emission rates from stack testing are the summation of all four stacks (A-D) emission rates. The following color designations were used:

- Orange lines/dots represent the HgT emission rate determined from stack testing.
- Red lines/dots represent the HgG emission rate determined from stack testing.
- Blue lines/dots represent the greenball feed rate. Note this is on the secondary y-axis on the right side of the graph.
- Purple lines/dots represent the mass flow rate of Hg fed into the process from the greenballs determined from process sampling.

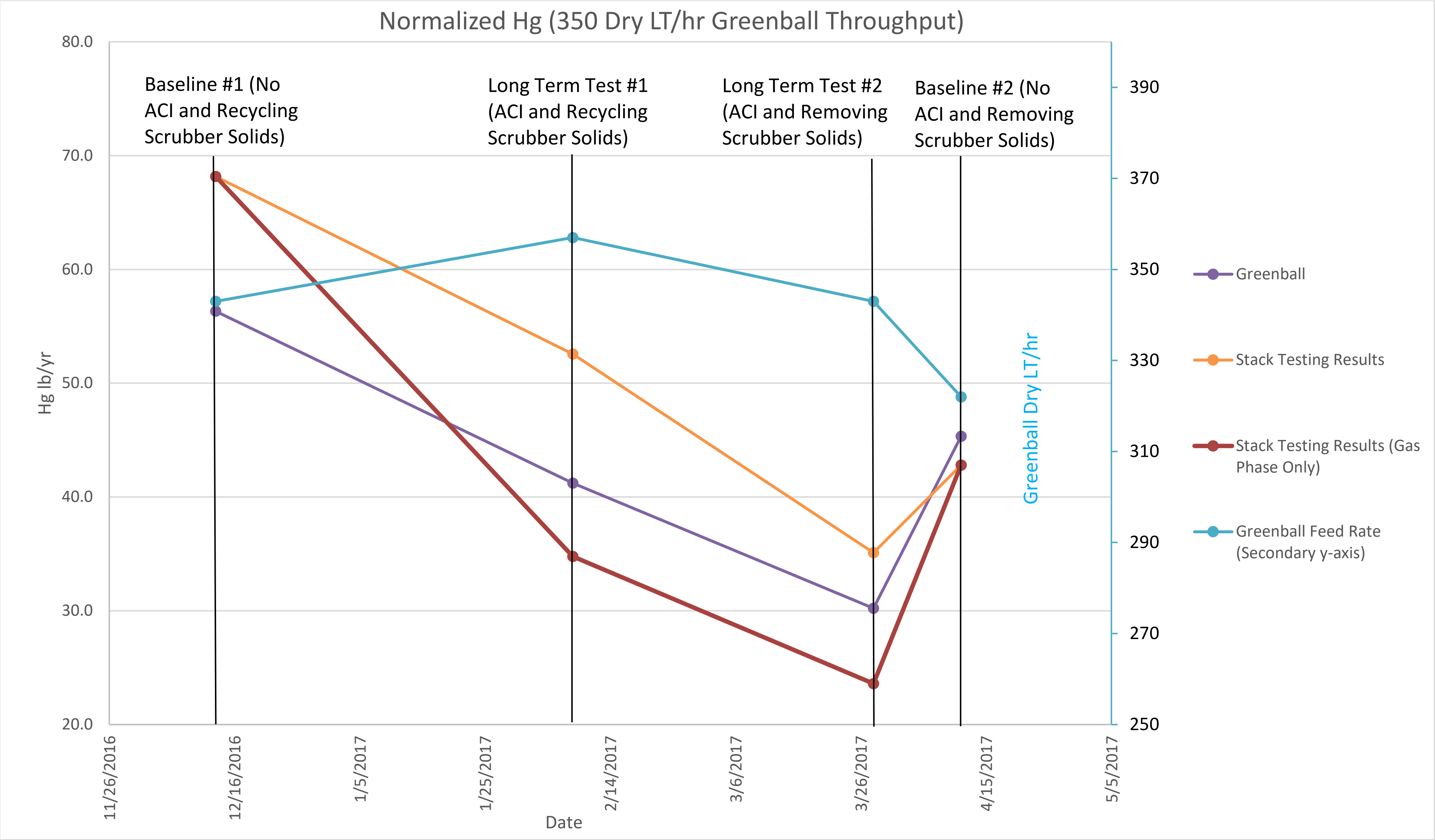

Figure 5-1 **ACI Stack Testing and Greenball Hg Results**

At first glance, it appears that the Hg emission rates were significantly reduced as a result of ACI (orange and red lines/dots) as shown from the Long Term #1 and #2 stack tests. However, the amount of Hg entering the furnace via the greenballs decreased in a similar fashion. To account for the Hg variation in the greenballs entering the furnace, the reduction in Hg emissions was calculated two ways. The first utilized a comparison of the ratio of the stack Hg to the greenball Hg. See Equation 1 for details.

Equation 1 Mercury Reduction Calculation Option #1

$$\boldsymbol{Hg\ Reduction}\ (\%) = \frac{\frac{\boldsymbol{Baseline\ Stack\ Hg}}{\boldsymbol{Baseline\ Greenball\ Hg}} - \frac{\boldsymbol{Test\ Condition\ Stack\ Hg}}{\boldsymbol{Test\ Condition\ Greenball\ Hg}}}{\frac{\boldsymbol{Baseline\ Stack\ Hg}}{\boldsymbol{Baseline\ Greenball\ Hg}}} * \mathbf{100}\%$$

The second alternative used to calculate the Hg reduction focused on the differences between stack and greenball Hg throughputs. See Equation 2 for details.

Equation 2 Mercury Reduction Calculation Option #2

$$Hg\ Reduction\ (\%) = \frac{(Baseline\ Stack\ Hg - Baseline\ Greenball\ Hg) - (Test\ Condition\ Stack\ Hg - Test\ Condition\ Greenball\ Hg)}{(Baseline\ Stack\ Hg - Baseline\ Greenball\ Hg)} * 100\%$$

The reductions in HgT observed at the stack cannot be attributed to ACI, but rather are directly related to Hg entering the furnace with the greenballs. Thus, ACI is ineffective at reducing HgT emissions under the testing conditions. HgG emissions appear to have decreased more than the Hg entering the process via greenballs when comparing the Baseline #1 and Long Term #1 tests. Therefore, the PAC did adsorb some of the Hg in the flue gas as HgG emissions decreased by 30% using Equation 1 and 27% using Equation 2, but overall Hg was still being emitted as HgP. This is validated by the fact that HgP accounted for 34% of the HgT emitted out of the stack during the Long Term #1 test in contrast to 9% under normal operating conditions with no ACI (refer to Attachment F).

When comparing the Baseline #1 test to the Long Term #2 test, stack HgT emissions decreased slightly more than the Hg entering the process with the greenballs. This suggests that the combination of ACI with the removal of scrubber solids from the process would provide little Hg control as HgT emissions decreased by 4% using Equation 1 and 10% using Equation 2. As discussed above, the reduction in HgT from ACI alone is negligible. Therefore, the reduction in HgT from Baseline #1 to the Long Term #2 test was only due to the removal of scrubber solids from the process. Under normal conditions, any Hg captured with scrubber solids would be recycled back to process. Removing this recycle explains the observed reduction in HgT.

This is confirmed by comparing the results of the Baseline #1 to the Baseline #2 test in that removing scrubber solids alone shows the potential to provide some reduction in HgT emissions as HgT emissions decreased by 22% using Equation 1 and 21% using Equation 2. HgT decreased more than the Hg entering the furnace with the greenballs compared to any other test. Again, this indicates that removing scrubber solids alone could provide some reduction in HgT emissions. This also reinforces the fact that any reduction in HgT observed between Baseline #1 and Long Term #2 test was not as a result of ACI.

The amount of HgT emitted out of the stack was higher than the Hg entering with the greenballs except during the Baseline #2 test. The amount of Hg coming out the stack during the Baseline #1, Long Term #1, and Long Term #2 stack sampling events were 21%, 28%, and 16% (respectively) higher than the Hg entering the furnace from the greenballs. This is in contrast to the Baseline #2 stack test event where the Hg coming out the stack was 94% of the Hg entering the furnace from the greenballs. Refer to Figure 5-4 for a snapshot of this trend. This variable amount of Hg entering the furnace compared to the Hg coming out the stack could be attributed to several factors:

- Equilibrium of Hg in the scrubber sump – It is possible that any Hg captured by the scrubbers is recycled via the scrubber sump and is then re-emitted as concentrations of Hg in the scrubber water change. This is not well understood and re-emission of Hg from the sump water could be affected by pressure, temperature, humidity, etc. It makes sense that percentage of stack Hg to greenball Hg during the Long Term #2 and Baseline #2 tests was lower than the Baseline #1 and Long Term #1 tests because the scrubber sump was directed to the tailings thickener. This greatly reduced the possibility of Hg recycle back to the scrubber water. Also, the scrubber sump sample during the Baseline #2 test contained no detectable amount of Hg.

- Varying accuracy of test methods - Care was taken to ensure that all process sampling and stack testing was performed in accordance with applicable standards and sampling techniques. However, it is possible that propagation of error or uncertainty in the measurement methods could create a noticeable difference. This is especially true given the low Hg concentration in the process samples or stack exhaust.

Stack and greenball Hg emission rates and throughputs were compared on a pound of Hg per dry long ton of greenball fed to the furnace during each test in Figure 5-2:

- Purple lines/dots represents the HgT stack testing results

- Yellow lines/dots represents the greenball Hg throughput

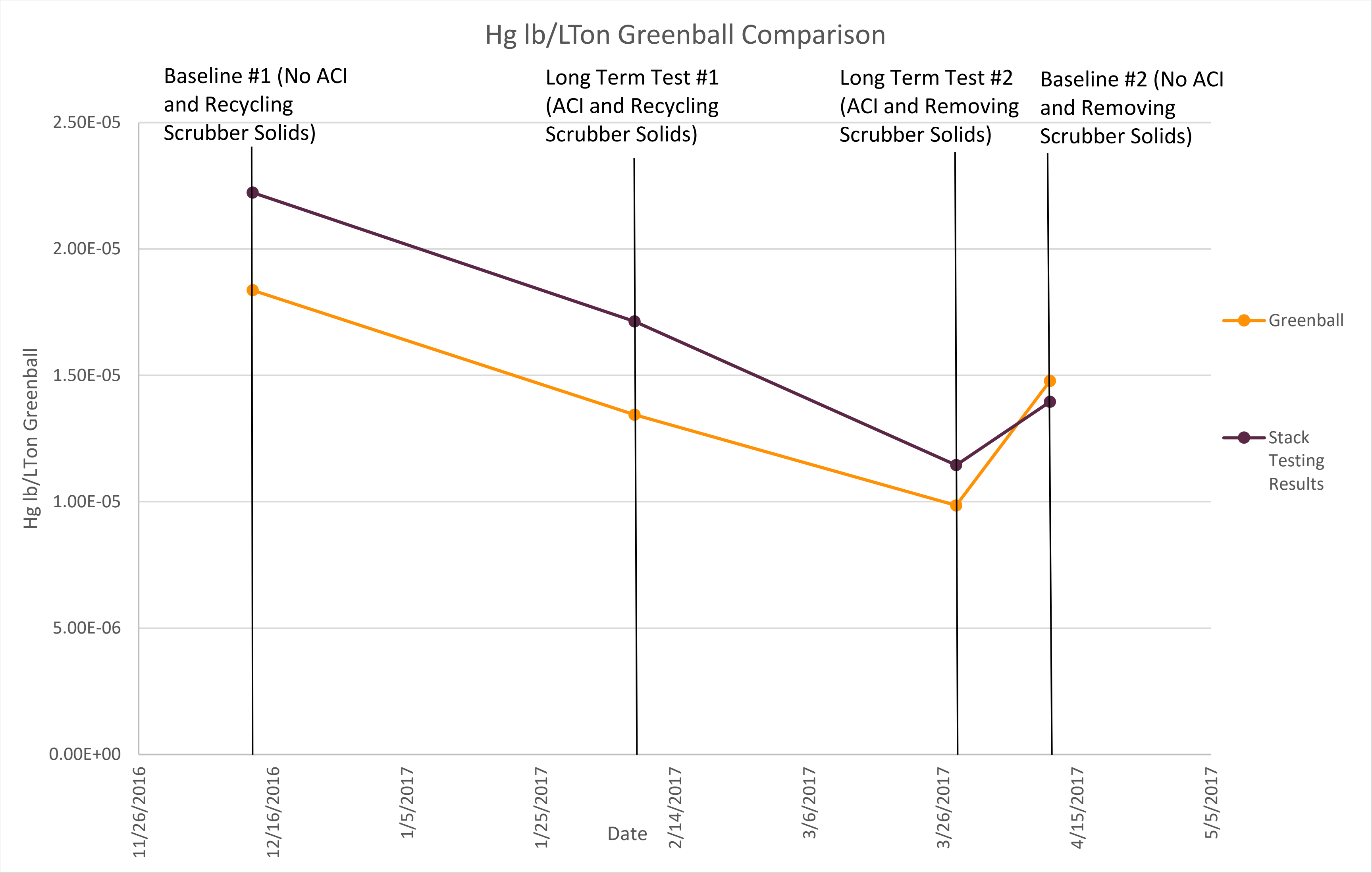

Figure 5-2 **Stack and Greenball Hg Comparison (lb/LTon)**

This comparison shows that greenball Hg decreases in parallel with the stack Hg between the Baseline #1 and the Long Term 1 tests. The reduction in stack exhaust is not a result of ACI, but rather the amount of Hg entering the process with the greenballs. Therefore, ACI did not reduce HgT emissions as calculated by Equation 1. Equation 2 yielded a HgT reduction less than 1%. As discussed previously, HgG decreased slightly more than HgT and the Hg entering the furnace with the greenballs. This demonstrates that the PAC was adsorbing some HgG, but was still being emitted in the form of HgP. This explains why HgT showed a negligible reduction. Therefore, ACI is not a potential control technology to reduce Hg emissions from Minorca's indurating furnace at the prescribed testing conditions (1 lb/mmacf injection rate).

It should be noted that the Ontario-Hydro Method (used during Long Term 1 and 2 tests) filters the PM from the stack exhaust prior to impinging the gas through acidic reagents to collect the gas phase Hg. Buildup of carbon on the sample filter may adsorb the gas phase Hg, giving a false indication of a reduction in HgG. This cannot be confirmed, but could explain why HgG emissions decreased slightly more than HgT from the Baseline #1 value to the Long Term 1 test. However, this does not change the conclusion that ACI did not achieve a noticeable reduction in HgT emissions.

Long Term #2 and Baseline #2 test data on a pound of Hg per long ton of greenballs basis shown in Figure 5-2 tells the same story as Figure 5-1. As previously described, any HgT reduction from ACI was negligible. Therefore, the reduction in HgT observed from Baseline #1 compared to the Long Term #2 and Baseline #2 tests were a result of the decreasing Hg content of the greenball feed and the removal of scrubber solids from the process by re-routing them to the tailings thickener.

Figure 5-3 provides a summary of all the Hg and particulate stack testing data. Note the following color codes:

- Black lines/dots represent the HgT stack testing results corrected only to the greenball feed rate.
- Green lines/dots represent the HgG stack testing results corrected only to the greenball feed rate.
- Yellow solid lines/dots represent the filterable particulate matter emission rate determined via stack testing. Refer to the secondary y-axis for this series.
- The yellow dashed line represents the average filterable particulate matter emission rate from 2015 stack testing. Refer to the secondary y-axis for this series.

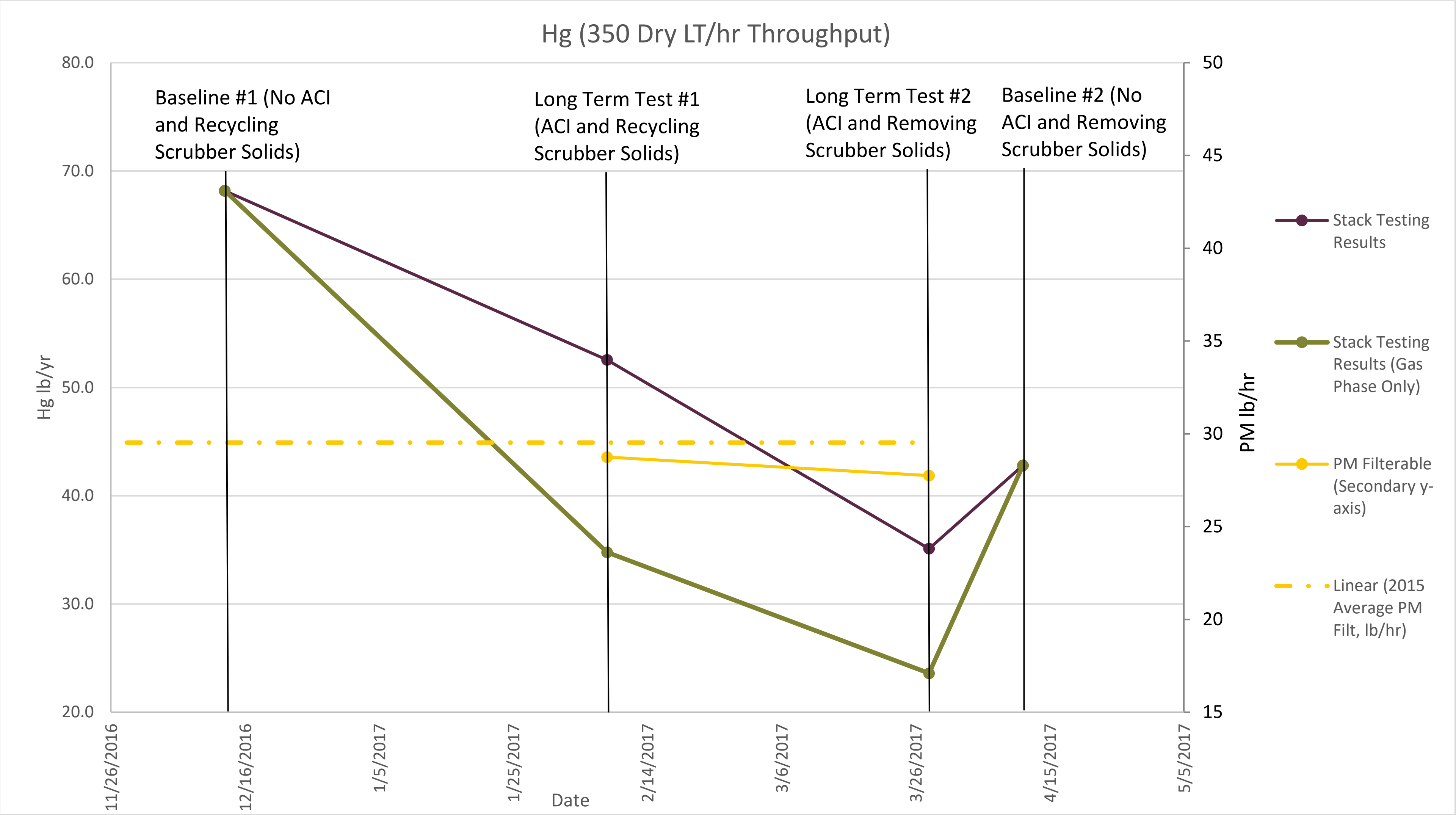

Figure 5-3 **ACI Stack Testing Comparisons**

Increased particulate emission rates as measured by the filterable particulates from EPA Method 5 in the stack exhaust were previously a concern from Phase II testing. Figure 5-3 indicates that the filterable particulate matter emission rate was not elevated during extended testing with ACI at an injection rate of 1 lb/mmacf compared to previous testing in 2015 with no ACI. Therefore, data from this extended test indicates that compliance with existing PM emission limits may be achieved at an injection rate of 1 lb/mmacf since the wet scrubbers were able to accommodate the increased particulate loading during the extended testing. It is unknown if long term full-scale installation of this technology would result in an actual increase in particulate emissions.

There were three instances that occurred on March 1st, 7th, and 11th, 2017 where the motor on the ACI auger was shut down for a period of time (5, 7, and 8 hours respectively). However, there is no evidence that suggests this short outage affected the Hg capture of ACI during the Long Term #2 test because the process still had 17 days to reach equilibrium.

Figure 5-4 provides additional trends from the scrubber sump sampling. Note the following color codes:

- Purple lines/dots represent the HgT stack testing data corrected to the greenball feed rate.
- Green lines/dots represent the scrubber sump process sampling that occurred during each stack test event.
- Blue lines/dots represent the scrubber sump weekly sampling that occurred during extended testing.
- Orange lines/markers represent the scrubber sump sampling during previous mass balance campaigns.
- The red line and yellow triangles represent the percentage of stack Hg to greenball Hg on the secondary y-axis.

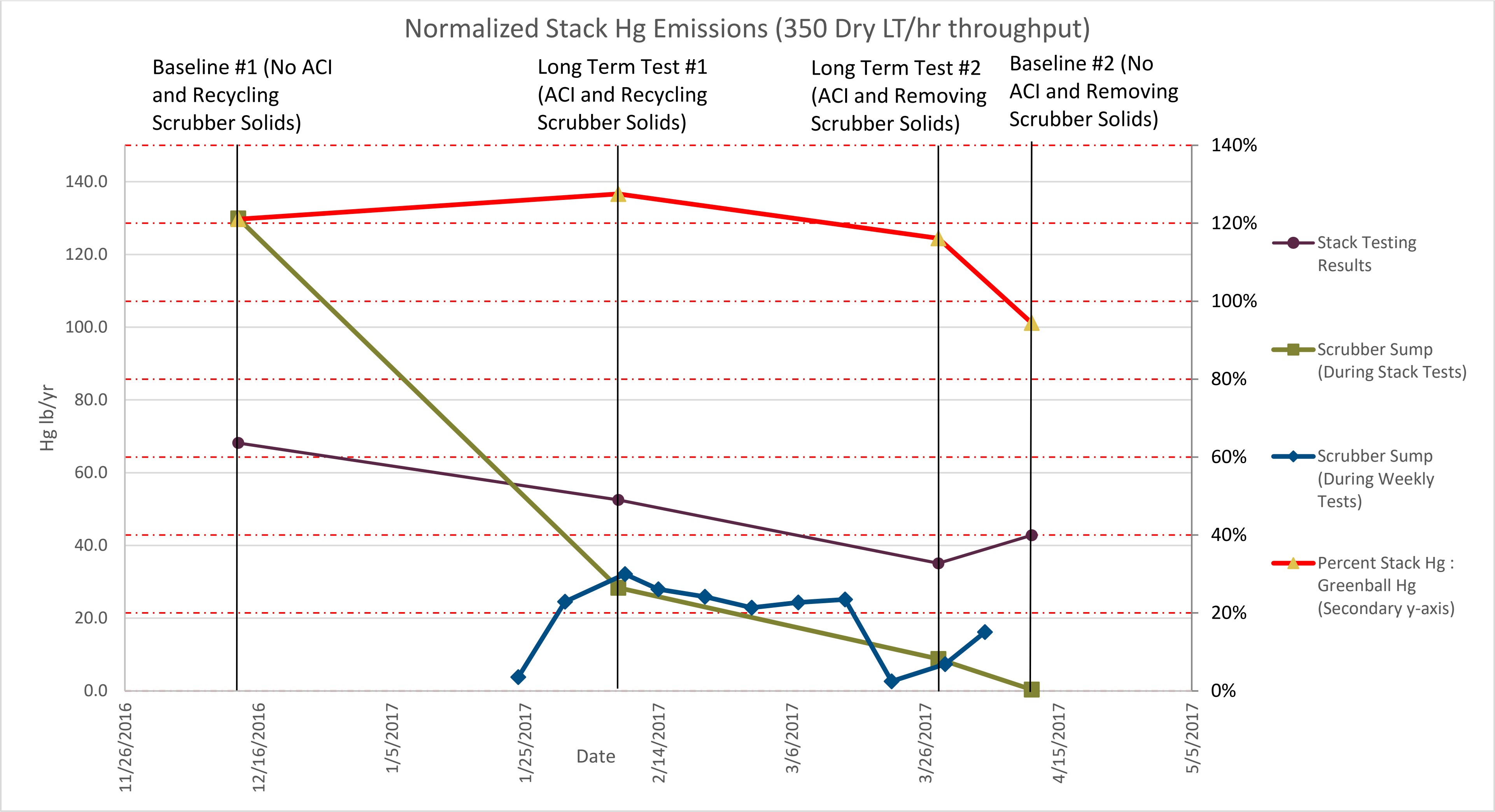

Figure 5-4 **Scrubber Sump Sampling Trends and Related Data**

The Baseline #1 scrubber sump Hg content appears to be abnormally high compared to all other scrubber sump samples analyzed. This is true even when comparing the results with historical mass balance sampling. Therefore, Baseline #1 scrubber sump data point is likely erroneous and cannot be used to effectively compare the impact of ACI. In addition, the amount of Hg in the scrubber sump should have increased due to ACI, but the opposite is seen.

As previously mentioned, the ratio of stack exhaust Hg to greenball Hg decreases during the Long Term #2 test; however, the scrubber sump Hg throughput also decreased. This is consistent with expectations as the scrubber sump was routed to tailings thickener for the Long Term #2 test. This is also true for the Baseline #2 test where the scrubber sump Hg decreased to 0.0 lb/yr. In addition, Figure 5-4 indicates the Baseline #2 HgT emission rate (corrected to a 350 dry LT/hr throughput) was lower than the Baseline #1 test. Again, this indicates that removing the scrubber solids alone may be an effective means to reduce HgT emissions from the furnace.

The pellet plant furnace was shut down on the afternoon of March 15th through the morning of March 20th due to a cooling air fan failure. The pellet plant scrubber sump was drained during this outage and replaced with fresh water. Following this shutdown, the scrubber sump also had level control issues due to a fire water valve leak, which added additional fresh makeup water to the scrubber sump. This is not normal operation for the sump, and the additional fresh water reduced the recycle water normally used for level control. Therefore, the decrease in scrubber sump Hg content is likely due to this process upset. The weekly sump sampling after the Long Term #1 test shows that Hg mass flow rate ranged from approximately 20-30 lb/yr up until the March 14, 2017 sampling event. The next sampling event on March 21, 2017 showed a large decrease in scrubber sump Hg, which could be related to the furnace upset. This discussion is included to emphasize that the scrubber sump sampling data after the upset may not be representative of normal operations.

Figure 5-5 shows the inputs and outputs of Hg to the process. This was in line with expectations that the rod mill and the tailings thickener underflow had the highest average totals of Hg per year. The rod mill represents the largest input, while the tails thickener underflow represents the largest output. The variability of these two samples points appear to correlate well with one another. Ultimately, the largest impact on Hg air emissions is dependent on the Hg entering the furnace with the greenballs. Note the following color codes:

- Blue lines/dots represent the rod mill discharge sampling.
- Green lines/dots represent the sands of the spiral classifier sampling.
- Yellow lines/dots represent the tails thickener under flow sampling.
- Orange lines/dots represent the greenball sampling.
- Red lines/dots represent the final pellet sampling.
- Purple lines/dots represent the HgT stack testing results normalized to the greenball feed rate.

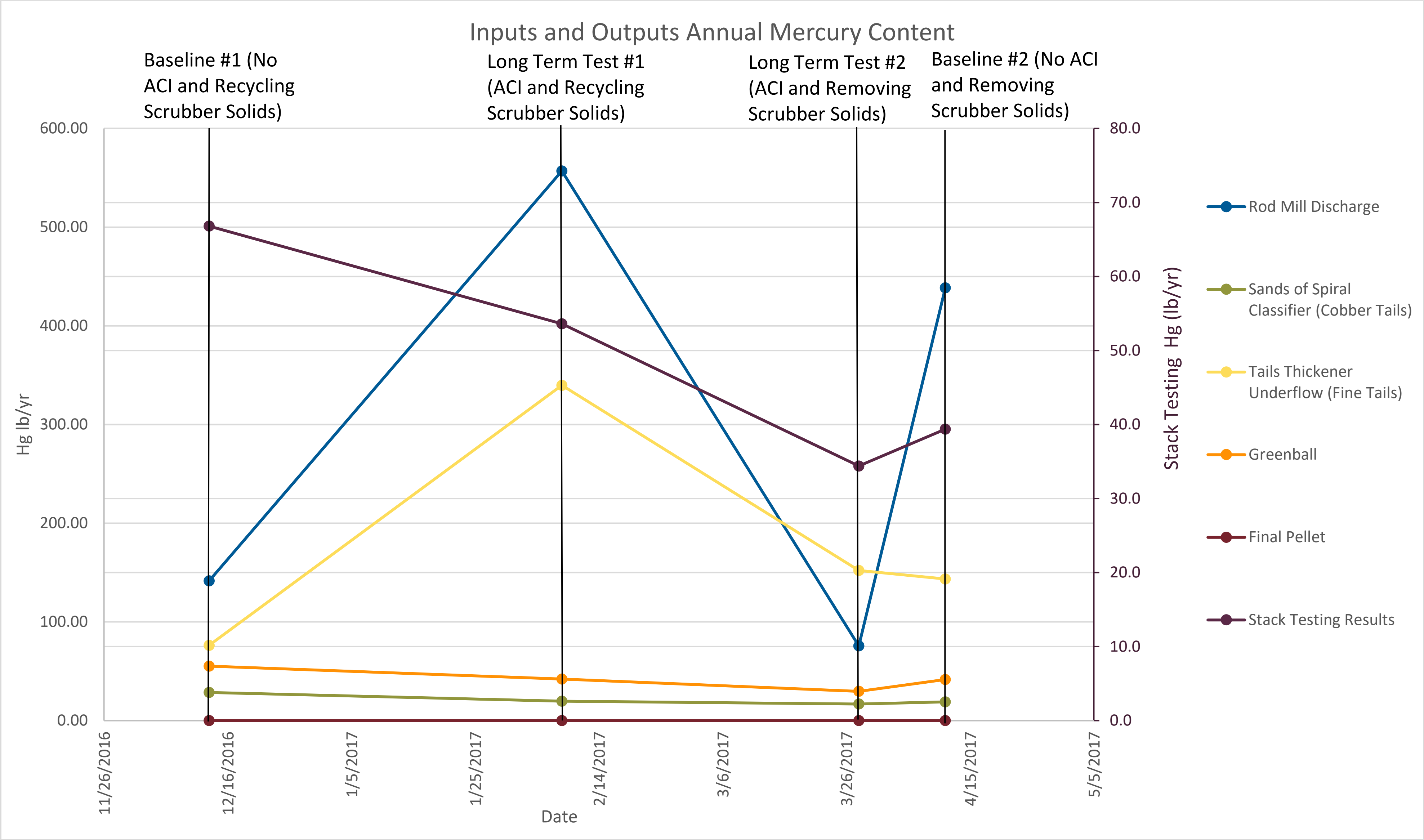

Figure 5-5 **Hg Inputs and Outputs**

5.2 Determination of ACI Feasibility

5.2.1 Technical Feasibility

As previously discussed, the results indicate that any reduction in Hg emissions from the indurating furnace with ACI was negligible. HgT emissions did not decrease between the Baseline #1 and Long Term #1 tests using Equation 1 while Equation 2 indicated a HgT reduction of less than 1%. The reduction in Hg coming out the stack was attributable only to the greenball Hg content decreasing rather than ACI. Therefore, ACI is not considered to be a potential control technology for Minorca at an injection rate of 1 lb/mmacf.

5.2.2 Economics Feasibility

ACI at an injection rate of 1 lb/mmacf is not considered to be a potential control technology to reduce Hg emissions at Minorca. Therefore, an economic analysis is not needed to determine if the technology is economically feasible.

There was no clear indication that operation/maintenance costs increased as a result of ACI.

5.2.3 Pellet Quality Impacts

Minorca did not notice any changes in pellet quality during or immediately following ACI.

5.2.4 Erosion/Corrosion or Equipment Degradation

After ACI testing, Minorca performed a visual inspection of the equipment in contact with the ACI to identify any abnormal erosion, corrosion, material buildup or equipment issues. The complete inspection report is included in Attachment N. Several locations were inspected and are listed in Table 5-1 below:

Table 5-1 Post ACI Inspection Results Summary (excerpt)

Equipment	Inspection Point ID	Inspection Point Description	Amount of Material Buildup[6]	Inspection Notes
Stack "A"	A1-1	1 point - base of the stack	Light to moderate	4/25/17 - 6:05 pm - Area good condition / Area not cleaned prior to inspection
	A1-2	1 point - transition area from the scrubbers to stacks	Light to moderate	4/25/17 - 6:03 pm - Area good condition / Area not cleaned prior to inspection
	A1-3	CEMS Probe	Light build-up on bottom of probe to moderate build-up on top of probe	5/1/17 - 11:40 am - Probe in good condition / Probe not cleaned
	A1-4	CEMS Filter	Amount of material buildup not documented	5/1/17 11:50 am - Filter was given as a sample
Scrubber "A"	A2	1 point at mid-body	Light	4/25/17 - 6:15 pm - Area good condition / Area not cleaned prior to inspection
	A3	2 points at lower-body[1]	Light to moderate	4/25/17 - 5:59 pm - Area good condition / Area not cleaned prior to inspection
Stack "B"	B1-1	1 point - base of the stack	Light to moderate	4/25/17 - 5:50 pm - Area good condition / Area not cleaned prior to inspection
	B1-2	1 point - transition area from the scrubbers to stacks	Moderate	4/25/17 - 5:46 pm - Area good condition / Area not cleaned prior to inspection
	B1-3	CEMS Probe	Light build-up on bottom of probe to moderate build-up on top of probe	5/1/17 - 11:21 am - Probe in good condition / Probe not cleaned
	B1-4	CEMS Filter	Amount of material buildup not documented	5/1/17 11:50 am - Filter was given as a sample
Scrubber "B"	B2	1 point at mid-body	Light	4/25/17 - 6:13 pm - Area good condition / Area not cleaned prior to inspection
	B3	2 points at lower-body[1]	Moderate	4/25/17 - 5:40 pm - Area good condition / Area not cleaned prior to inspection

Equipment	Inspection Point ID	Inspection Point Description	Amount of Material Buildup[6]	Inspection Notes
Stack "C"	C1-1	1 point - base of the stack	Moderate to Heavy	4/25/17 - 5:35 pm - Area good condition / Area not cleaned prior to inspection
	C1-2	1 point - transition area from the scrubbers to stacks	Light	4/25/17 - 5:30 pm - Area good condition / Area not cleaned prior to inspection
	C1-3	CEMS Probe	Moderate to Heavy	5/1/17 - 11:02 am - Probe in good condition / Probe not cleaned
	C1-4	CEMS Filter	Amount of material buildup not documented	5/1/17 11:50 am - Filter was given as a sample
Scrubber "C"	C2	1 point at mid-body	Light	4/25/17 - 6:10 pm - Area good condition / Area not cleaned prior to inspection
	C3	2 points at lower-body[1]	Moderate	4/25/17 - 5:25 pm - Area good condition / Area not cleaned prior to inspection
Stack "D"	D1-1	1 point - base of the stack	Moderate to Heavy	4/25/17 - 5:20 pm - Area good condition / Area not cleaned prior to inspection
	D1-2	1 point - transition area from the scrubbers to stacks	Light	4/25/17 - 5:15 pm - Area good condition / Area not cleaned prior to inspection
	D1-3	CEMS Probe	Heavy	5/1/17 - 10:00 am - Probe in good condition / Probe not cleaned Note: Photo taken after probe was cleaned
	D1-4	CEMS Filter	Amount of material buildup not documented	5/1/17 11:50 am - Filter was given as a sample
Scrubber "D"	D2	1 point at mid-body	Moderate	4/25/17 - 4:30 pm - Area good condition / Area not cleaned prior to inspection
	D3	2 points at lower-body[1]	Moderate	4/25/17 - 5:03 pm - Area good condition / Area not cleaned prior to inspection
Scrubber recirculating tank	E1	1 point	Amount of material buildup not documented	4/26/17 - 9:25 am - No access to tank interior / Sample from drain pipe

Equipment	Inspection Point ID	Inspection Point Description	Amount of Material Buildup[6]	Inspection Notes
Windbox Exhaust Fan	G1	1 point at wind box belly[2]	None	4/26/17 - 9:30 am - Area in good condition/ Light to moderate wear / Area not cleaned prior to inspection
	G2	1 point at outlet side[3]	None	4/26/17 - 9:40 am - Area in good condition/ Light to moderate wear / Area not cleaned prior to inspection
	G3	2 points at inlet side[3]	None	4/26/17 - 9:38 am - Area in good condition/ Light to moderate wear / Area not cleaned prior to inspection
Multi Clone (3 lower discharge cones)	H1	1 point at sump	Light	4/26/17 - 9:55 am - Area good condition / Area not cleaned prior to inspection
	H2	3 points at cones discharge at ground level[4]	Amount of material buildup not documented	4/26/17 - 9:50 am - Area good condition / Area not cleaned prior to inspection / Water and product in sump
	H3	3 points on cones at second level[4]	Light	4/26/17 - 9:58 am - Area good condition / Area not cleaned prior to inspection
	H4	1 point at top	Light	4/25/17 - 6:25 pm - Area good condition / Area not cleaned prior to inspection
Denver sump	I1	1 point in the sump	Amount of material buildup not documented	4/26/17 - 10:20 am - Area good condition / Area not cleaned prior to inspection / Water and product in sump
Ducting Prior to Scrubber (3 injection points per duct)	J1	3 points in ducting off process gas header[5]	Light (mostly pellets)	4/26/17 - 10:09 am - Area good condition / Area not cleaned prior to inspection
	J2	1 point at access of process gas header	Moderate to Heavy (mostly pellets)	4/26/17 - 10:04 am - Area good condition / Area not cleaned prior to inspection

1 - A single composite sample from two sample points, one at both the front and back access doors, was collected to represent the lower-body of each scrubber.

2 - A sample was not collected from the belly of the windbox exhaust fan because there was no buildup of material.

3 - Samples were collected from material found outside the access door to the windbox fan believed to represent material from the fan compartments.

4 - Each of these were comprised of material collected from three separate sampling points at the inspection point.

5 - This sample was comprised of material collected from each of the three ducts off the process gas header.

6 - The amount of material buildup in the inspected area is described using the terms light, moderate and heavy. Light buildup is defined as areas with up to ½ inch of material; moderate buildup is ½ - 2 inches of material; heavy is 2 – 4+ inches of material with the exception of the continuous emissions monitoring system (CEMS) probes. Light buildup on the CEMS probes is defined as a visible dusting of material; moderate buildup is up to ⅛ inch of material; heavy is ⅛– ¼ inch of material.

Photos were taken to document material build up and composite samples were taken from each location to determine its carbon and bromine content.

The inspection did observe light to heavy material buildup in several locations. Refer to Attachment N for details. However, material buildup usually consisted of both carbon and already present process material. It is unknown if buildup from a full-scale installation of ACI would cause significant maintenance or operating problems.

Inspections showed that all areas were in good condition and comparable to inspections completed during annual maintenance outages following normal operations. There was light or moderate wear on the windbox exhaust fan, but this is not specifically due to the ACI and plant personnel indicated that this was normal. There were no elevated bromine or carbon contents with regard to specific locations and no obvious visual corrosion concerns that arose as a result of the brominated PAC exposure. Testing of such a short duration is likely insufficient to observe any erosion, corrosion, or equipment degradation concerns.

5.2.5 Additional Environmental Impacts

As previously discussed in Section 5.1, ACI did not decrease HgT emissions. HgG decreased by 30% using Equation 1 and 27% using Equation 2 as a result of ACI. This indicates that some Hg was adsorbing onto the PAC. Therefore, more Hg was emitted in HgP form. This was validated as the HgP emissions accounted for 34% of the HgT emissions coming out of the stack during the Long Term #1 test. This is approximately a 25% increase in HgP speciation relative to normal operations (refer to Attachment F for details). This report does not evaluate this change in HgP emissions in relation to the goals of the TMDL, which sought to minimize local deposition. However, the increase in HgP emissions should be evaluated from a local deposition perspective should Minorca consider ACI injection testing at higher injection rates in the future.

6.0 Conclusions

This round of ACI testing revealed several important conclusions about this technology's ability to reduce Hg emissions at Minorca:

- ACI did not reduce HgT emissions at an injection rate of 1 lb/mmacf. Higher injection rates were not evaluated because Phase II testing indicated that this would jeopardize compliance with existing PM limits. Therefore, this technology under the testing conditions is not considered to be a potential control technology for Minorca.
- Filterable particulate matter emissions did not exceed 2015 stack test results with ACI. Therefore, this short term test suggests that compliance with current particulate limits may be achievable with ACI at an injection rate of 1 lb/mmacf. It is unknown if there would be an actual emissions increase with ACI.
- Scrubber sump Hg did not increase when ACI began. However, it did decrease once the scrubber sump was routed to the tailings thickener because the rerouting removed Hg recycle within the process.
- Removing scrubber solids alone may be an effective way to reduce Hg emissions.
- No abnormal erosion/corrosion or equipment degradation was observed after a post-testing inspection of the equipment exposed to PAC.
- Varying amounts of material buildup were observed in several locations, but it is unclear if this would create additional operation and maintenance issues for a full-scale installation of ACI.
- Minorca did not observe any adverse impacts to pellet quality during the extended testing.
- Economics were not evaluated because ACI did not reduce mercury emissions at an injection rate of 1 lb/mmacf. Minorca did not observe any increase in operation or maintenance costs associated with the existing equipment.
- No safety/hygiene issues were identified with ACI.
- More Hg was emitted in the form of HgP as a result of ACI. This may add to the problem of local Hg deposition, the very opposite of what the TMDL seeks to achieve.

Attachment A

Minnesota Taconite Phase II Research – Evaluation of Carbon Injection to Increase Mercury Capture – ArcelorMittal Minorca Mine Inc. – Final Report

MINNESOTA TACONITE PHASE II RESEARCH - EVALUATION OF CARBON INJECTION TO INCREASE MERCURY CAPTURE

ARCELORMITTAL MINORCA MINE INC.

Final Report

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DISCLAIMER

EXECUTIVE SUMMARY

ADA-ES, Inc. (ADA) was awarded a contract to test Activated Carbon Injection (ACI) at five taconite ore processing plants in northern Minnesota as part of the Minnesota Taconite Mercury Reduction Research Phase II Program. The purpose of Phase II is to determine the level of mercury reduction possible using ACI. This report presents the results of the Phase II ACI test at the ArcelorMittal Minorca plant (Minorca).

Three commercially available powdered activated carbons (PACs) were tested in a PAC Screening Test from 6/24/13 to 6/27/13 to determine the best PAC to use for the Phase II test. Albemarle's BPAC was selected because it performed better than the other PACs and achieved 91% HgG reduction in stack D and 67% HgG reduction in stack B at an ACI rate of 3 lb/mmacf.

Phase II Testing was conducted from 7/10/13 to 8/8/13 using BPAC at 3 lb/mmacf and injecting only into the Windbox Exhaust. The ACI rate was constant except during minor plant outages and for ACI equipment maintenance. ADA installed one Hg-CEMS in stack D for the entirety of testing and another was moved between stacks A, B, and C. Barr Engineering performed weekly particulate testing on the stack during Phase II testing.

The results of Phase II testing showed that the gas phase mercury (HgG) reduction, as measured by the mercury continuous emission monitor system (Hg-CEMS), and considering all four stacks, was 76% at 3 lb/mmacf. However, the total mercury (HgT) reduction calculated using the MM30B sorbent trap data was 54%. Therefore, the test indicates that the target of 75% Hg reduction is not obtainable at Minorca with the current system configuration.

Throughout this report it is important to distinguish between gas phase mercury (HgG), as measured by the mercury continuous emission monitor system (Hg-CEMS), and total mercury (HgT) which is the sum of the particulate bound or particulate phase mercury (HgP) and HgG. Hg-CEMS cannot measure HgP, but ADA also used a modified EPA Method 30B (MM30B) procedure during Phase II that can be used to estimate HgP. It is important note that ADA often uses the MM30B as a research tool to independently verify the operations of the Hg-CEMS and to measure mercury in gas streams where no Hg-CEMS data is available. Mercury reductions will be reported as HgG when measured with the Hg-CEMS, and as HgT when measured by the MM30B when available.

Barr will provide a separate report of the particulate tests conducted at Minorca.

ACRONYMS

PM	Particulate Matter
Hg	Mercury
HgT	Total Mercury
Hg0	Elemental Mercury
Hg2	Oxidized Mercury
HgG	Gas Phase Mercury
HgP	Particulate Bound Mercury
Hg-CEMS	Mercury Continuous Emissions Monitor System
SO_2	Sulfur Dioxide
NOx	Nitrogen Oxide(s)
ACI –	Activated Carbon Injection
PAC –	Powdered Activated Carbon
HPAC	Albemarle's High Temp Brominated PAC
BPAC	Albemarle's Brominated PAC
FPP	Fast PAC Premium - ADA-CS's Ground Brominated PAC
PPPP	Power PAC Premium Plus - ADA-CS's Double Brominated PAC
ADA-CS	ADA-Carbon Solutions
ADA	ADA-ES, Inc.
Barr	Barr Engineering Co.
AMUSA	ArcelorMittal
USS	United States Steel Corp.
Cliffs	Cliffs Natural Resources
Hibtac	Hibbing Taconite Facility
Utac	United Taconite Facility
Minntac	Minnesota Taconite Facility
Keetac	Keewatin Taconite Facility
Minorca	Minorca Taconite Facility
PST	PAC Screening Test
OL	Ohio Lumex Mercury Analyzer
MM30B	Modified EPA Method 30B
acfm	Actual cubic feet per minute of gas
scfm	Standard cubic feet per minute of gas
μg/wscm	Micrograms of Hg per wet standard cubic meter of gas
ng/g	Nanograms of Hg per gram of sample
lb/mmacf	Pounds of PAC per million actual cubic feet of gas
ME	Mist Eliminator

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1.0 INTRODUCTION

1.1 Project Purpose and Scope

ADA-ES, Inc. (ADA) was awarded a contract to test Activated Carbon Injection (ACI) at five taconite ore processing plants in northern Minnesota as part of the Minnesota Taconite Mercury Reduction Research Phase II Program which broadened the scope of testing to medium-term operations (roughly a one month timespan) at multiple facilities. The purpose of Phase II is to determine the level of mercury reduction.

The five sites selected for this program are:

- Cliffs Natural Resources (Cliffs)
    - Line 3 at Hibbing Taconite (Hibtac)
    - Line 2 at United Taconite LLC (Utac)
- United States Steel Corp (USS)
    - Agglomerator Line 7 at Minntac
    - Keetac
- ArcelorMittal (AMUSA)
    - Minorca Mine (Minorca)

At each site, the ACI test was divided into three phases: Set-up, the PAC Screening Tests (PST), and Phase II testing. During Set-up, ADA installed the ACI equipment and mercury monitoring systems needed to accomplish the goals of the project.

The purpose of the PST was to develop a performance curve for each commercially available, brominated, powdered activated carbon (PAC) tested and determine which PAC would perform the best at each site. The PST involved testing each PAC for one day at three to four injection rates. The data from the PST was then used to select a PAC and ACI rate for Phase II testing. During the PST, the host site subcontracted Barr Engineering Co. (Barr) to conduct particulate matter (PM) loading tests at each injection rate.

The Mercury Phase II project team (ADA, host site reps and Barr) selected three PACs to be used for the PST at Minorca. One of the standard PACs tested at the first two sites was replaced with a coarse ground PAC for this test to determine if particulate collection efficiency across the scrubber could be improved by using a coarser material.

- Albemarle
  - HPAC – A brominated PAC developed for higher temperature applications
  - BPAC – A standard brominated PAC
- ADA-Carbon Solutions (ADA-CS) - ADA-CS is not affiliated with ADA-ES.
  - ACS DEV 2013N (2013N) – A course ground enhanced brominated PAC.

At the completion of the PST, the project team reviewed the data and selected a PAC and ACI rate to be used during Phase II testing.

The purpose of Phase II testing was to investigate the longer term effects of recycle and process changes with ACI. Most of the five test sites recycle material collected downstream of the furnace back into the process. Therefore, it was anticipated that PAC, and the mercury (Hg) absorbed on the PAC, could also end up back in the Green Balls and affect product quality or provide a recycle loop for the mercury that could reduce Hg reduction efficiency. Phase II testing at Minorca was allotted a maximum of 30-days.

During Phase II testing, the host site collected periodic samples at various locations throughout the plant. These samples were dewatered by the host site and the solids were provided to ADA for Hg analysis. Results provided initial insight into whether mercury was infiltrating the process streams as a result of recycling. Barr was also contracted by the host site to periodically conduct PM testing on the stacks.

Throughout the PST and Phase II testing, ADA employed the ThermoFisher mercury continuous emission monitor system (Hg-CEMS) to measure mercury emission at the stack. ADA also used a modified EPA Method 30B (MM30B) to periodically measure the Hg concentration of the inlet gas (before ACI), and to validate the performance of the Hg-CEMS at the stack. Throughout this report it is important to distinguish between gas phase mercury (HgG) and total mercury (HgT) which is the sum of the particulate bound or particulate phase mercury (HgP) and HgG. Hg-CEMS cannot measure HgP, but the MM30B can be used to estimate HgP. For this project, ADA used the MM30B as a research tool to independently verify the operations of the Hg-CEMS and to measure mercury in gas streams where no Hg-CEMS data was available. The modification to the M30B procedure included taking only single pairs of measurements instead of multiple pairs, and the use of two section sorbent traps instead of three-section spiked traps (see Section 2.2.4). Mercury reductions will be reported as HgG when measured with the Hg-CEMS, and as HgT when measured by the MM30B when available.

To calculate Hg reduction using Hg-CEMS data, a baseline (no ACI) HgG stack emission was determined by averaging data over a period time (30 minutes to several hours) before ACI was initiated and when the process was deemed to be operating normally. The same process was then used to determine HgG emission with ACI. The two HgG averages were then used to calculate HgG reduction. Minorca splits the waste gas between four stacks, so this process was repeated on each stack to calculate an overall Hg reduction.

To calculate HgT reduction using the sorbent trap data, all available stack data taken before ACI began and when the process was deemed to be operating normally was averaged to give a baseline value for HgT. The same was done for any data taken with ACI. The two HgT averages were then used to calculate HgT reduction.

This report only pertains to the testing conducted at the ArcelorMittal Minorca plant.

1.2 Facility Description

The indurating furnace at the Arcelor Mittal Minorca Mine is a straight grate furnace that can burn either natural gas or fuel oil. Unfired pellets from the balling disks are screened for size before entering the furnace. The pellets travel through the updraft, downdraft and preheat sections before reaching their peak temperature (2450°F) in the firing zone. The pellets then pass through the first and second cooling zones before being discharged to the stockpile. Figure 1 depicts the gas streams and sampling locations for Minorca. Two separate exhaust gas streams exit the furnace: the Hood Exhaust and the Windbox Exhaust. The two exhaust streams are driven by separate fans, after which they combine at a common header and then split into four streams that pass through recirculating venturi scrubbers and exit through four stacks. Particulate control devices downstream of the furnace consist of a multiclone dust collector on the Windbox Exhaust and the four recirculating venturi scrubbers. At Minorca, solids from the scrubbers are recirculated back directly to the concentrate thickener. However, solids from the multiclone dust collectors were discharged from the process to a settling pond during testing. The gas flow rate for the Hood and Windbox Exhausts are about 535,000 acfm each, for a total of 1,070,000 acfm.

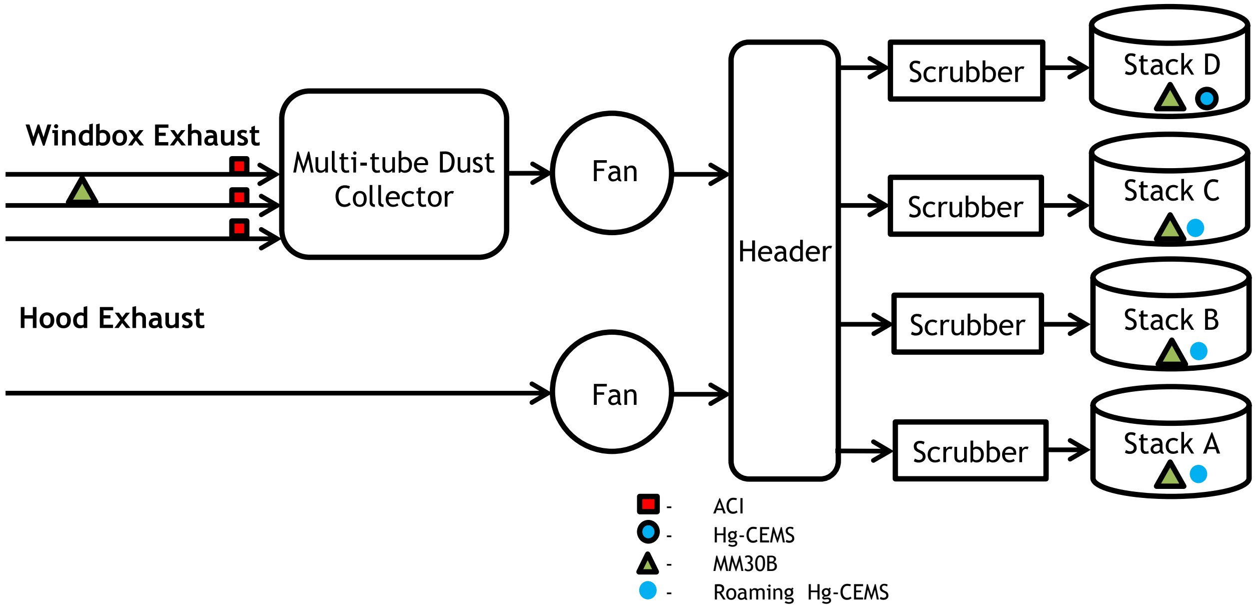

Figure 1. Minorca Gas Stream and Sampling Locations

1.3 Test Plan

The ACI test was divided into three phases: Set-up, the PAC Screening Tests (PST), and Phase II testing. The purpose of the PST was to develop a performance curve for each commercially available, brominated, powdered activated carbon (PAC) tested and determine which PAC would perform the best at each site. The PST involved testing each PAC for one day at three or four injection rates. Data from the PST was used to select a PAC and ACI rate for Phase II testing.

At Minorca, the original plan called for testing each of the proposed PACs at 3, 5, and 7 lb/mmacf (pounds of PAC per million actual cubic feet of gas) during the PST. However, results at Hibtac, with a similar exhaust gas configuration as Minorca, indicated that testing at 1, 3 and 5 lb/mmacf would be sufficient to achieve a goal of 75% HgG reduction during the PST. Each ACI rate was run for several hours during which Barr performed PM testing on Stack D only. Hg reduction was based on baseline Hg-CEMS concentration measured at the beginning of each day and the Hg concentration averaged over at least 30-minutes of steady operation of the Hg-CEMS during each run.

During previous testing at Hibtac, the Hood Exhaust was found to contain low mercury emissions, lacked the surface area associated with the multiclone, and had reduced residence time compared to the Windbox Exhaust. Therefore, for Phase II testing at Minorca, the project team decided to forgo PAC injection into the Hood Exhaust, and instead focus completely on mercury capture in the Windbox Exhaust to maximize the effectiveness of the PAC.

Based on the results of the PST, the project team decided to use BPAC at 3 lb/mmacf for the Phase II testing. The Phase II test continued for the full 30 days due to the extensive solids sample testing the plant was conducting. The following samples were collected and analyzed by ADA.

- Green Balls - Every day
- Multi-tube Collector drop out - Twice during Phase II testing
- Concentrate Thickener Overflow – Twice during Phase II testing
- Pellets - Twice during Phase II testing
- Fine Tailings - Twice during Phase II testing

Minorca collected a larger number of samples and analyzed them for both carbon and mercury. The data was shared with ADA and included in this report. The process samples included:

- Green Balls – Twice Daily on Week Days during Phase II testing
- Pellets– Twice Daily on Week Days during Phase II testing
- Multiclone drop out – Twice Daily on Week Days during Phase II testing
- Thickener Overflow – Twice Daily on Week Days during Phase II testing
- Fine Tailings – Twice Daily on Week Days during Phase II testing

Figure 2 and Figure 3 indicate with a red “X” where the above samples were collected.

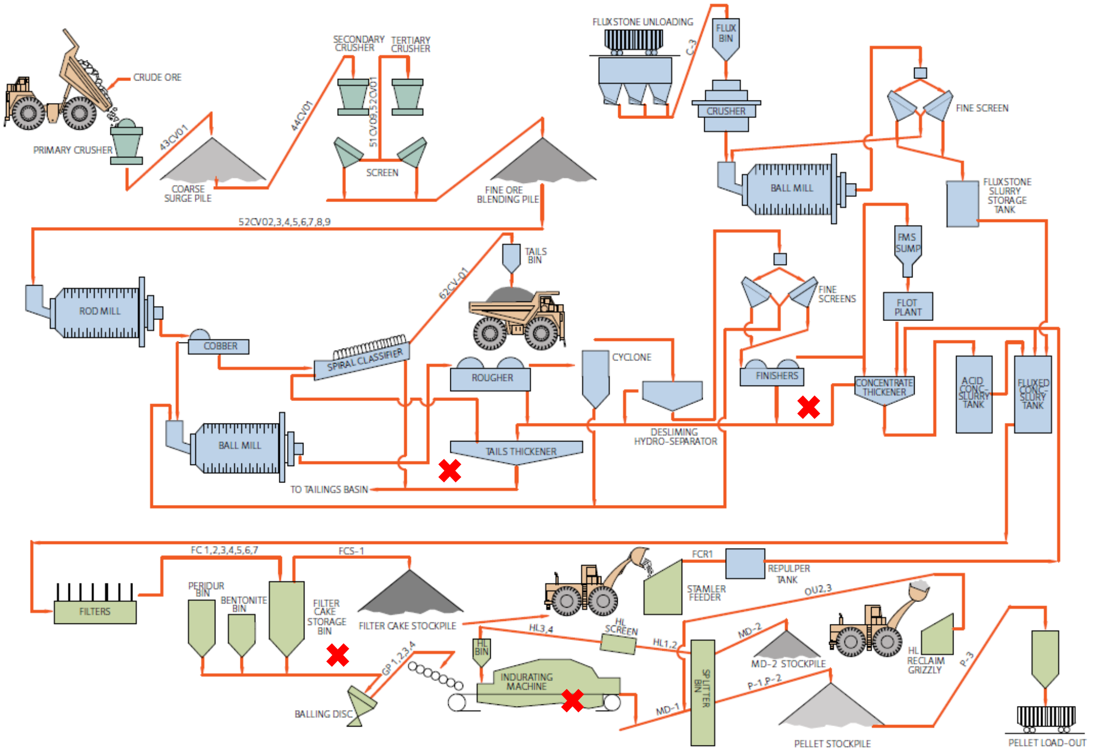

Figure 2. Process Diagram with Sampling Locations

Since Minorca has four stacks, two Hg-CEMS were used to record the mercury emission trends. Based on initial testing, stacks C and D had the highest Hg emissions and the team decided to dedicate one Hg-CEMS to stack D, and the other was periodically moved between the other three stacks A, B, and C. The Hg-CEMS only recorded data on stacks B and D during the PST, but one was moved between stacks A, B, and C during Phase II testing. Barr collected weekly PM data during Phase II testing.

1.3.1 ACI Injection Port Locations

As shown in Figure 1 and Figure 3 (blue “X”), ACI ports were installed upstream of the Multi-tube Collector on the Windbox Exhaust. Figure 4shows the lance arrangement used at Minorca during PST and Phase II testing. The red “X” indicates where the multiclone samples were taken.

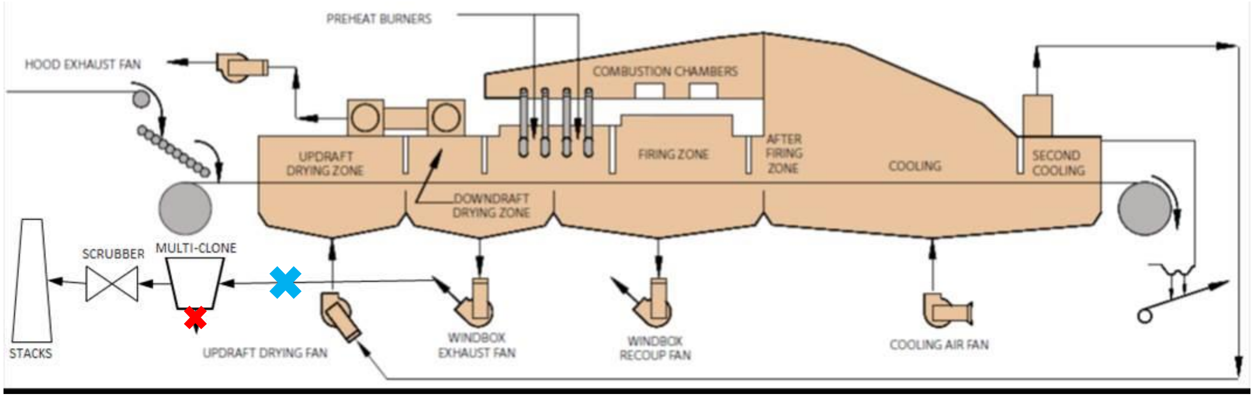

Figure 3. PAC Injection Location

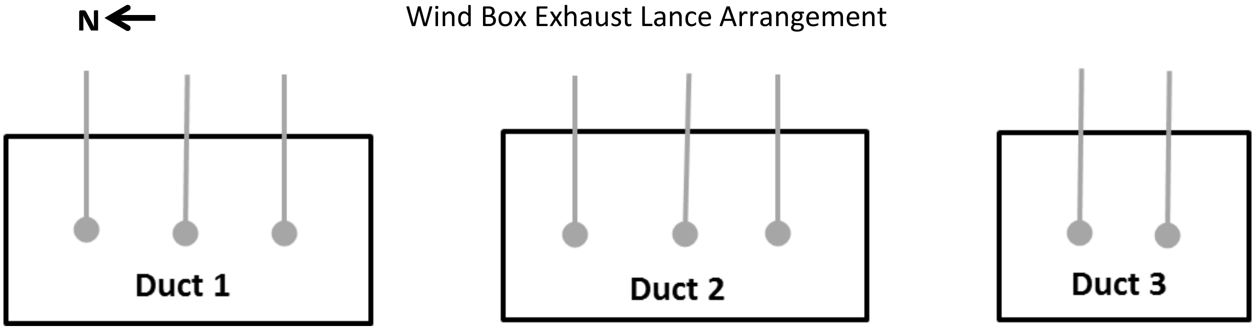

Figure 4. PST and Phase II Testing ACI Lance Arrangements at Minorca

1.3.2 Mercury Measurement Port Locations

Sample ports for the Hg-CEMS and MM30B were available on all four stacks. Ports for inlet MM30B sampling were installed prior to the ACI ports on the Windbox Exhaust duct.

1.3.3 Test Chronology

The major events that occurred during the test at Minorca are shown below in Table 1.

Table 1. Minorca Test Chronology

Day	Date	Description
Monday	06/17/13	ADA begins installation of equipment and Hg-CEMS
Monday	06/24/13	HPAC tested at 1, 3, 6 lb/mmacf. Barr performed PM test at stack at each rate
Wednesday	06/26/13	BPAC tested at 1, 3, 5 lb/mmacf. Barr performed PM test at stack at each rate
Thursday	06/27/13	2013N tested at 1, 5, 7 lb/mmacf. Barr performed PM test at stack at each rate
Wednesday	07/03/13	Project team decides to use BPAC at 3 lb/mmacf (192 lb/hr)
Wednesday	07/10/13	Started Phase II Testing with BPAC at 3 lb/mmacf (192 lb/hr)
Thursday	08/08/13	Phase II Testing completed
Tuesday	08/13/13	Demobilization completed

2.0 METHODS

2.1 ACI System

Since Phase II testing had not ended at Hibtac when the PST was scheduled to commence at Minorca, ADA's smaller DemoPAC injection system was used for the PST. After Hibtac concluded, the Mini-Silo was installed and used at Minorca for Phase II testing. DemoPAC, shown in Figure 5, is a small system that is easy to transport and setup, but has a lower sorbent capacity, only holding one supersack (1000 lb) at a time. The DemoPAC is approximately 16-ft high (two 8-ft sections), with a 6-ft x 6-ft footprint and has an empty weight of approximately 2,000 lbs.

Figure 5. DemoPAC Injection Equipment

The Mini-Silo, shown in Figure 6, is approximately 25-ft high, has an 8-ft x 8-ft footprint, an empty weight of 14,000 lb and a capacity of 17,000 lb of PAC. It can be loaded either with supersacks or from a bulk truck as was done at Minorca. Table 2 gives the specifications for the Mini Silo. The sorbent injection system also includes PAC conveying lines and injection lances. The silo was installed outdoors next to the Windbox and Hood Exhaust fans. Temporary sorbent transport hoses were installed between the silo and the injection lances.

Figure 6. ADA Portable Injection Silo (Mini Silo)

Table 2. Technical Specifications for the Mini Silo

Utility	Specification
Electrical	480VAC / 3PH / 100A
Air	Clean, Dry Air at 90-100 psi and 15 scfm
I&C	4-20 mA signal (production rate)
Dimensions	~ 8-ft x 8-ft x 25-ft (L x W x H)
Weight	~14,000 lb empty
Installation	Anchor skid, lift top portion and bolt to lower portion
Location	Set up at grade below injection point

ADA purchased all sorbents and arranged for shipment and delivery. Sorbent can be provided in 1000 lb supersacks as was done during the PST or 50,000 lb pneumatic tank trucks as was done during Phase II testing. A supersack is loaded into the silo via a hoist that raises it to the top of the silo where it is dumped through an opening into the silo. The Mini-Silo and the DemoPAC have a Programmable Logic Controller and computer program system that controls the system operation and adjusts the variable speed screw feeder to meter sorbent injection rates.

Motive air is supplied by a positive displacement blower, shown in Figure 7. The technical specifications for the blower are summarized in Table 3. Flexible hose carries the sorbent from the feeder to a distribution manifold located near the injection grid. At Minorca, the primary conveying hose was split into two secondary lines that were further divided into four legs each to create the eight-lance arrangements discussed above in Figure 4.

Figure 7. PAC Blower

Table 3. Technical Specifications for the PAC Blower

Utility	Specification
Electrical	480VAC / 3PH / 60A, 120VAC
Dimensions	6-ft x 4-ft x 6-ft (L x W x H)
Weight	2,750 lb
Installation	Place on level surface
Location	≤ 20 feet from Silo

2.2 Mercury Measurement Techniques

This section discusses several of the most common methods used to measure mercury emissions from waste gas streams. A short explanation of each method will be presented along with the pros and cons. More specifically, the following methods will be considered:

- EPA Method 29 (M29)
- EPA Method 30B (M30B) – And ADA's modifications
- Ontario Hydro (O-H) Method or ASTM Method D6784-02
- Mercury Analyzers or Mercury Continuous Emission Monitoring Systems (Hg-CEMS)

For this project ADA used Hg-CEMS and MM30B. The Hg-CEMS were used to continuously monitor speciated mercury emissions from the stack. MM30B was used for two purposes. First, it was used to track the Hg concentration in the waste gas at the furnace exit prior to the ACI grid to determine if inlet mercury concentration changed due to the effect of recycle or from process changes. Also, MM30Bs were used to check the performance of the Hg-CEMS at the stack. It is important to note that in the original test plan, the data collected from MM30Bs were not intended to be used to calculate the Hg reduction performance of the process. However, as the project progressed, additional MM30B tests were added to the project scope in the hope of being able to do so.

2.2.1 EPA Method 29

EPA Method 29 (M29) is an isokinetic, wet chemistry, batch sampling method developed to measure metal emissions in waste gas streams. Up to 17 different metallic species can be measured with M29, including mercury. Figure 8 shows the sample train used in this method. The gas sample is drawn isokinetically into a heated sample probe, through a heated glass fiber filter, and then through a series of glass impingers submerged in an ice bath. The sample nozzle, probe, and filter collect the particulate matter in the gas sample. The first set of impingers contains an acidified aqueous solution of hydrogen peroxide. A blank impinger is placed between the impinger sets to prevent carryover. The second impinger set contains an acidified aqueous solution of potassium permanganate that absorbs all of the metal species including mercury. The last impinger contains silica gel to remove the moisture from the gas sample. Finally, the gas passes through a dry gas meter that measures the total dry gas sample volume. The solutions are then recovered and analyzed by various spectroscopy methods for the elements of interest. A two hour minimum sampling time is recommended for Method 29. Increasing the sample time can improve the detection limits. All glassware components must be rinsed during sample recovery and the rinsate analyzed for additional mercury. Pre- and post-test leak-checks must be performed and the method requires multiple runs for quality assurance/quality control.

Method 29 can be used to estimate HgP by separately reporting the mercury collected with the particulate in or on the nozzle, probe, and filter. However, the particulate may absorb some of the HgG, misrepresenting the partitioning of mercury between particulate and gas phases. The absorption of HgG on the filter substrate is dependent upon the nature and constituents of the collected particulate matter. However, the sum of HgG and HgP accurately represents the total mercury emissions.

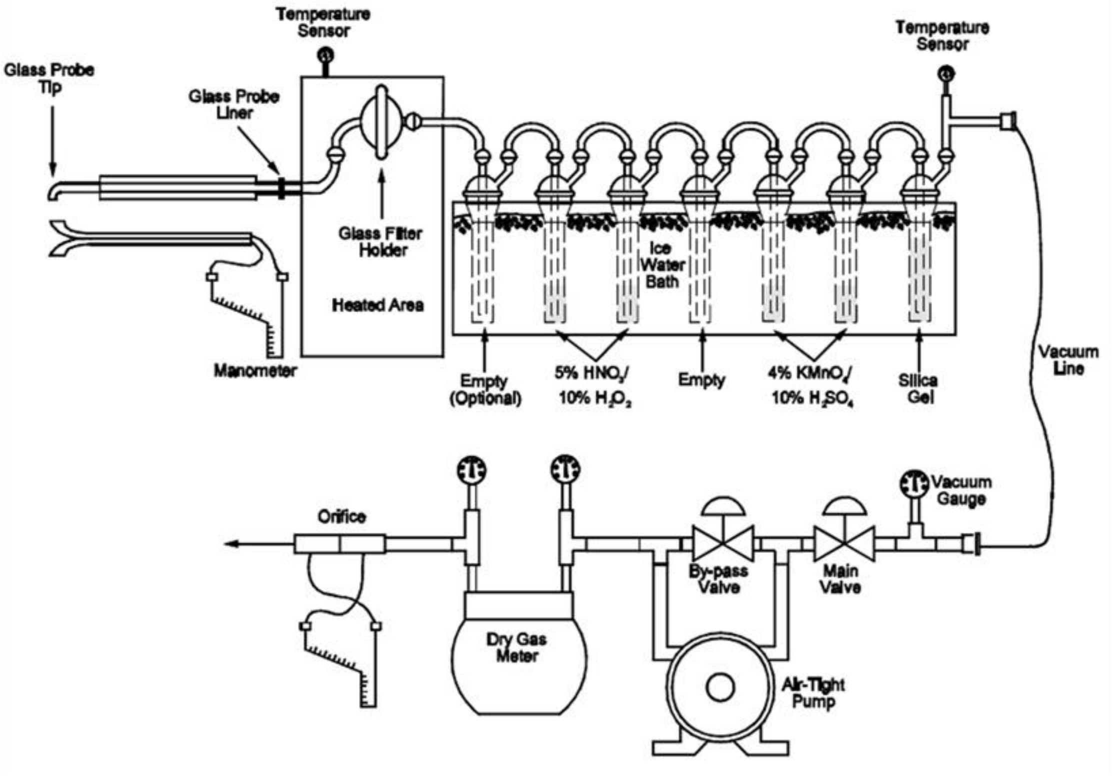

Figure 8. Method 29 Sample Train

2.2.2 Ontario Hydro

The Ontario-Hydro Method (O-H) is similar to Method 29 however; it was developed to separately measure both the oxidized (Hg2) and elemental (Hg0) mercury species in the gas sample. Any system that can measure both mercury species is said to be able to “speciate” the mercury. Figure 9 shows the sample train used in this method. The sample console is identical and the sample collection train is very similar to M29. For the O-H method, the first impinger set contains aqueous potassium chloride solution which selectively removes the Hg2 from the gas sample. Hg0 is then captured in the following impingers containing either acidified aqueous potassium permanganate or acidified hydrogen peroxide. The final impinger contains silica gel desiccant to remove moisture from the gas sample. All glass elements of the system must be rinsed during sample recovery, and the rinsate is recovered and analyzed for additional mercury. A leak check is performed before and after the test. The nozzle, probe, filter, and impingers are recovered and sent to a lab to be analyzed by various spectroscopy methods. A high level of quality assurance/quality control is required to properly conduct the O-H method.

This batch method has a higher detection limit than other wet chemistry methods, but can measure the HgP and speciated gaseous mercury levels in a sample. A two hour minimum sampling time is recommended for the O-H method. Increasing the sample time can improve the detection limits. However, particulate matter on the filter may absorb some of the gas phase mercury and can also change the speciation of the sampled mercury, misrepresenting the partitioning of mercury between particulate and gas phases or the mercury speciation. The absorption of HgG on the filter substrate is dependent up on the nature and constituents of the collected particulate matter.

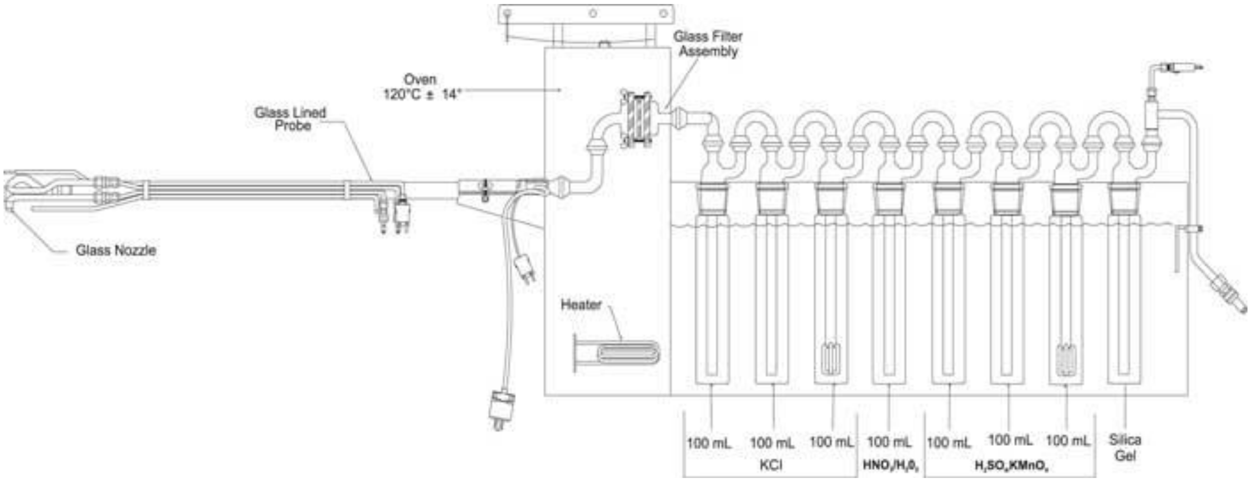

Figure 9. Ontario Hydro Method

2.2.3 Hg-CEMS

Mercury Continuous Emission Monitoring Systems (Hg-CEMS) were developed to provide continuous, real time measurements of speciated gas phase mercury. This is the only measurement method that provides continuous Hg measurement. However, because they rely on real time spectroscopy measurement for mercury detection, they cannot be used to measure HgP. The discussion below mostly pertains to the ThermoFisher (Thermo) system that ADA is most familiar with. Other suppliers, such as Tekran and Ohio Lumex, also provide Hg-CEMS that operate on slightly different principles, but, in general, the main components and operations are similar. For example, Tekran employs a wet chemical system to speciate mercury whereas Thermo developed a dry system.

A diagram of the Thermo system used for both Hg-CEMS is shown in Figure 10. It is comprised of an analyzer, calibrator, controller, and an extraction probe along with additional peripheral components such as a zero air supply and heated umbilical. The Thermo probe contains an inertial particulate filter, a nitrogen dilution module (40:1 dilution typical), a splitter to divide the diluted sample into two streams; one for measuring gas phase elemental mercury (Hg0) and one for measuring total gas phase mercury (HgG), and a converter to convert all of the Hg in the gas sample to Hg0. The inertial filter is an important component of the probe. It was designed so that a gas sample can be extracted from a stream containing particulates without passing the sample through a filter cake as is done in the other measurement methods.

The design basis for detecting Hg in the Hg-CEMS is atomic spectroscopy whereby the gas sample is exposed to ultraviolet light at 253.7 nm so that an electron in the outer most orbital of Hg0 absorbs a photon, becomes excited, then decays back to the ground energy state, emitting (fluorescing) a photon of light at the same wavelength. To detect mercury, analyzers can either measure the amount of light absorbed (Cold Vapor Atomic Absorption Spectroscopy or CVAAS), or the amount of light that fluoresces (Cold Vapor Atomic Fluorescence Spectroscopy or CVAFS), as is done in the Thermo system. Since Hg2 does not have electrons in the outer orbital, it cannot be measured by this technique. Therefore, in order to speciate Hg, the system divides the sample into two streams one of which is further treated to convert all of the Hg to Hg0. These two streams are alternately analyzed so that one produces a value for Hg0 only and the other HgT (gas phase only). Hg2 is then calculated by the difference.

The calibrator produces a gas stream with a selectable Hg0 concentration. The cal gas is transported to the probe and enters the system before the inertial filter. During cals, the probe is isolated so that only cal gas is flowing through the probe. ADA checks the system calibration at least once a day. All calibration checks and adjustments are provided in Appendix B. MM30B data at the stack is included in Appendix D along with comparisons to the Hg-CEMS data.

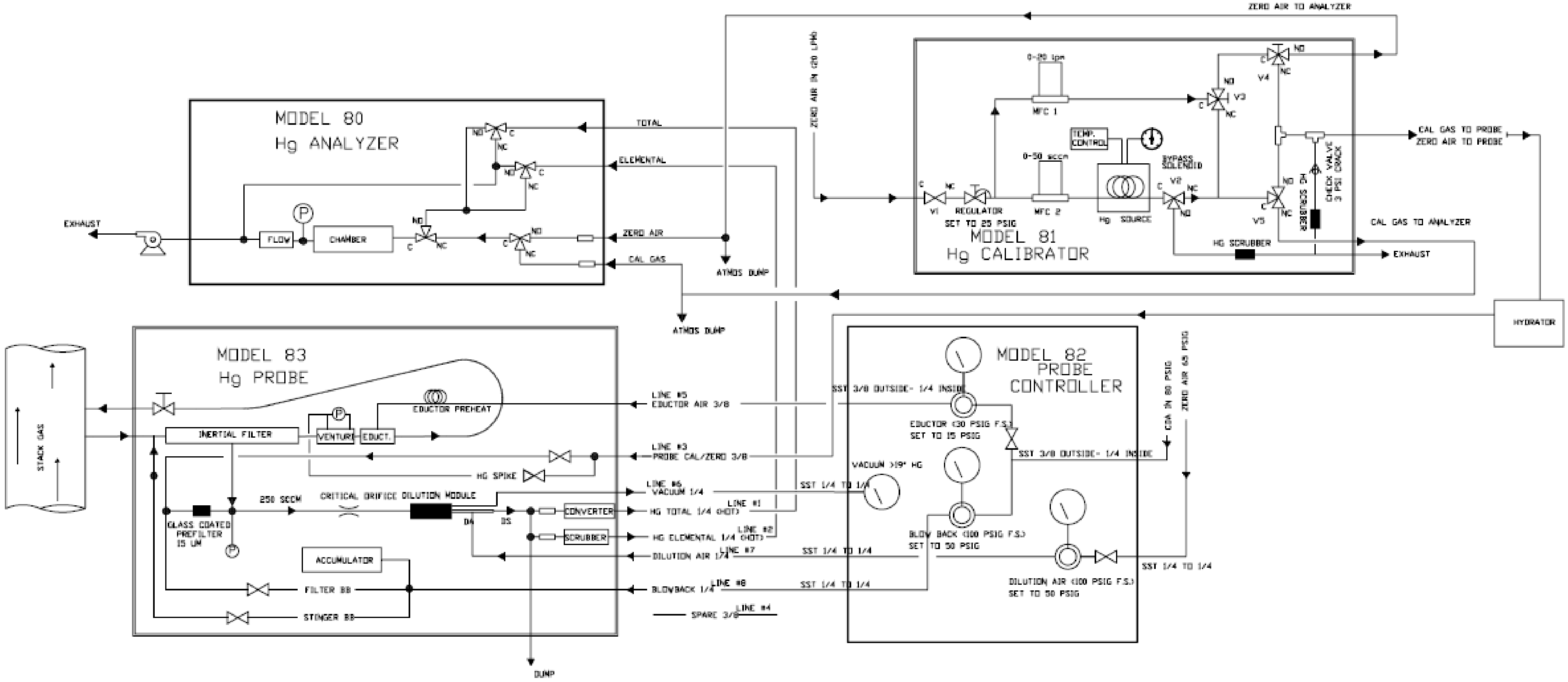

Figure 10. Hg-CEMS Diagram

2.2.4 EPA Method 30B – And ADA's Modifications

EPA Method 30B (M30B) was developed by the Electric Power Research Institute, with assistance from ADA, as a simpler method for measuring Hg than M29 and O-H. M30B specifies that it is to be used in low particulate gas streams and was designed to measure only HgT assuming HgP was negligible. However, for this project, ADA separately analyzed the first glass wool section of the sorbent trap that theoretically contains all of the HgP to provide an estimate for both HgP and HgG.

Figure 11 is a schematic of M30B sample system and Figure 12 is a diagram of the HG-324K System manufactured by the Environmental Supply Company and used by ADA for this project. The system consists of a temperature controlled, two channel probe, sample dryers, and a console that controls the sampling rate, measures the gas sample, and records operating data including temperatures, sampling volume, and barometric pressure. For the procedure, two sample traps (shown in Figure 13) are inserted into the end of the probe and the probe is inserted into the gas stream. A sample is drawn at a constant sample rate through the traps, dried, and measured. The traps are then recovered and the various sections are analyzed. ADA analyzed the traps on-site using the 915+ mercury analyzer by Ohio Lumex. Sample times can vary from as little as 30 minutes to as long as 30-days. ADA ran all traps for 60 minutes.

M30B sorbent traps consist of three sections of specially treated PAC separated by glass wool. The primary purpose of the glass wool is to retain and separate the carbon sections in the glass sample tube. However, the first glass wool section also acts to filter particulate matter from the gas sample. The first PAC section contains enough material to absorb the mercury in a typical gas sample for at least 30 days. The second PAC section is used for QA/QC purposes and is often called the "breakthrough" section. To meet QA/QC requirements, the Hg in this section must be less than 10% of the total Hg. The third PAC section contains a spiked quantity of Hg and is used for QA/QC. Upon analysis, the measured mercury in this section must agree with the spiked amount. The final glass wool section keeps the PAC from being sucked into the probe during sampling. For this project, ADA used a two section trap which did not contain the spiked section. This is the main reason the method is referred to as a modified M30B – MM30B in this report.

In a typical analysis of sorbent traps, the first glass wool and PAC sections are analyzed together to produce a single value for HgT. The second and third glass wool and second PAC sections are also analyzed together and used for QA/QC purposes to demonstrate that no breakthrough occurred during sampling. However, ADA often analyzes the first glass wool section and accompanying particulate matter separately to ascertain an estimate for HgP. However, there are two caveats to the procedure. First, the particulate matter that collects on the first glass wool section may absorb some of the HgG, misrepresenting the partitioning of mercury between particulate and gas phases. The absorption of HgG on the glass wool substrate is dependent upon the nature and constituents of the collected particulate matter. Secondly, as it is not designed nor intended to measure HgP, M30B is not done isokinetically so does not collect a true representative sample of particulate matter in the gas stream. At best, the M30B provides an estimate of HgP and the partitioning of mercury between particulate and gas phases in the stack gas stream.

At Minorca, HgP was found to be a significant portion of HgT when ACI was operating. This is important for several reasons. First, since the Hg-CEMS cannot measure HgP the data from Hg-CEMS data could not be used to calculate the total Hg reduction during ACI operation. Also, in order to assess if the Hg-CEMS are operating properly by use of the MM30B, only the HgG component of the trap data could be compared to the Hg-CEMS values for QA/QC purposes. However, if the particulates collected in the sorbent trap scrub a significant portion of the Hg from the sample gas, the trap HgG will still not agree well with the Hg-CEMS values. In this case as long as the Hg-CEMS values falls between the trap HgT and HgG the only thing that can be ascertained is that it is likely that the particulates in the trap are scrubbing Hg. If the Hg-CEMS values fall below the trap HgG, it is likely that the Hg-CEMS is not operating properly.

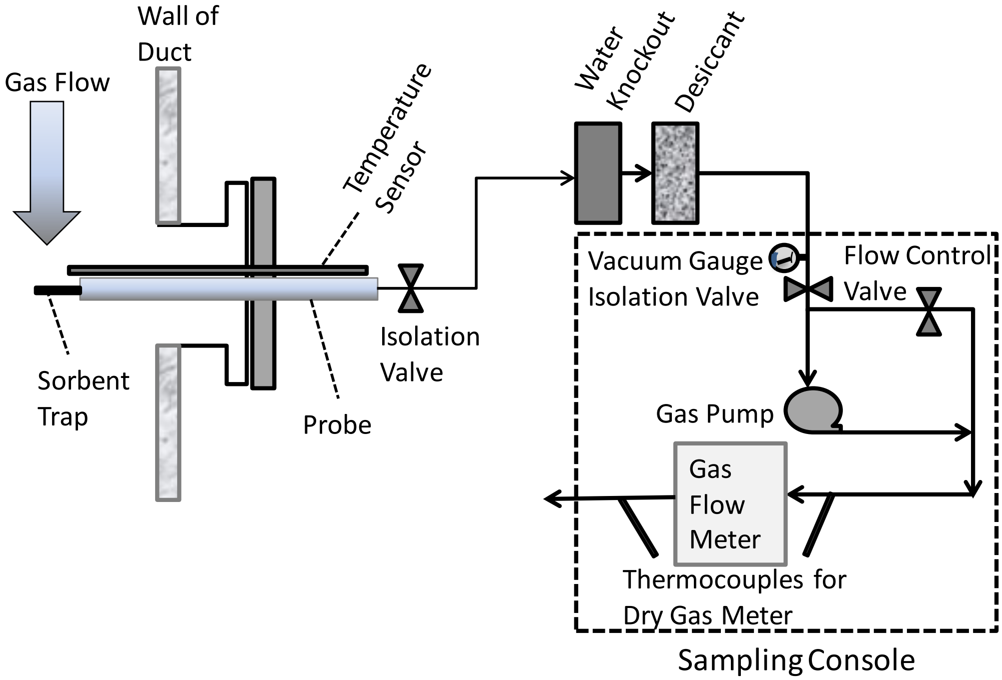

Figure 11. Method 30B Sample Train

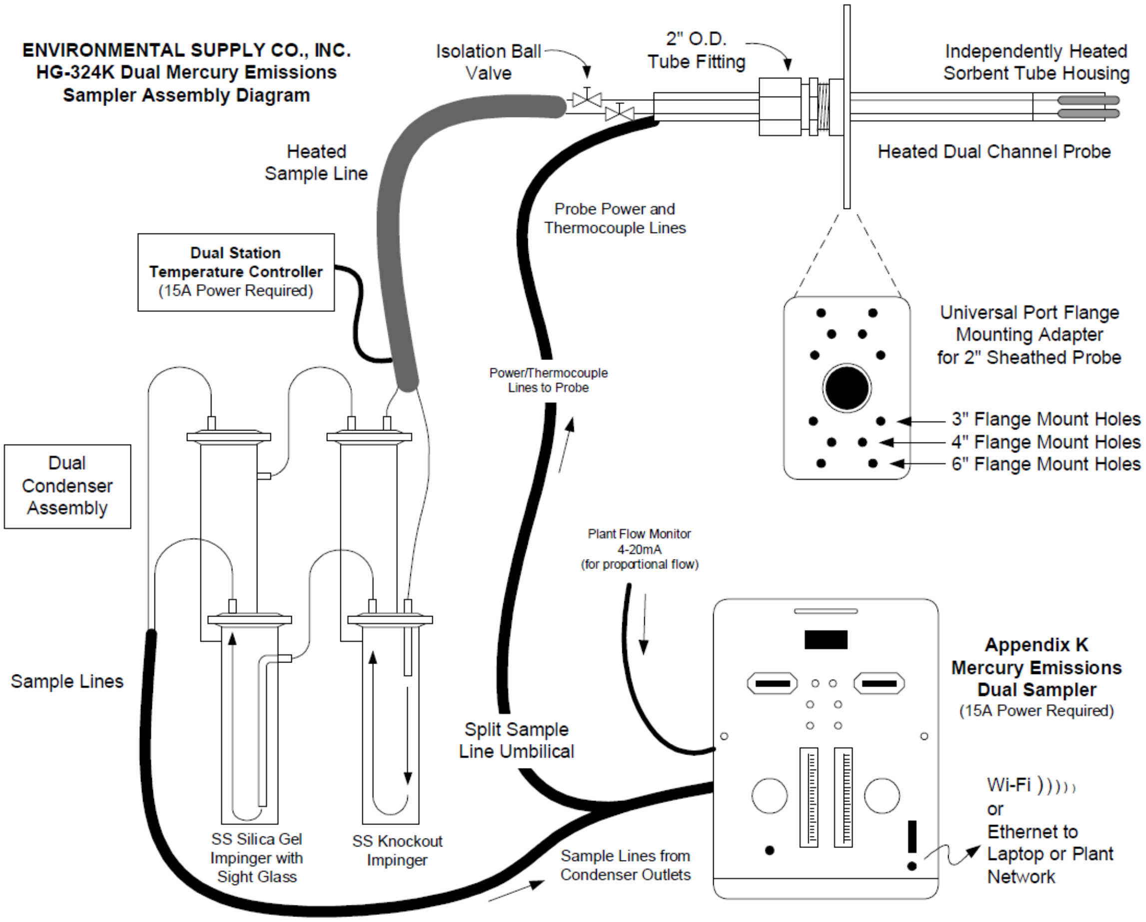

Figure 12. Environmental Supply Company HG-324K System

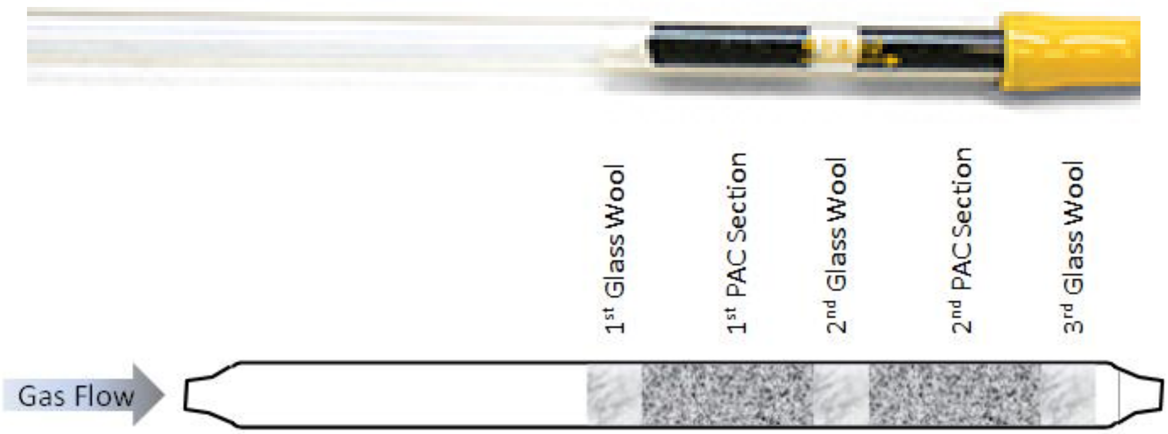

Figure 13. MM30B Two Section Sorbent Trap

2.3 Solids Sampling and Analysis

As discussed above, several of the host sites, including Minorca, recycle the process solids back to different points in the process. At Minorca, solids from the scrubber are recycled directly back to the concentrate thickener tank, however for this test solids from the multitube collector were disposed of. Therefore, it is likely that PAC, and the Hg absorbed on the PAC, would also be recycled into the green balls and the Hg would be re-released during the induration process. To investigate the possible effect of recycle, the host site sampled and analyzed several process streams on a regular basis. ADA received a split of selected samples twice during the test for analysis with the Ohio Lumex (OL). ADA received the independent analysis results conducted by Minorca for all the samples for both carbon and Hg analysis. Results of the analysis are included in Section 4.

Samples were collected from the following locations:

- Green Balls
- Multi-tube Collector drop out
- Concentrate Thickener Overflow
- Pellets
- Fine Tailings

2.4 Ohio Lumex

ADA used the OL RA-915+ to quantitatively recover and quantify Hg from sorbent traps and process samples. The analyzer meets the requirements for analysis specified in M30B. It utilizes differential atomic absorption spectrometry (Zeeman Effect) to measure mercury. The trap sections are inserted into the RP-91C furnace attachment and heated to 800C to vaporize and convert the mercury from a bound state to an atomic state. Organic compounds are completely burned to produce non-interfering carbon dioxide and water. The analyzer produces a desorption curve from which the mass of mercury emitted can be determined by comparison to desorption curves produced from National Institute of Standards and Technology traceable mercury standards. Samples containing 0.2 ppb to 30,000 ppm Hg can be analyzed. Results are obtained in minutes allowing for near real-time, onsite sample analysis. All of the raw data obtained with the OL for process samples and sorbent traps are included in Appendix C.

3.0 PAC SCREENING TEST (PST)

3.1 Description

The goals of the PAC Screening Test were:

- Determine which of several commercially available PACs performed the best.
- Determine what PAC rate was needed to achieve 75% Hg reduction.
- Perform PM stack tests for each PAC at each rate tested on stack D only.

The original plan called for testing PAC rates of 3, 5 and 7 lb/mmacf. However, because ADA had previously tested at Hibtac, which has a very similar exhaust gas layout as at Minorca, it was discovered that the higher rates of injection were not needed when a multi-tube dust collector is present. Therefore, rates of 1, 3 and 5 lb/mmacf were tested for the three candidate PACs.

A typical day of PAC screening involves:

1. Calibrate the Hg-CEMS
2. Obtain Hg-CEMS baseline data
3. Begin testing at the first ACI rate
4. Barr PM Test (when steady conditions are reached as determined by the Hg-CEMS)
5. Change ACI rate and repeat Step 4
6. Continue until all three rates have been tested

Each PAC was tested during a single day and the system was allowed to recover overnight. At Minorca, Hg levels returned to the original baseline conditions after running without ACI overnight. However, Hg reduction was calculated using baseline data obtained shortly before ACI began each day.

3.2 Results

Figure 14 through Figure 16 show the results of the PST at Minorca. Each figure has six traces and four shaded areas. The shaded areas represent the period during which the Hg-CEMS data was averaged in order to determine the HgG reduction.

- Black Dots – Plant Production Rate
- Red Dots – Stack D Hg-CEMS gas phase total Hg, µg/wscm
- Pink Dots – Stack D Hg-CEMS gas phase elemental Hg, µg/wscm
- Dark Green Dots – Stack B Hg-CEMS gas phase total Hg, µg/wscm
- Light Green Dots – Stack B Hg-CEMS gas phase elemental Hg, µg/wscm
- Purple Line – PAC Rate, lb/mmacf
- Grey Shade – Data period averaged to calculate baseline Hg
- Blue Shade – Data period averaged to calculate Hg at low ACI rate
- Red Shade – Data period averaged to calculate Hg at medium ACI rate
- Green Shade – Data period averaged to calculate Hg at high ACI rate

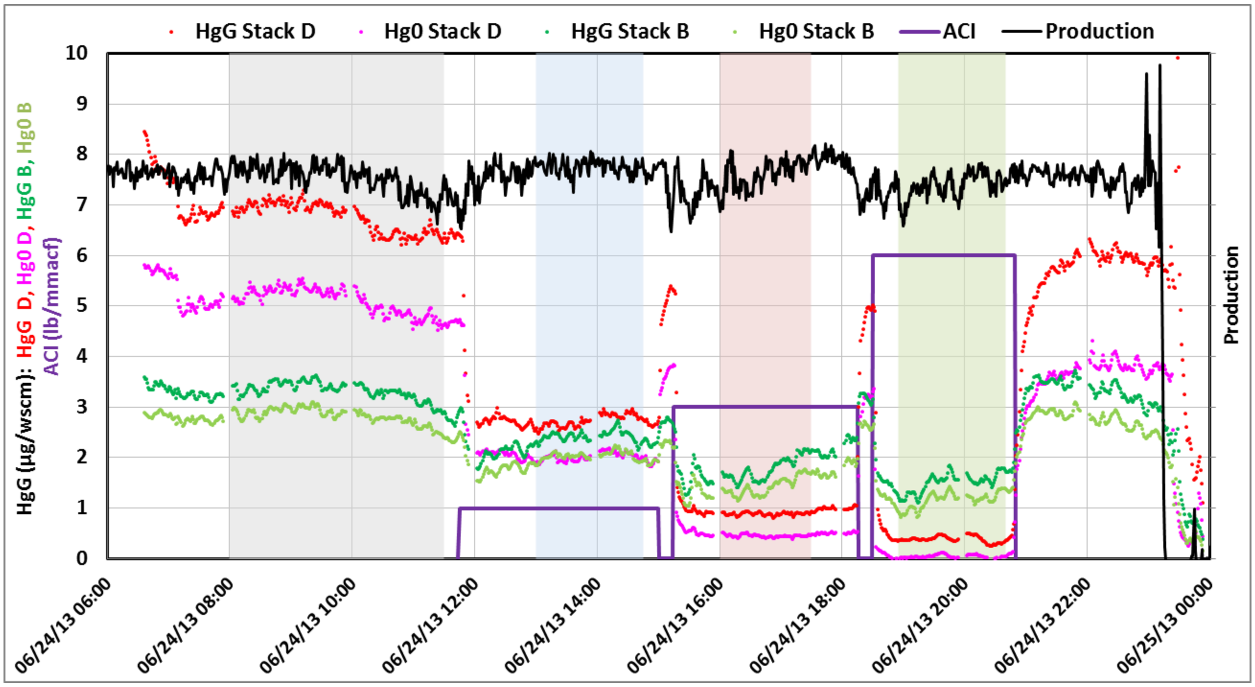

Figure 14. HPAC Screening Test Results

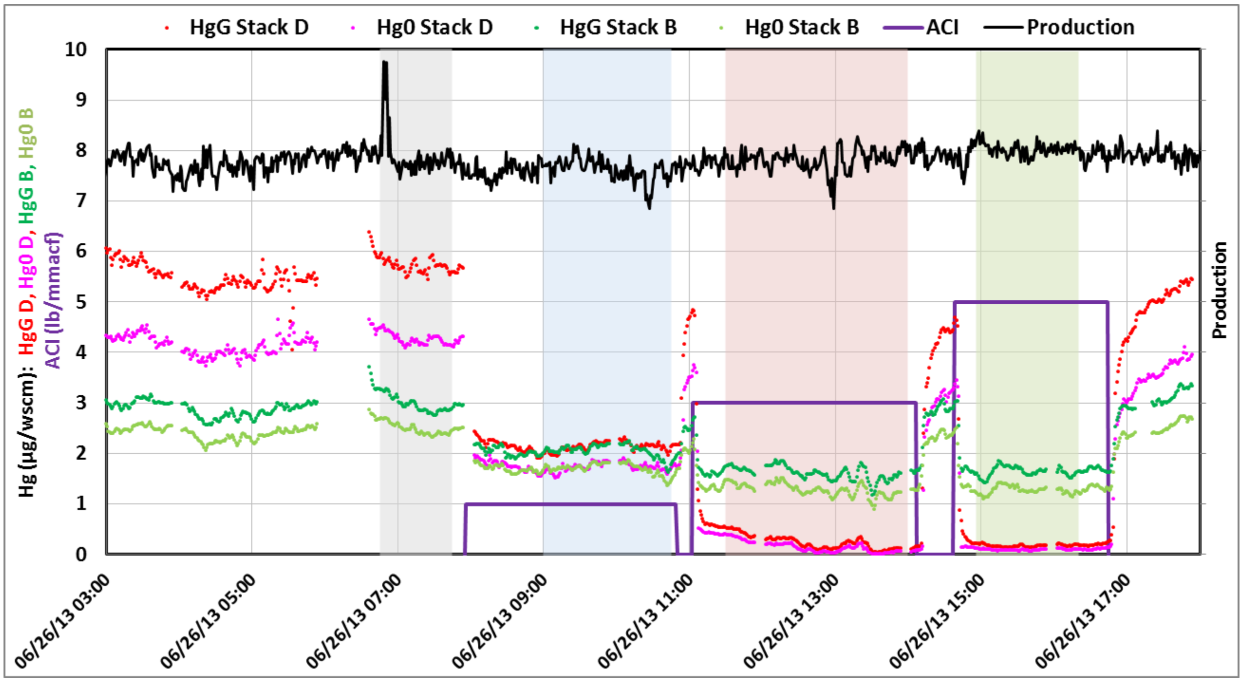

Figure 15. BPAC Screening Test Results

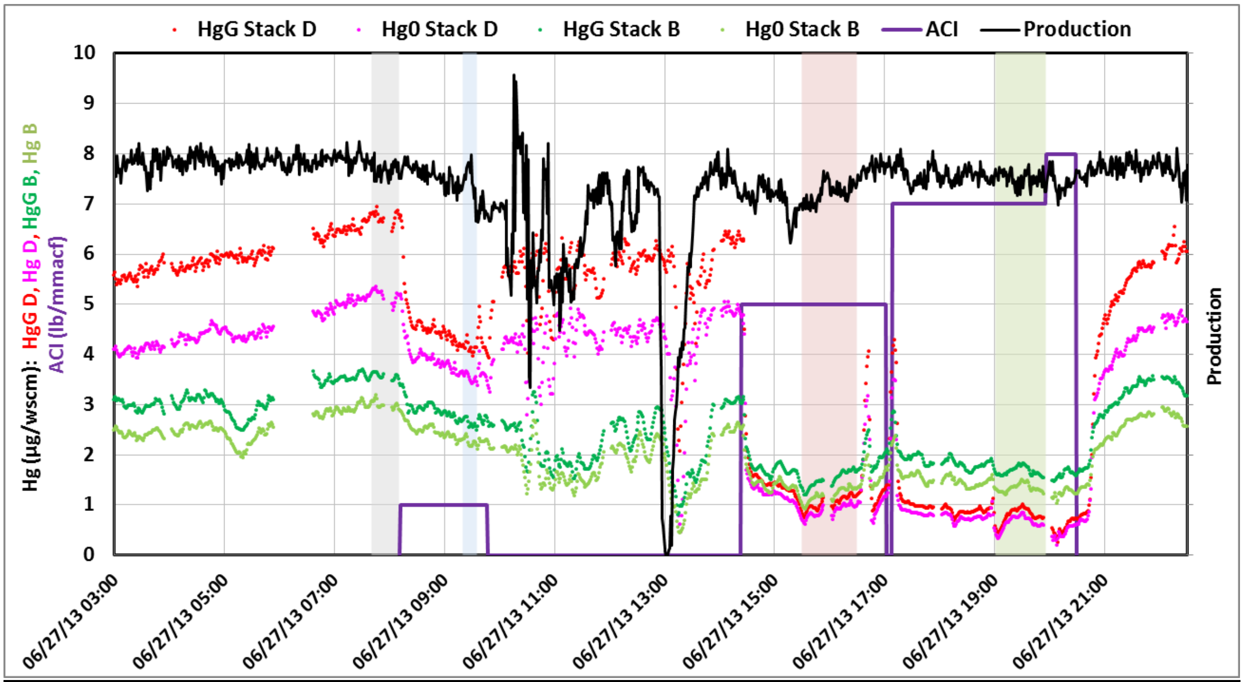

Figure 16. 2013N Screening Test Results

Table 4 is a compilation of the PST results showing the HgG baseline and test values for each PAC and ACI rate tested for both stacks D and B along with the calculated HgG reduction for each test as measured by the Hg-CEMS. Hg reduction was plotted in Figure 17 to produce a comparison of PAC performance. The figure shows that all of the PACs achieved 75% HgG reduction on stack D at 5 lb/mmacf. However, the coarser PAC did not perform as well in stack D as the other two PACs.

All of the PACs showed moderate reduction on stack B, but none reached 75% reduction. As shown in Figure 18, no injection occurs in the Hood Exhaust so there is no stack reduction for stacks A and B except from the limited mixing that occurs in the header.

BPAC was selected for Phase II testing at 3 lb/mmacf because it performed as well as the other PACs on stack B and much better on stack D. It is also a moderately priced, readily available sorbent.

Table 4. Summary of the PAC Screening Test at Minorca

Hg-CEMS, µg/wscm	HPAC	BPAC	2013N
Baseline Stack D	6.75	5.70	6.73
Baseline Stack B	3.32	2.96	3.57
With ACI			
1 lb/mmacf Stack D HgG (µg/wscm)	2.73	2.12	4.14
1 lb/mmacf Stack B HgG (µg/wscm)	2.42	2.05	2.63
Removal Stack D	**60%**	**63%**	**39%**
Removal Stack B	**27%**	**31%**	**26%**
3 lb/mmacf Stack D HgG (µg/wscm)	0.88	0.23	n/a
3 lb/mmacf Stack B HgG (µg/wscm)	1.76	1.60	n/a
Removal Stack D	**87%**	**96%**	n/a
Removal Stack B	**47%**	**46%**	n/a
5 lb/mmacf Stack D HgG (µg/wscm)	n/a	0.17	1.03
5 lb/mmacf Stack B HgG (ug/wscm)	n/a	1.63	1.50
Removal Stack D	n/a	**97%**	**85%**
Removal Stack B	n/a	**45%**	**58%**
6 lb/mmacf Stack D HgG (µg/wscm)	0.37	n/a	n/a
6 lb/mmacf Stack B HgG (ug/wscm)	1.49	n/a	n/a
Removal Stack D	**94%**	n/a	n/a
Removal Stack B	**55%**	n/a	n/a
7 lb/mmacf Stack D HgG (µg/wscm)	n/a	n/a	0.78
7 lb/mmacf Stack B HgG (ug/wscm)	n/a	n/a	1.66
Removal Stack D	n/a	n/a	**88%**
Removal Stack B	n/a	n/a	**53%**

ug/wscm – micrograms of Hg per wet standard cubic meter of gas.
n/a – system was not tested at this rate.

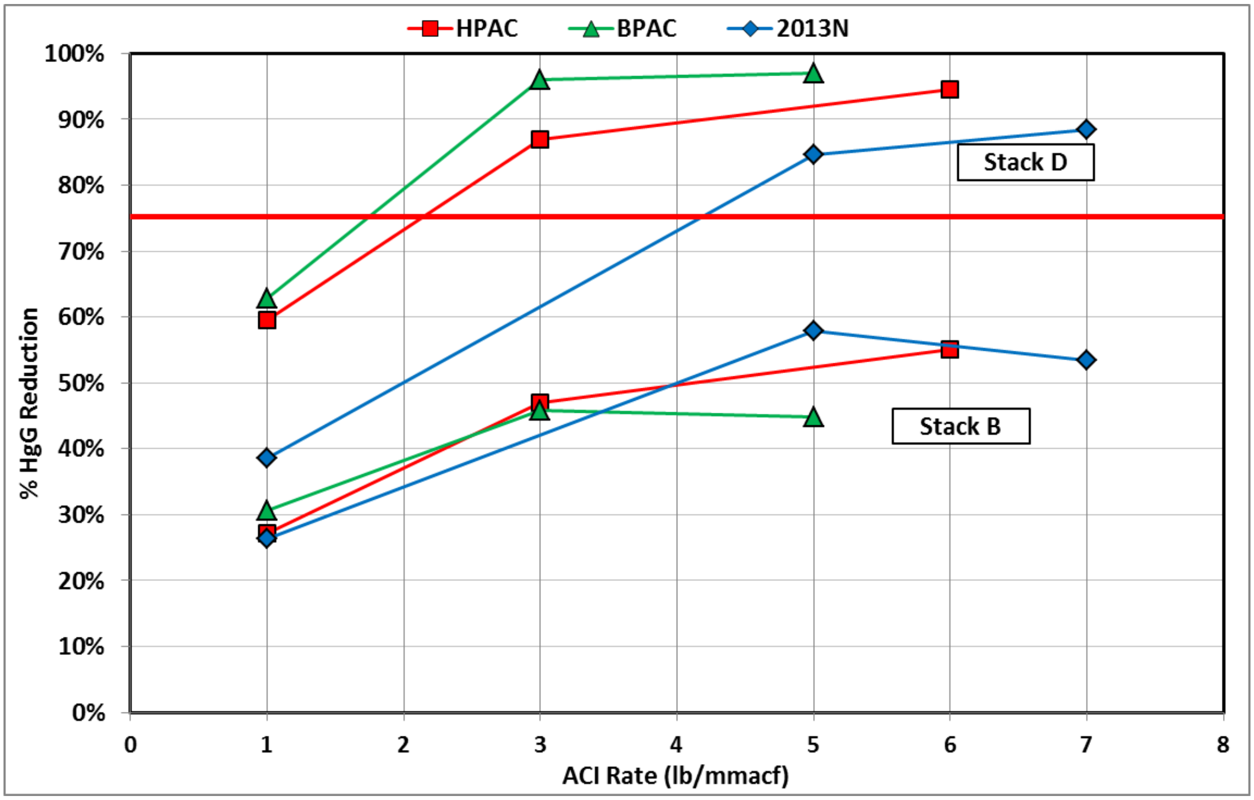

Figure 17. Comparison of the PAC Screening Test Results for HgG

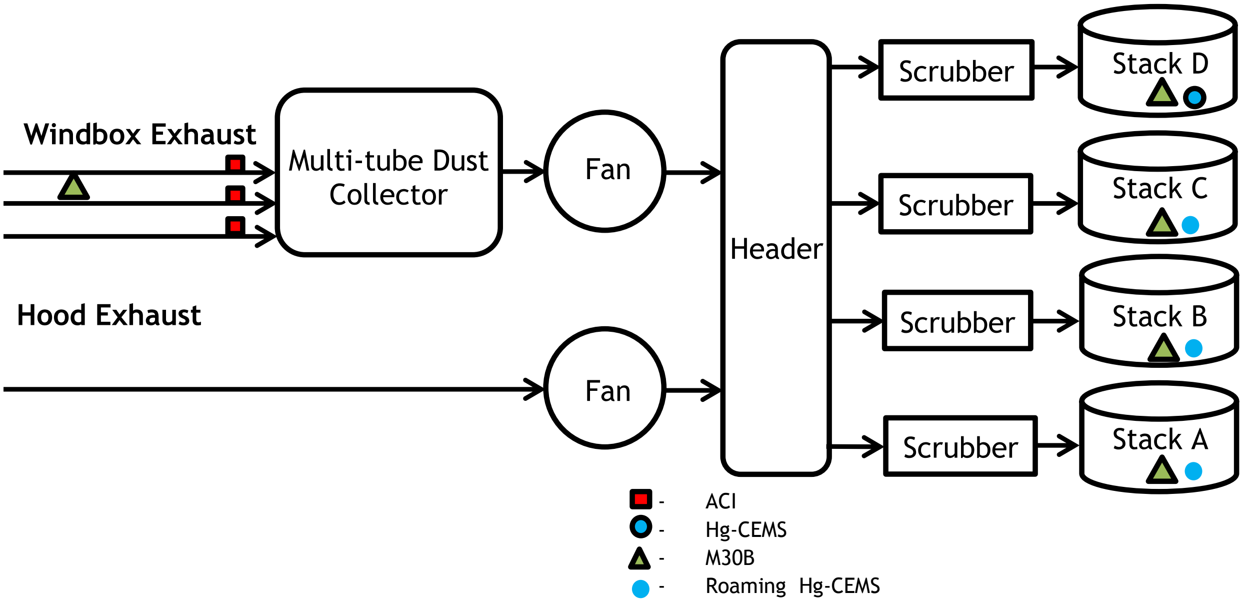

Figure 18. Minorca Gas Stream and Sampling Locations

4.0 PHASE II TESTING

4.1 Description

The goals of Phase II testing were:

- Determine the long term Hg reduction performance for BPAC at 3 lb/mmacf
- Determine the effects of PAC/Hg recycle on the mercury concentration in the process streams and the effects on Hg reduction
- Perform periodic PM tests at the Stack (Barr)

A typical day of Phase II testing involves:

1. Calibrate the Hg-CEMS
2. Collect and analyze samples
3. Collect and analyze MM30B sorbent traps

Phase II Testing commenced on 7/10/13 and was completed on 8/8/13 as scheduled. The ACI rate was held at 3 lb/mmacf except for short periods when the plant was off-line or minor maintenance was required on the Hg-CEMS or Mini-Silo. Barr performed weekly PM testing during Phase II testing.

4.2 Results

4.2.1 Phase II Testing

Figure 19 through Figure 23 show the data collected prior to and during Phase II testing. The shaded areas represent the periods during which the Hg-CEMS data were averaged in order to determine the HgG reduction. The figures use the following color designations:

- Black Dots – Plant Production Rate
- Red Dots – Stack D Hg-CEMS total gas phase Hg, µg/wscm
- Green Dots – Stack B Hg-CEMS total gas phase Hg, µg/wscm
- Orange Dots – Stack C Hg-CEMS total gas phase Hg, µg/wscm
- Blue Dots – Stack A Hg-CEMS total gas phase Hg, µg/wscm
- Purple Line – PAC Rate, lb/mmacf
- Pink Line – Approximate shift in baseline
- Light Red Shade – Data period averaged to calculate Stack D total gas phase Hg
- Light Green Shade – Data period averaged to calculate Stack B total gas phase Hg
- Light Orange Shade – Data period averaged to calculate Stack C total gas phase Hg
- Light Blue Shade – Data period averaged to calculate Stack A total gas phase Hg

Figure 19 shows the baseline HgG data for all four stacks during the 10 days before Phase II testing began. The shaded sections in Figure 19 were the baselines chosen for each stack (C and D have the same time period). These periods represent relatively steady operation for production and Hg levels and were close to the beginning of the testing period.

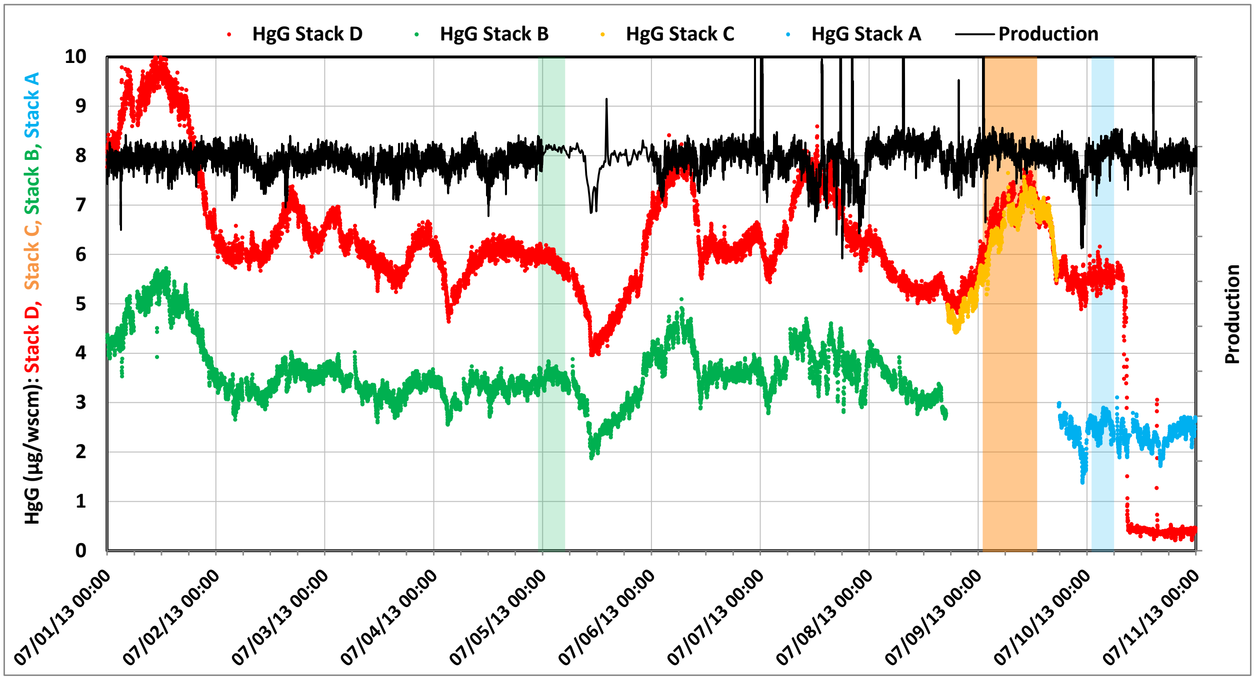

Figure 19. Phase II Testing Baseline Stack Data

Figure 20 through Figure 23 show the results of Phase II testing at Minorca. The figures show the mercury trend of the two stacks being sampled at any given time. Figure 23 shows all the stack data on a single graph. One Hg-CEMS probe was positioned in stack D for the duration of Phase II testing, and the second was rotated between stacks A, B, and C every two to three days. When ACI commenced, Figure 22 shows immediate and significant reduction in HgG emissions in stack D and C, and Figure 20 and Figure 21 show more gradual and less significant reduction in stacks A and B. This was expected because PAC was only being injected into the Windbox Exhaust that preferentially exits through stacks C and D. The data shows that some minimal mixing must occur between the Windbox and Hood Exhaust gas in the common header based on the HgG reductions measured in stacks A and B. HgG emissions in stack D were fairly stable with values usually under 1.0 µg/wscm during testing.

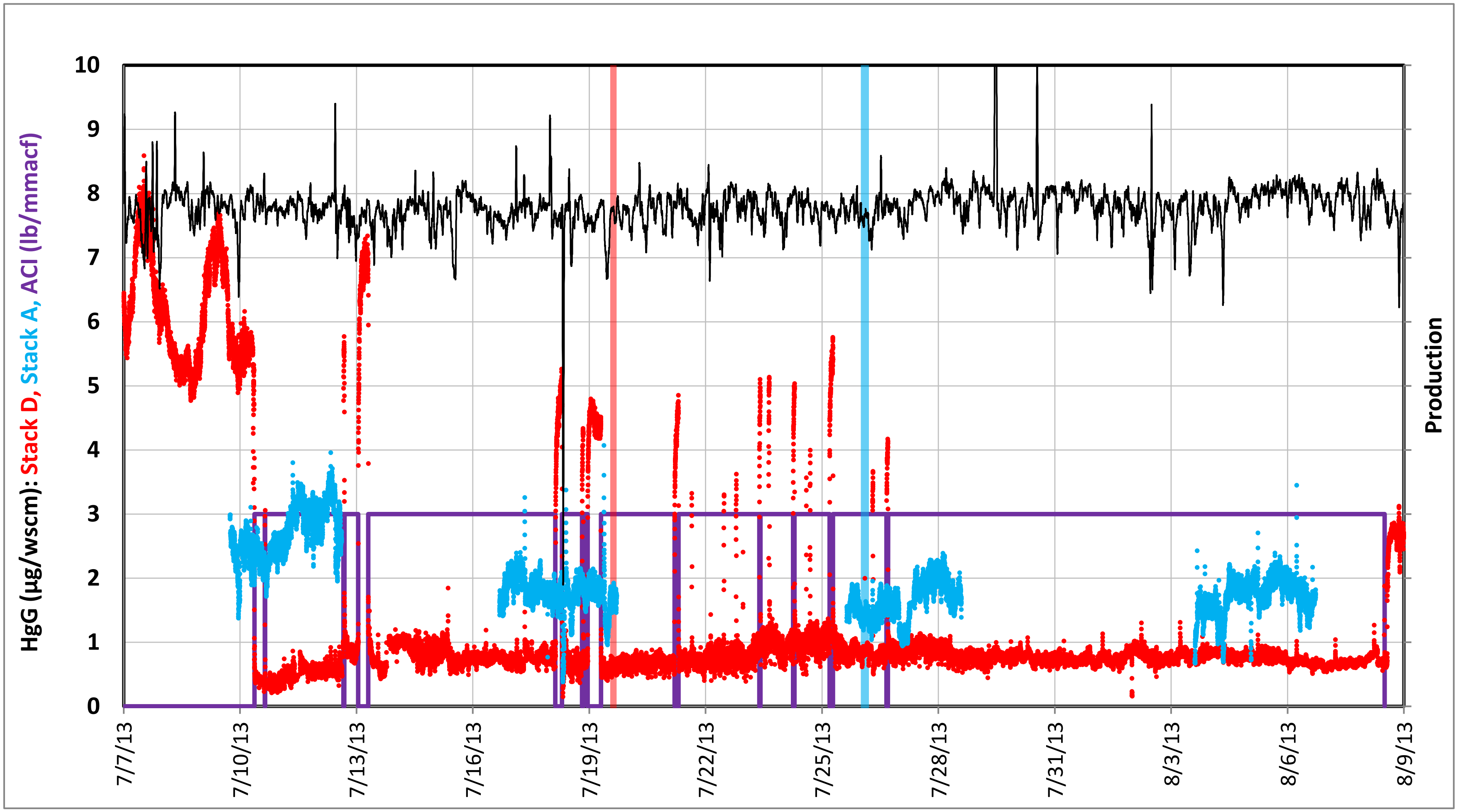

Figure 20. Phase II Testing - Stack D and A Emissions

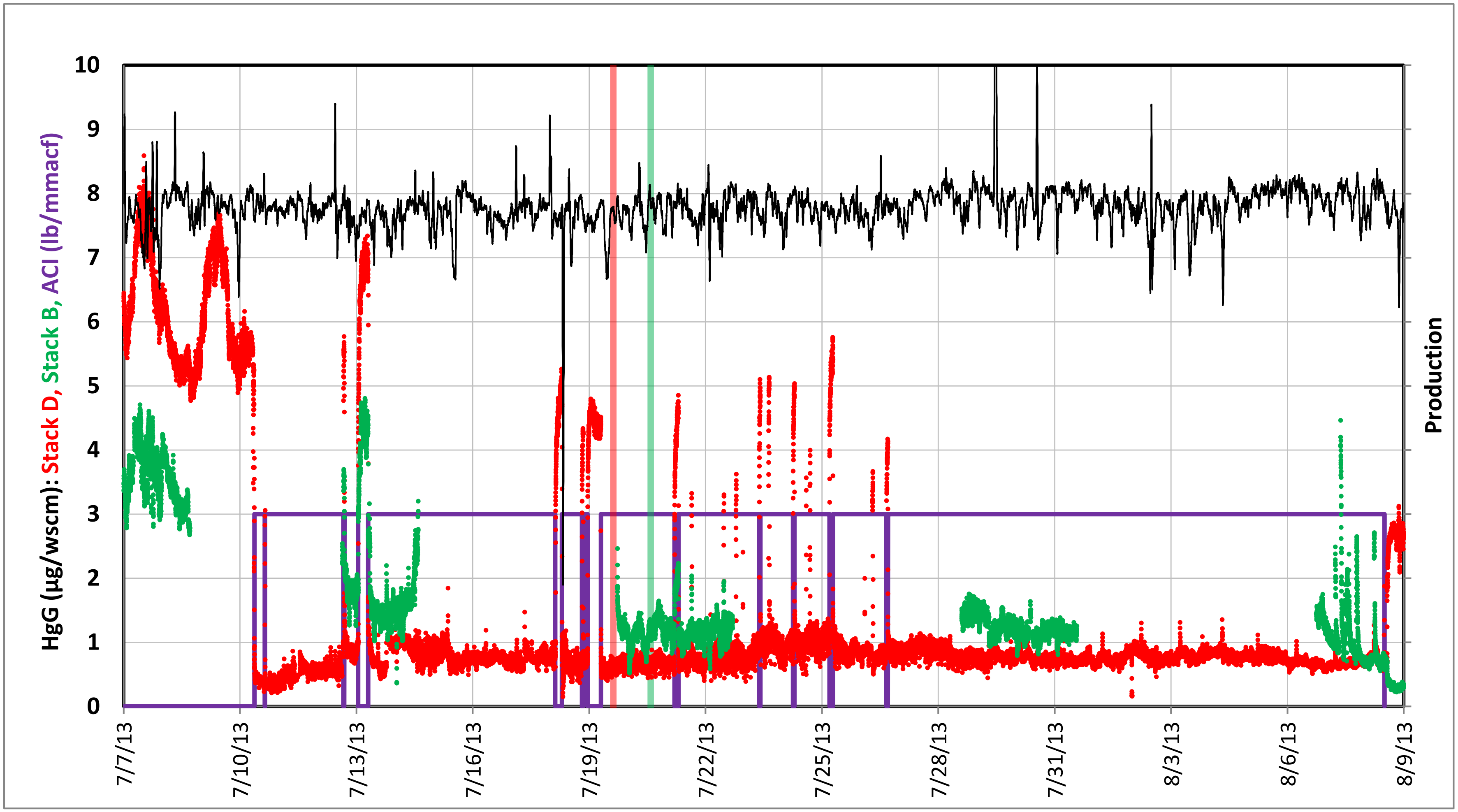

Figure 21. Phase II Testing - Stack D and B Emissions

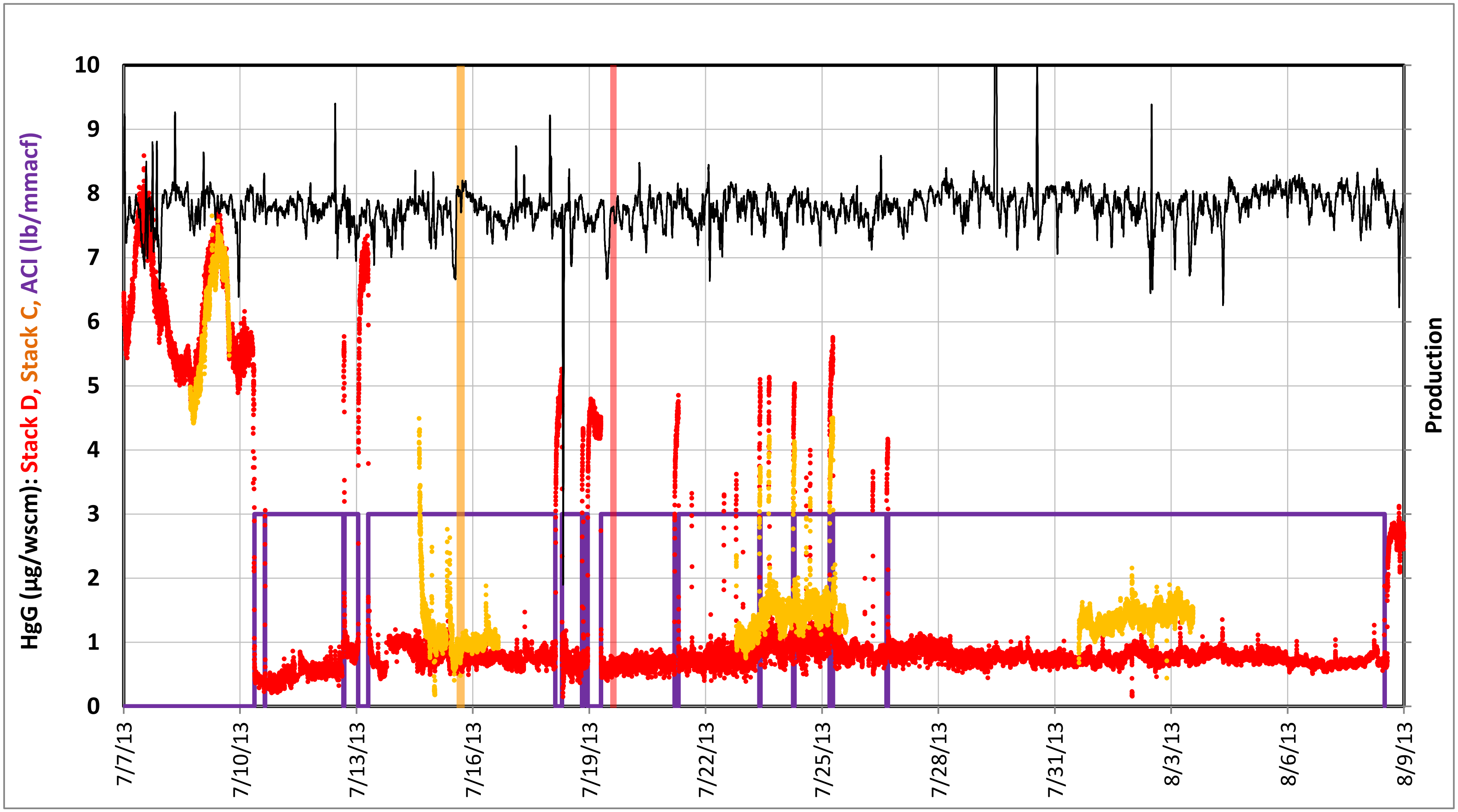

Figure 22. Phase II Testing - Stack D and C Emissions

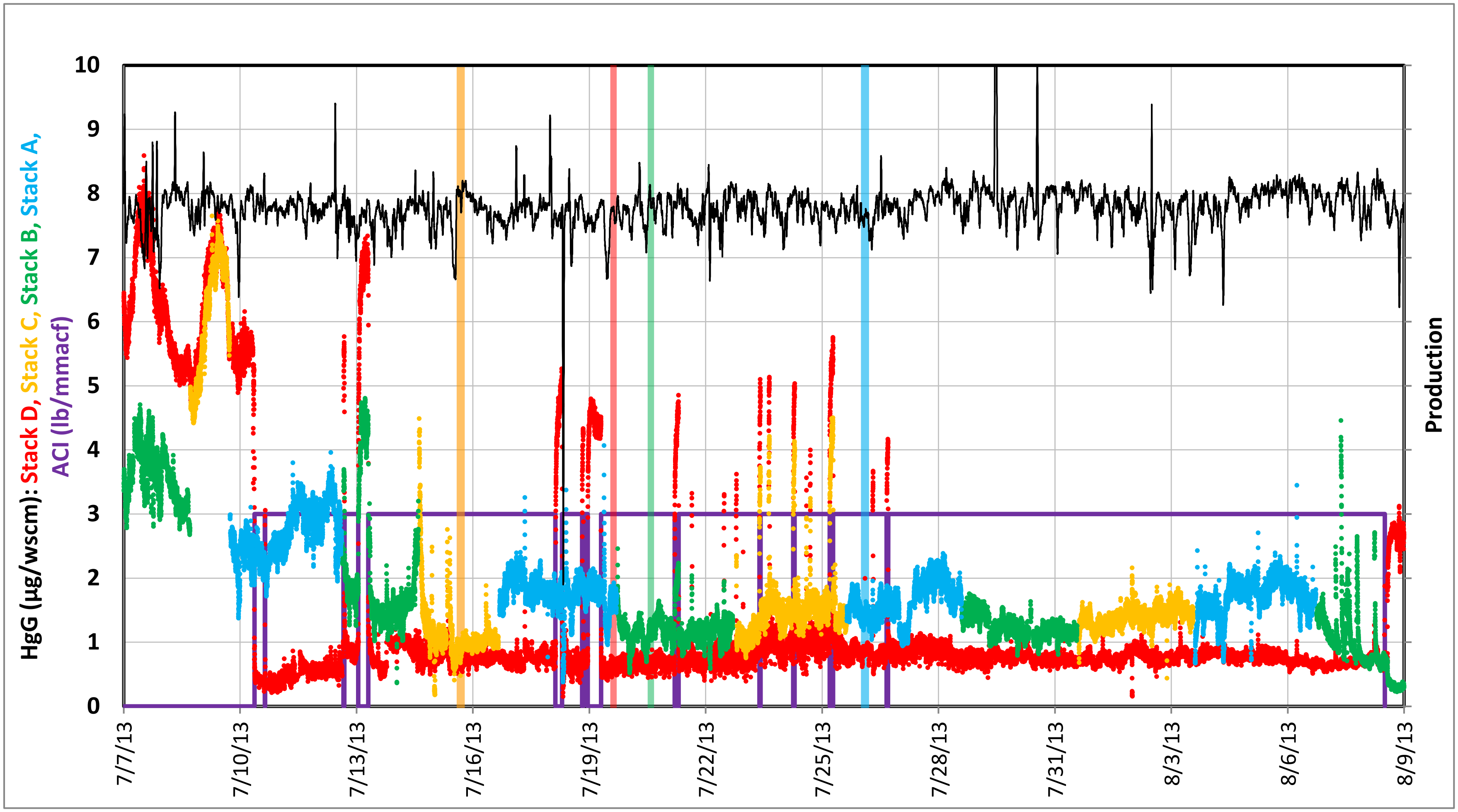

Figure 23. Phase II Testing - Stack Emissions

The results of Phase II testing, summarized in Table 5, list the Baseline and ACI Hg emissions, as well as the calculated Hg reductions, for the Hg-CEMS and MM30B measurements. Hg-CEMS data represent the HgG reduction whereas the MM30B data represents HgT reduction and includes particulate bound mercury (HgP). The table shows that stacks C and D had the highest baseline values and the highest reduction percentages. The total HgG reduction, considering all four stacks, was 76%. However, the HgT reduction based on MM30B data was 54%.

Table 5. Phase II Testing Mercury Reduction Summary via Hg-CEMS and MM30B

CEMS Hg-Gas Phase (ug/wscm)	Stack D	Stack C	Stack B	Stack A	Total
Baseline	7.26	5.85	3.02	3.51	19.64
With ACI	0.39	0.72	0.94	1.71	3.77
Reduction	**95%**	**88%**	**69%**	**51%**	**76%**

MM30B Hg-Total (ug/wscm)	Stack D	Stack C	Stack B	Stack A	Total
Baseline	11.11	6.74	3.46	4.07	25.38
With ACI	3.50	3.13	1.72	2.28	10.64
Reduction	**68%**	**54%**	**50%**	**44%**	**54%**

4.2.2 Stack MM30B Data

Figure 24 through Figure 27 show a comparison of the stack MM30B and Hg-CEMS data for each of the four stacks. The figure presents the MM30B data in three parts; HgT-dark symbol, HgG-medium colored symbol, and HgP-light symbol. Hg-CEMS values are shown as a line in the same color as the MM30B symbol for HgG. This was done because it was discovered that HgP was a significant portion of HgT as determined by analyzing the first glass wool section of the sorbent trap, which is assumed to contain all of the particulate, separately from the two sorbent sections. The Hg-CEMS can only measure gas phase mercury, so if the gas contains a significant fraction of HgP, the Hg-CEMS and MM30B will not agree well. The figure shows that the Hg-CEMS values agreed well with the MM30B HgG data for all stacks and the HgP was a major fraction of the mercury leaving Stacks C and D. The values for this graph were used in Table 5. This topic is discussed further in the QA/QC section and in Appendix D.

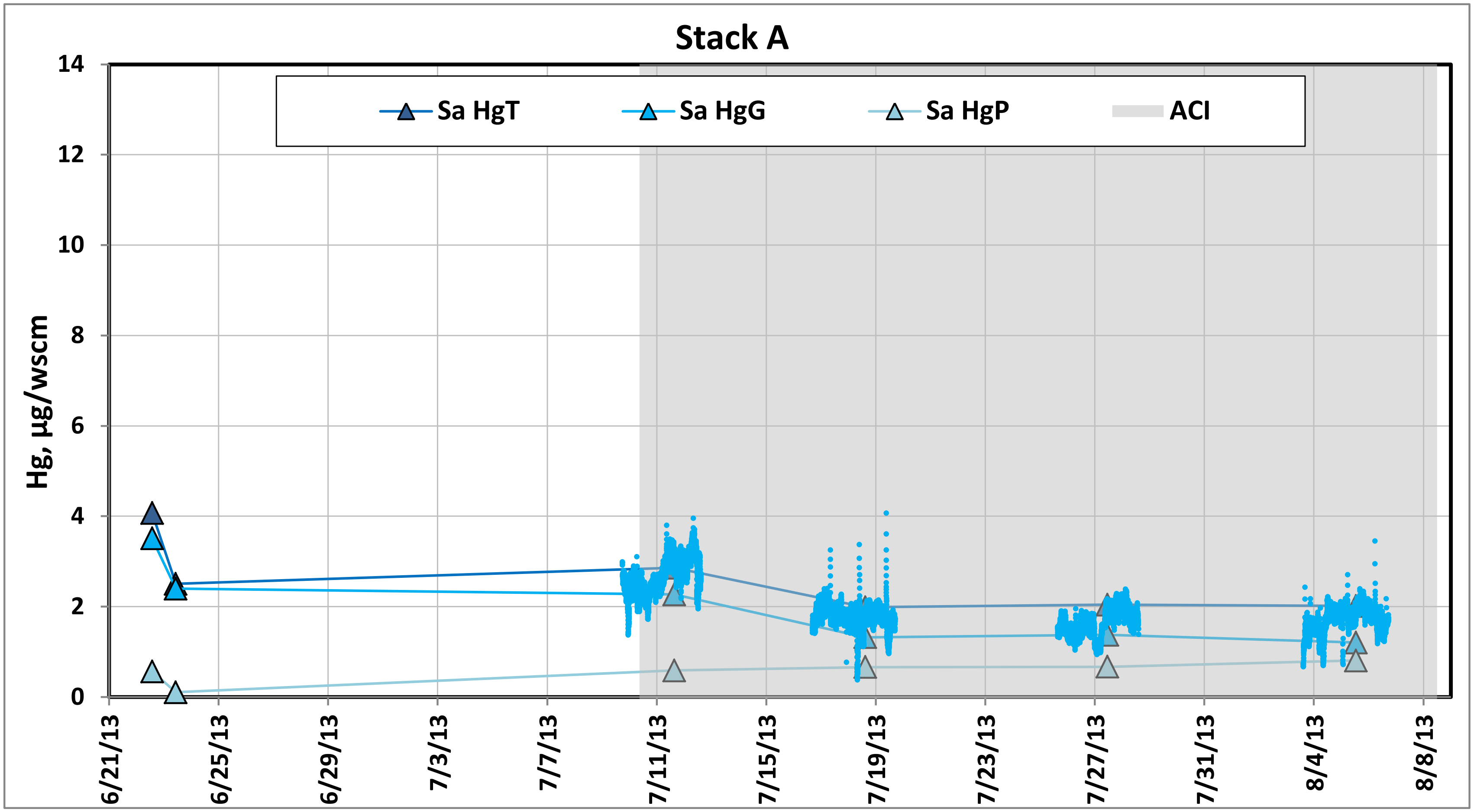

Figure 24. Stack A MM30B Data vs. Hg-CEMS

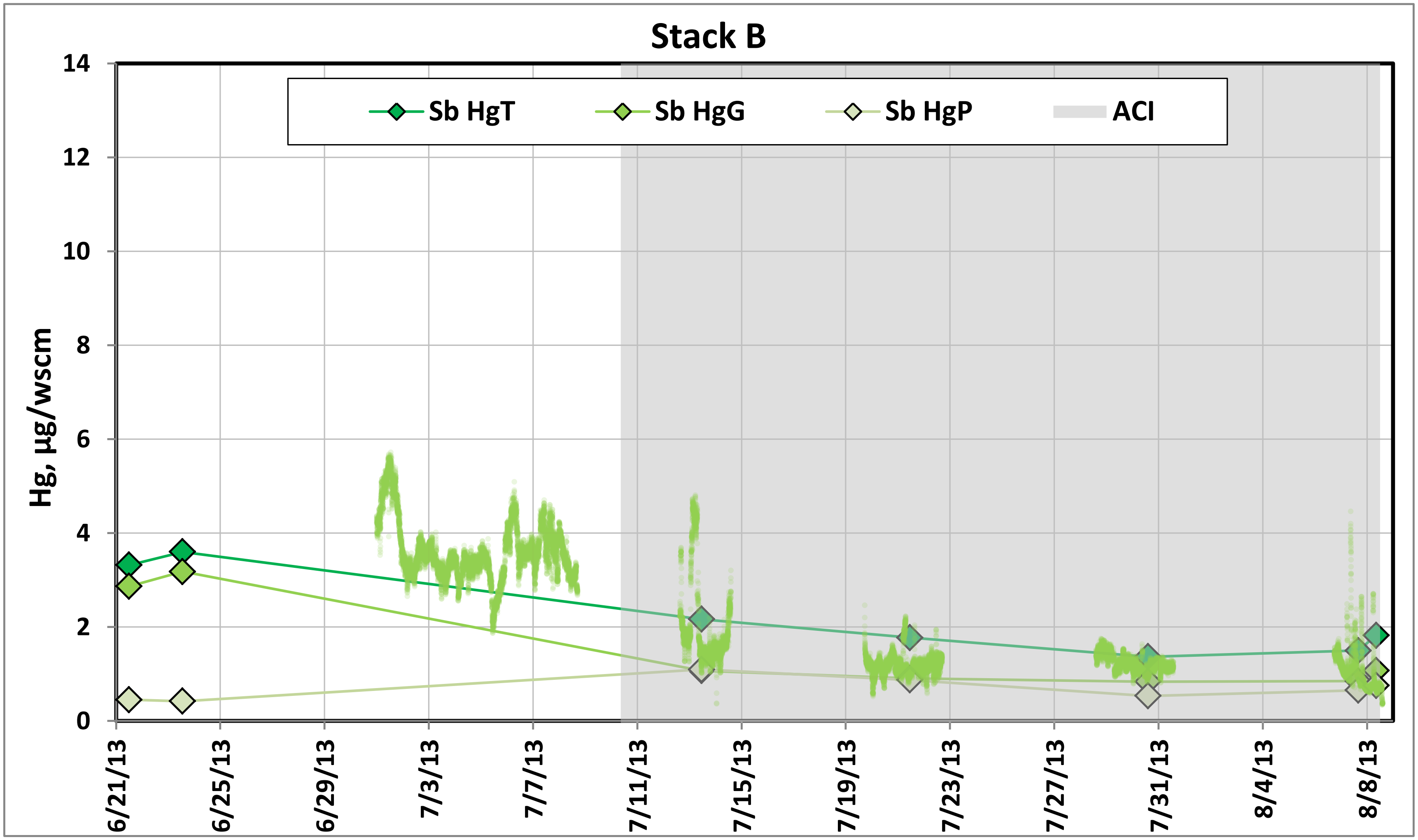

Figure 25. Stack B MM30B Data vs. Hg-CEMS

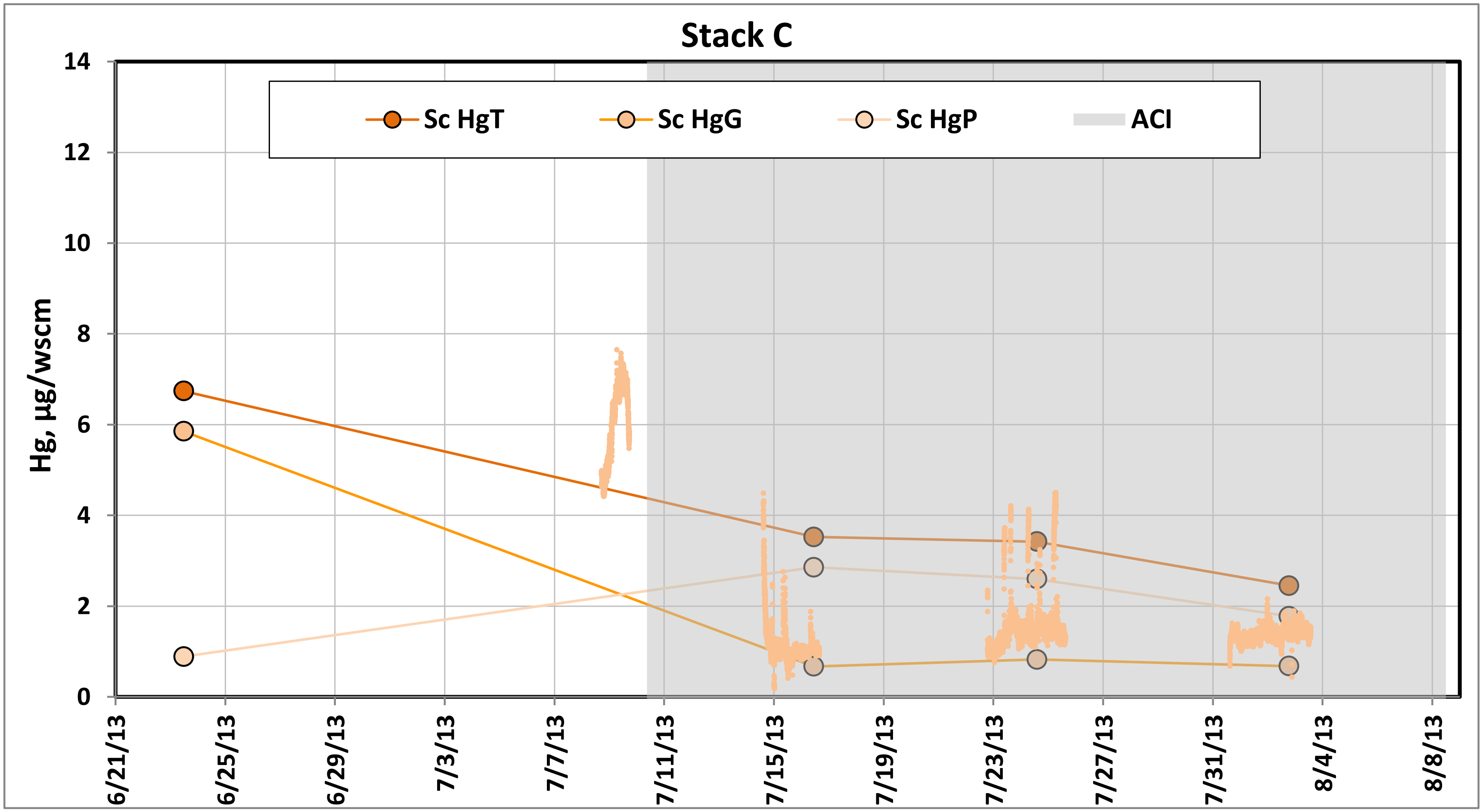

Figure 26. Stack C MM30B Data vs. Hg-CEMS

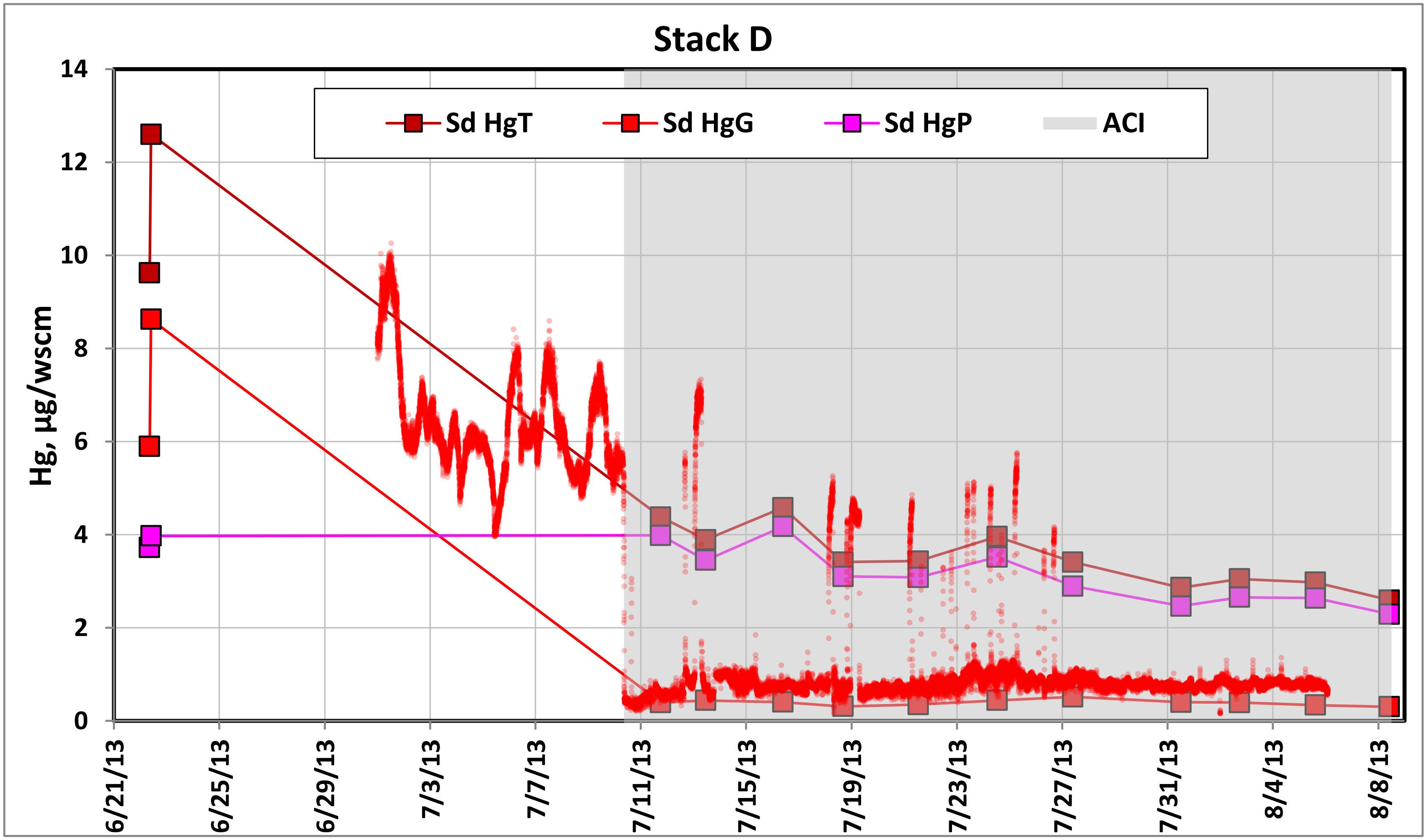

Figure 27. Stack D MM30B Data vs. Hg-CEMS

4.2.3 Inlet MM30B Data

Figure 28 shows the results of the MM30B sorbent traps that were collected upstream of the ACI grid including tests in each of the four inlet ducts prior to the PST. The gray shaded area represents Phase II testing. The red markers represent Hg concentration in the Green Balls. The figure shows that during the limited 30-day test, there was little or no increase in the inlet mercury concentration from Hg/PAC recycled back to the process. The inlet mercury corresponded well with changes in the Hg concentration of the Green Balls. Extended testing would be required to further identify long-term, inlet mercury concentration changes.

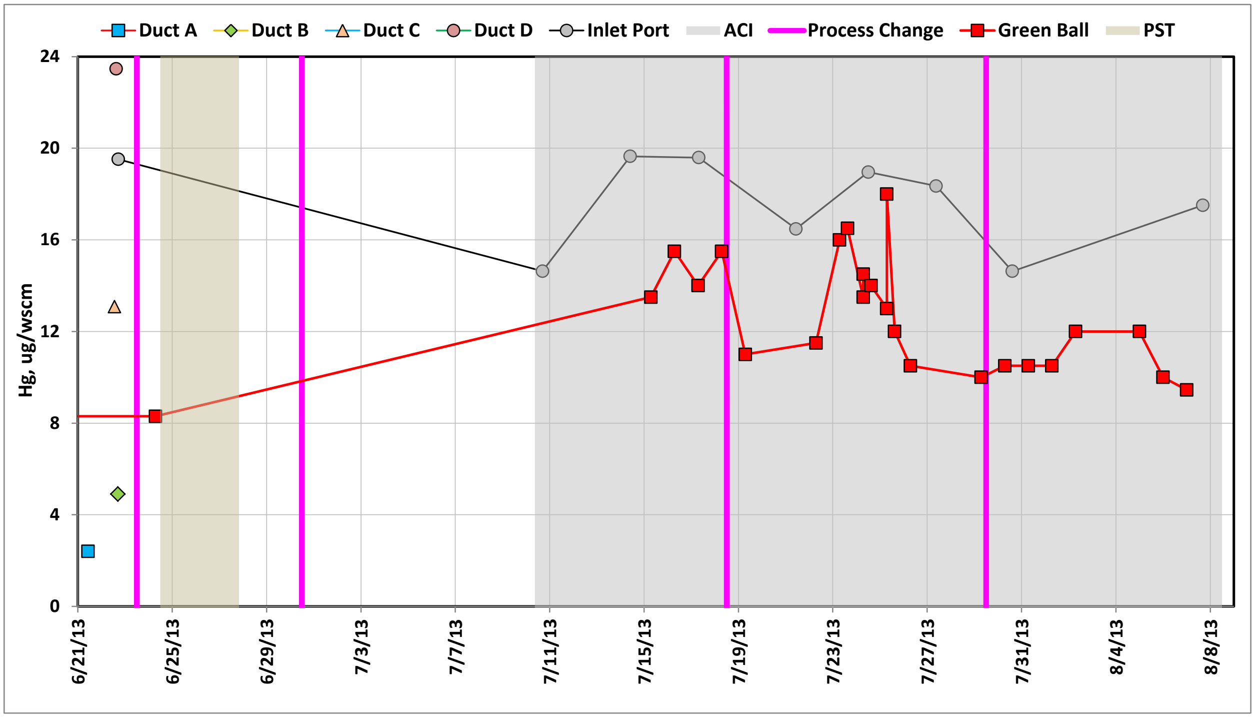

Figure 28. Inlet MM30B Data with Greenball Hg Data

4.2.4 Sample Carbon Analysis

Several samples were analyzed, as shown in Figure 29, for carbon content in an effort to track the Hg. It is believed that by tracing the carbon through the process it can be determined where the Hg is going because it is attached to the carbon and difficult to leach.

Multiclone, Thickener Overflow, Fine Tails, Green Balls, and Fired Pellets samples were analyzed by an independent lab for total carbon. Figure 30 through Figure 34 show the results of the analysis. Figure 30 and Figure 31 indicate the multiclone collector and thickener overflow sample carbon content had risen slightly. However, Figure 32, Figure 33, and Figure 34 do not show any significant increase in fine tails, green balls, or pellets.

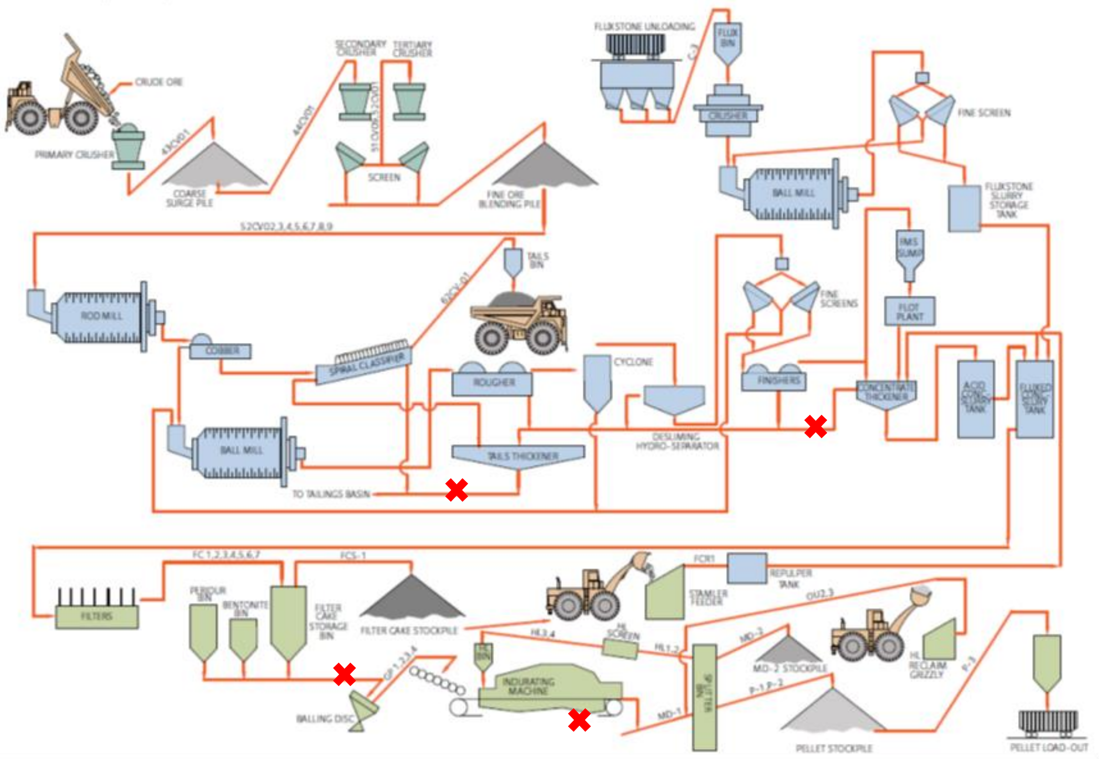

Figure 29. Process Diagram with Sampling Locations

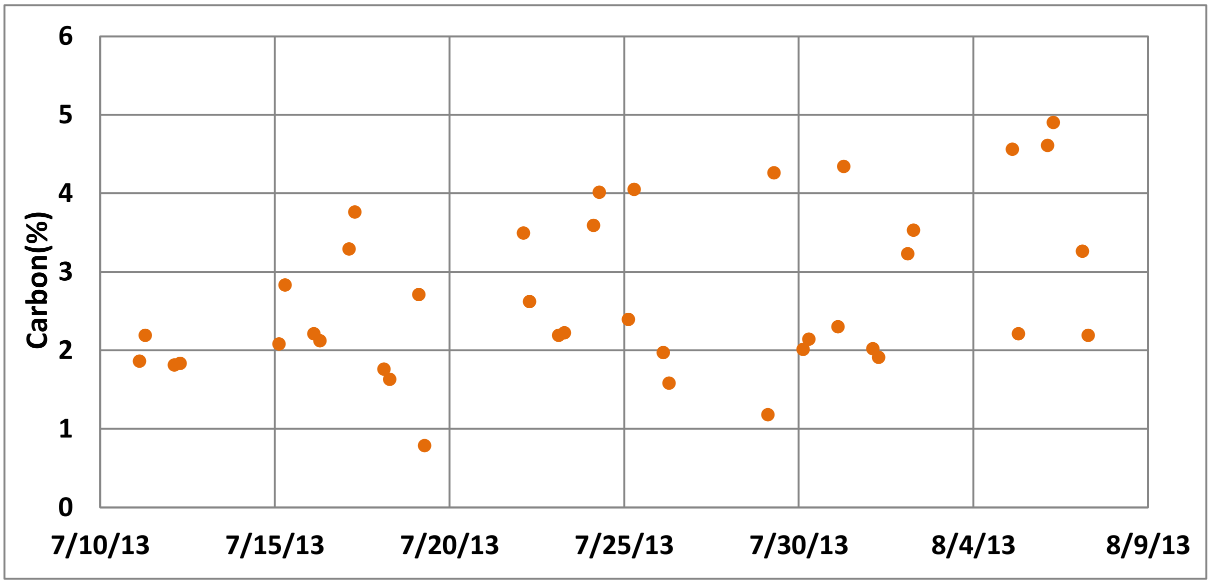

Figure 30. Phase II Testing Multiclone Carbon Analysis

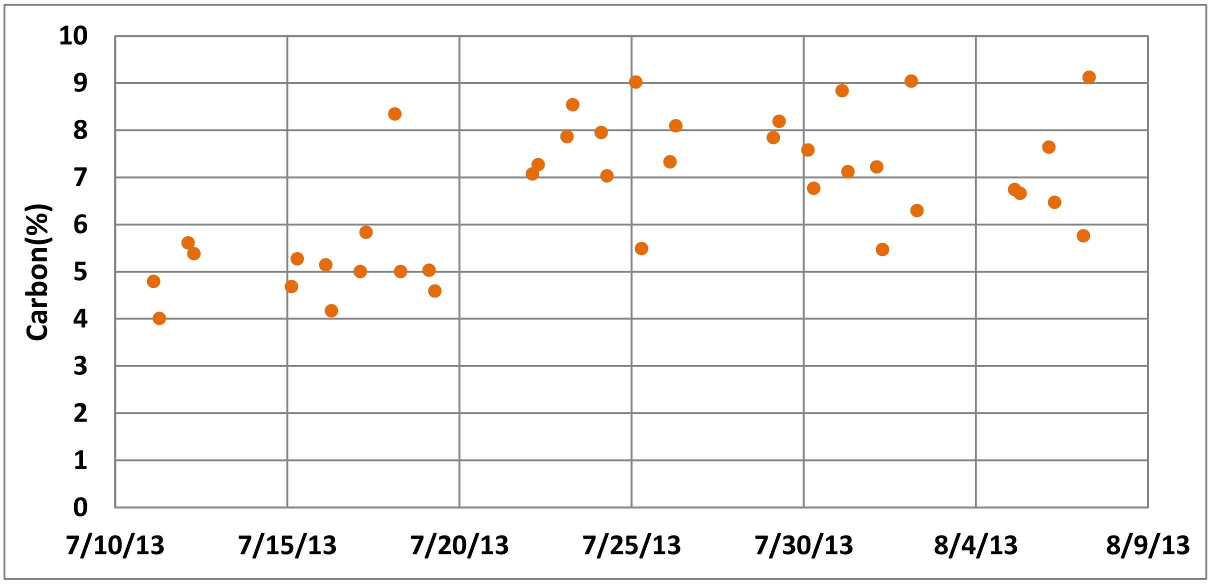

Figure 31. Phase II Testing Thickener Overflow Carbon Analysis

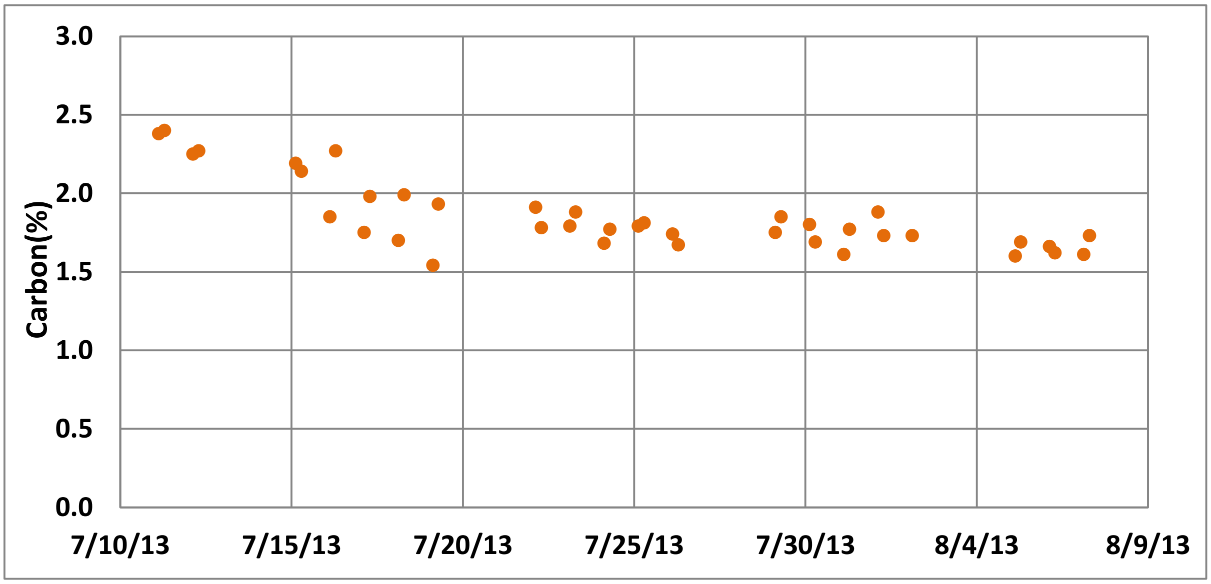

Figure 32. Phase II Testing Fine Tails Carbon Analysis

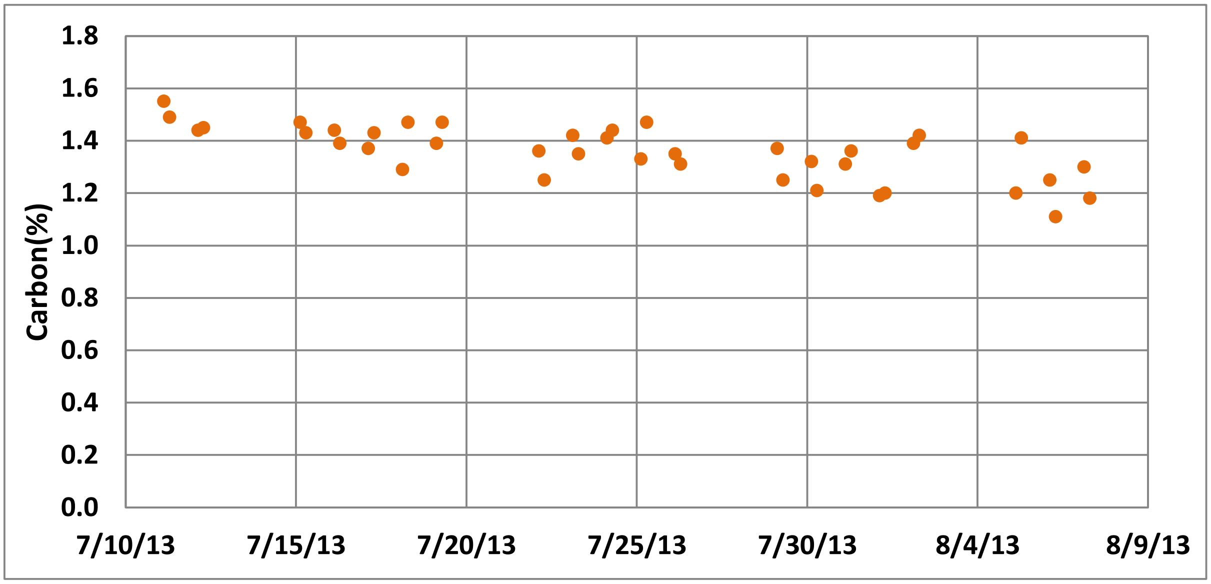

Figure 33. Phase II Testing Green Ball Carbon Analysis

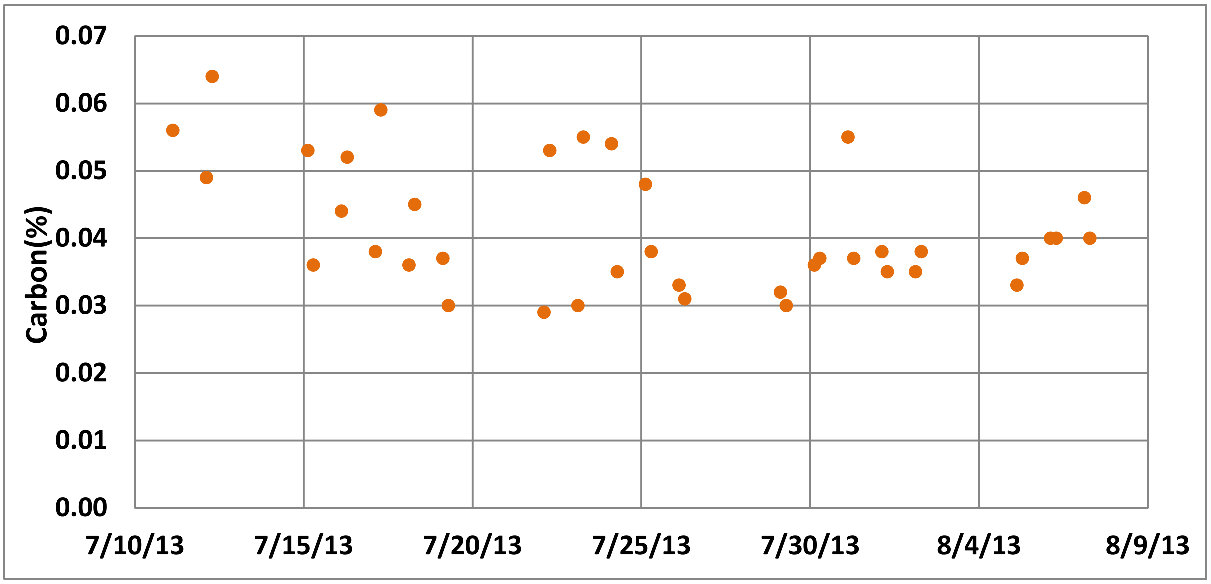

Figure 34. Phase II Testing Fired Pellets Carbon Analysis

4.2.5 Solids Analyses for Hg

Minorca recycles the solids collected in the scrubber back to the concentrate thickener; there is no magnetic separator in this recycle loop. Therefore, it is possible that PAC, and the Hg absorbed by the PAC, could also be recycled into the green balls and the Hg would be re-released during the induration process. Since the scrubber water is recycled back to the concentrate thickener directly, it is possible the mercury could exit the process with the fine tailings (see Figure 29). The Phase II testing (30 days) was of sufficient length for PAC concentrations to reach steady levels in the internal process vessels; however, there are external influences the would require much longer test periods to determine the ultimate fate of Hg collected on the PAC.

To determine the fate of mercury recycled with the PAC in the scrubber water, several process streams were sampled on a regular basis. The host site contracted an independent lab to analyze the samples and provided ADA with a split on several occasions for analysis with the OL.

ADA received samples according to the schedule below.

- Green Balls - Every day
- Pellets - Twice during Phase II testing
- Multiclone drop out - Twice during Phase II testing
- Thickener Overflow - Twice during Phase II testing
- Fine Tailings - Twice during Phase II testing

Minorca had the following samples analyzed for mercury.

- Green Balls – Twice Daily on Week Days during Phase II testing
- Pellets– Twice Daily on Week Days during Phase II testing
- Multiclone drop out – Twice Daily on Week Days during Phase II testing
- Thickener Overflow – Twice Daily on Week Days during Phase II testing
- Fine Tailings – Twice Daily on Week Days during Phase II testing

Figure 35 through Figure 43 show the results of the ADA OL Hg analysis and the independent lab Hg analysis of the solid samples in nanograms of mercury per gram of solid sample (ng/g) on a dry basis. Due to the relatively short test duration and small sample data set, more testing is needed to evaluate long-term Hg trend in the test samples. It is important to take notice of the range of the y-axis because what may appear to be a significant change in the Hg concentration may not be very significant compared to Hg concentrations in the other samples.

Figure 35 shows the ADA measured Hg concentration in the Green Ball samples from before the Screening Test to the end of Phase II testing. Figure 36 displays the Green Ball Hg concentration obtained by the independent lab for Phase II testing only. In general, Hg in the Green Balls was relatively stable and the two analyses agreed well.

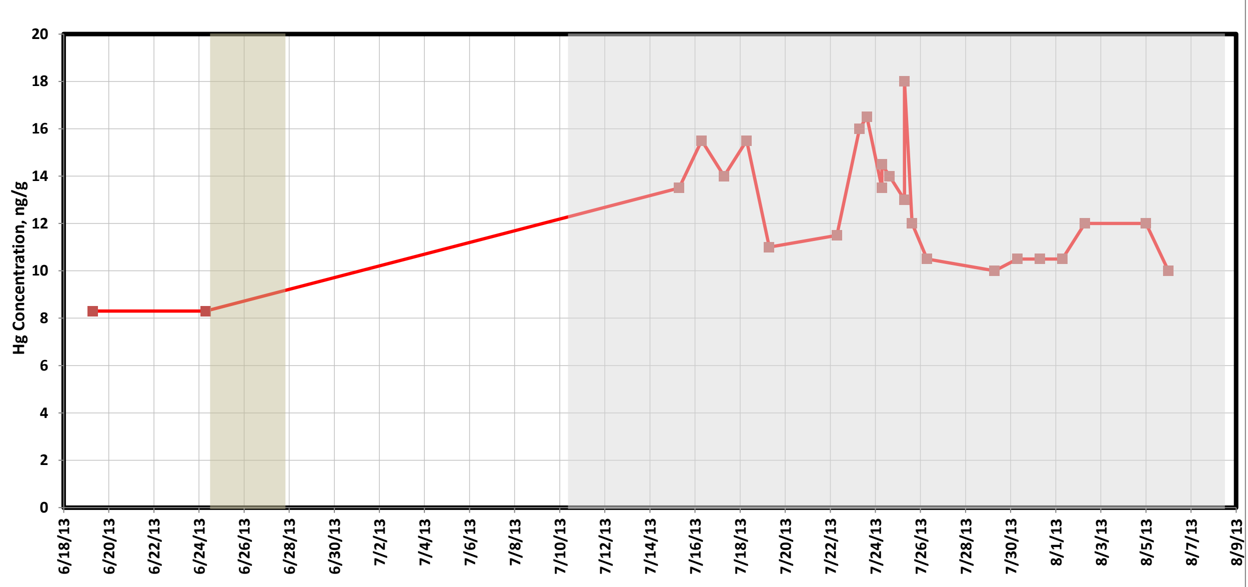

Figure 35. ADA Green Ball Hg Analyses

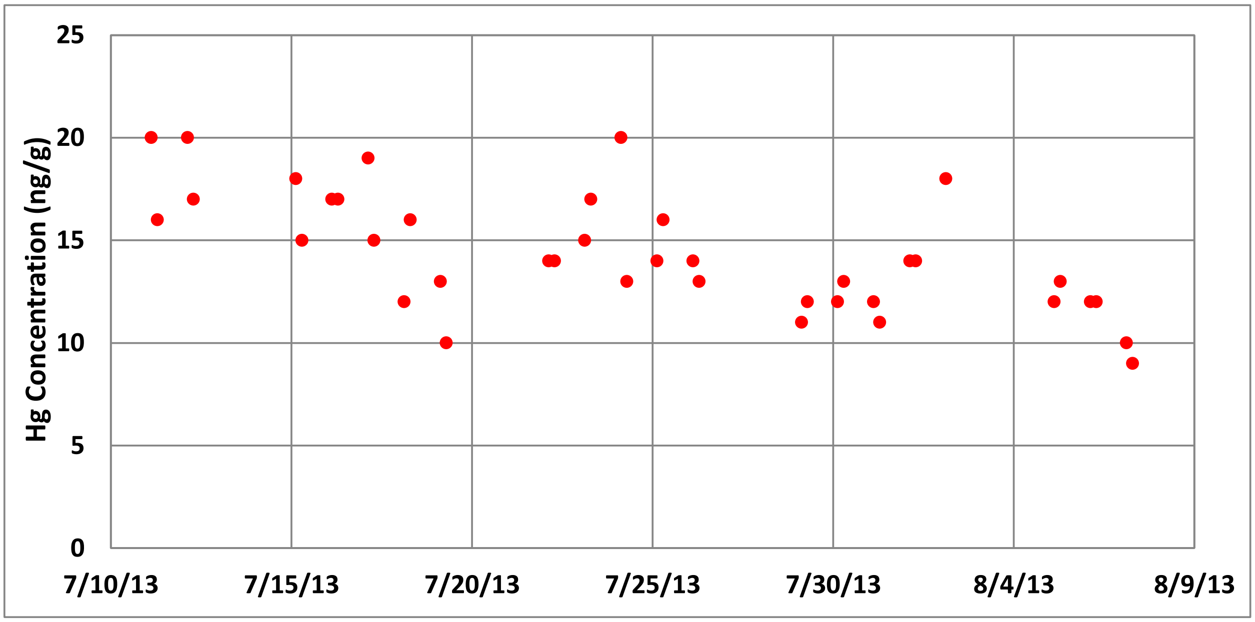

Figure 36. Independent Phase II Testing Green Ball Hg Analysis

Figure 37 shows the ADA measured Hg concentration in the Thickener Overflow from before and during Phase II testing. Figure 38 displays the independent lab results from the Thickener Overflow Phase II testing Hg analysis. Both analyses of the limited data set show elevated Hg during Phase II testing with a downward trend towards the end of Phase II testing. Note that the mercury concentration in this sample was higher than the other samples. PAC is smaller and less dense than taconite particulates so it is reasonable to find high Hg concentrations in these samples. Extended testing is needed to further evaluate the long term trends.

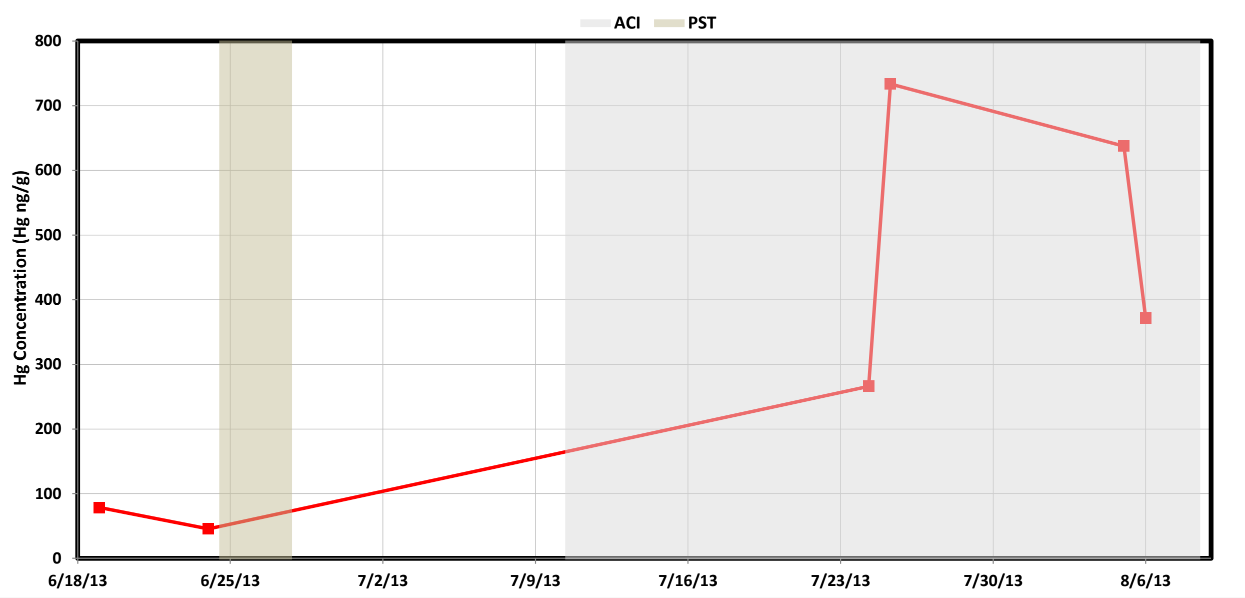

Figure 37. ADA Thickener Overflow Hg Analysis

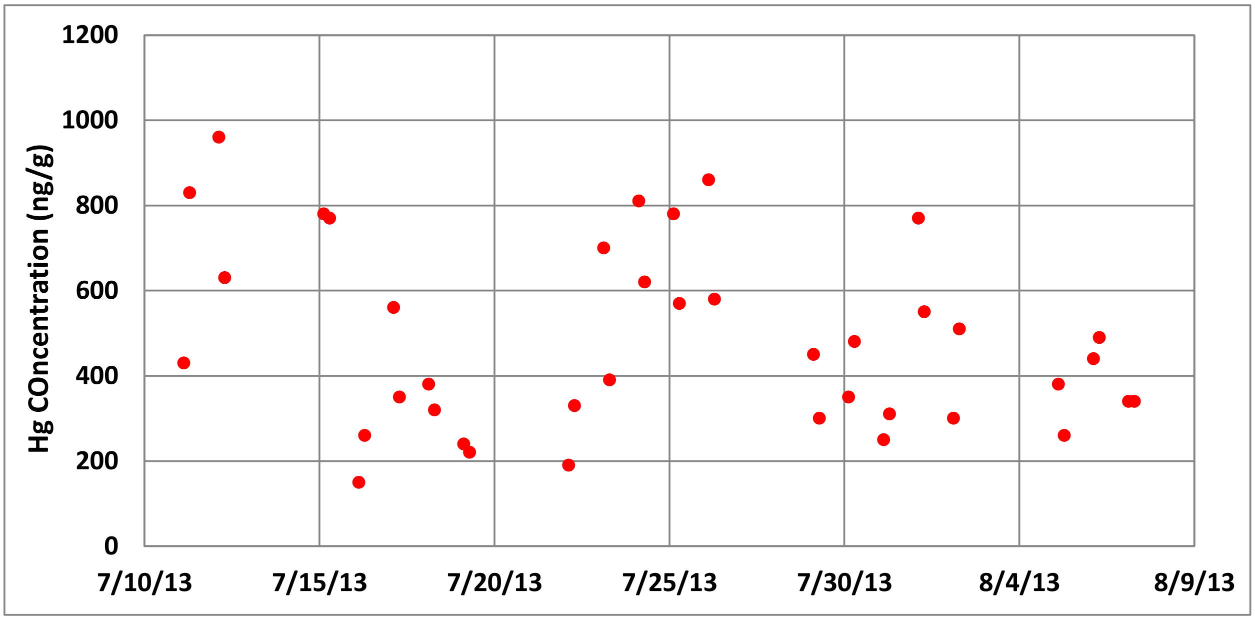

Figure 38. Independent Phase II Testing Thickener Overflow Hg Analysis

Figure 39 shows the ADA measured Hg concentration of the Multiclone solid samples which were collected at the drop out valves. Figure 40 displays the Hg analysis results from the independent lab for Phase II testing only. Both analyses show higher Hg concentration during Phase II testing, however, the analysis obtained by the independent lab shows less Hg concentration than some of ADA's results.

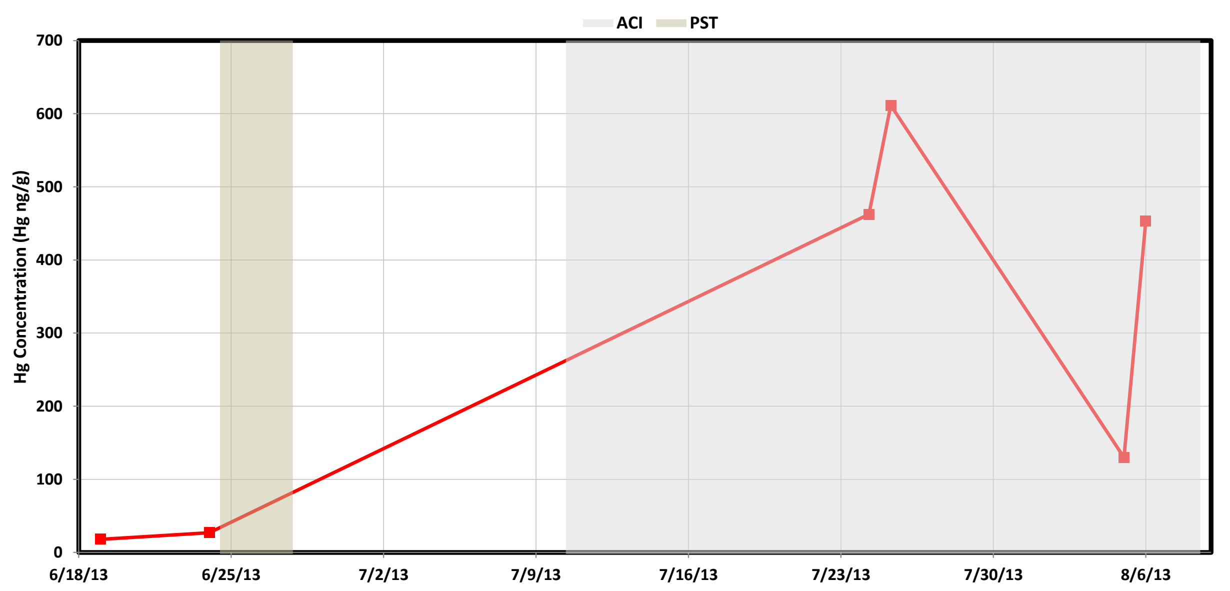

Figure 39. ADA Multiclone Hg Analyses

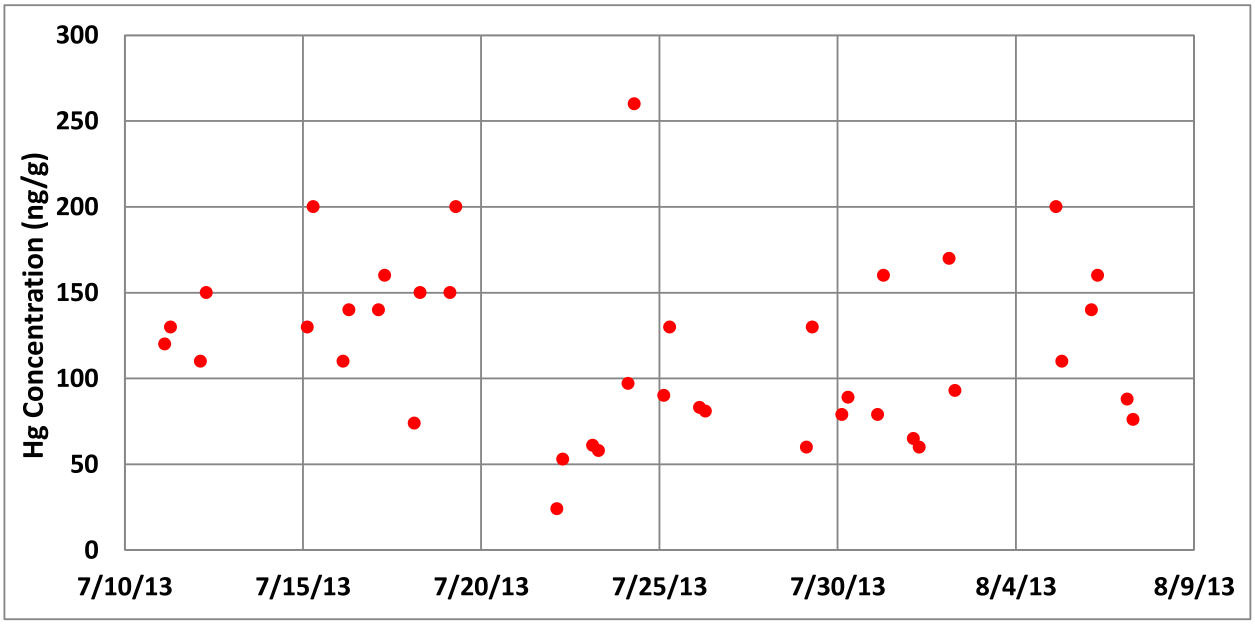

Figure 40. Independent Phase II Testing Multiclone Hg Analysis

Figure 41 shows the ADA obtained Hg concentration in the Fine Tailings. Figure 42 displays the Hg concentration acquired by the independent lab. Both analyses indicate higher concentrations at the beginning of Phase II testing but the available data appear to decrease toward the end of Phase II testing.

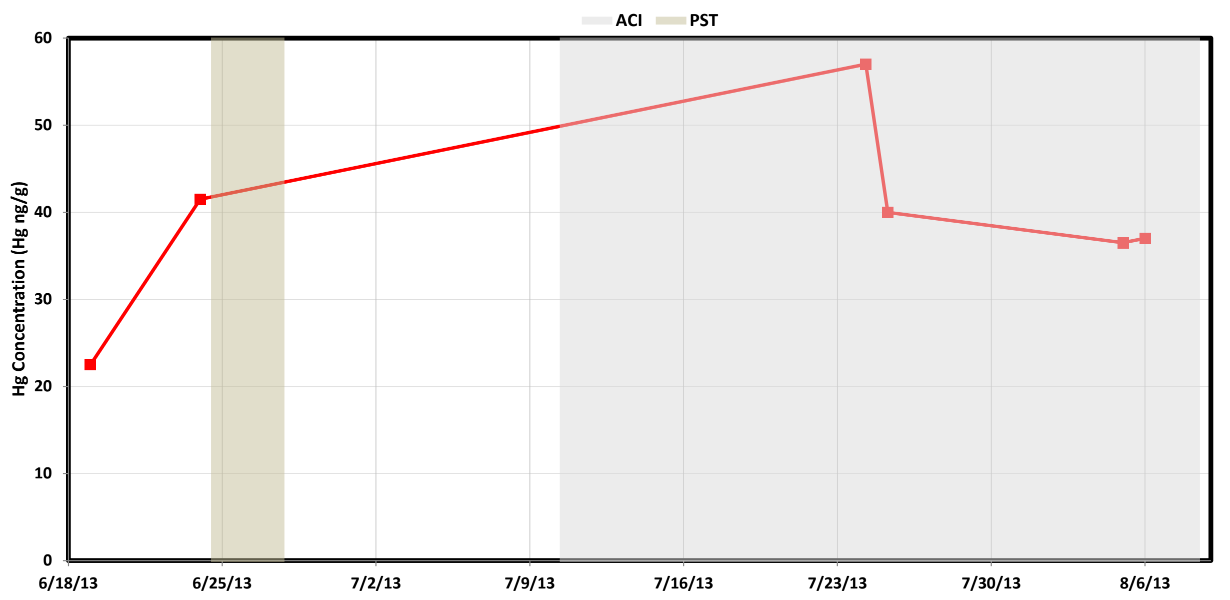

Figure 41. ADA Fine Tailings Hg Analyses

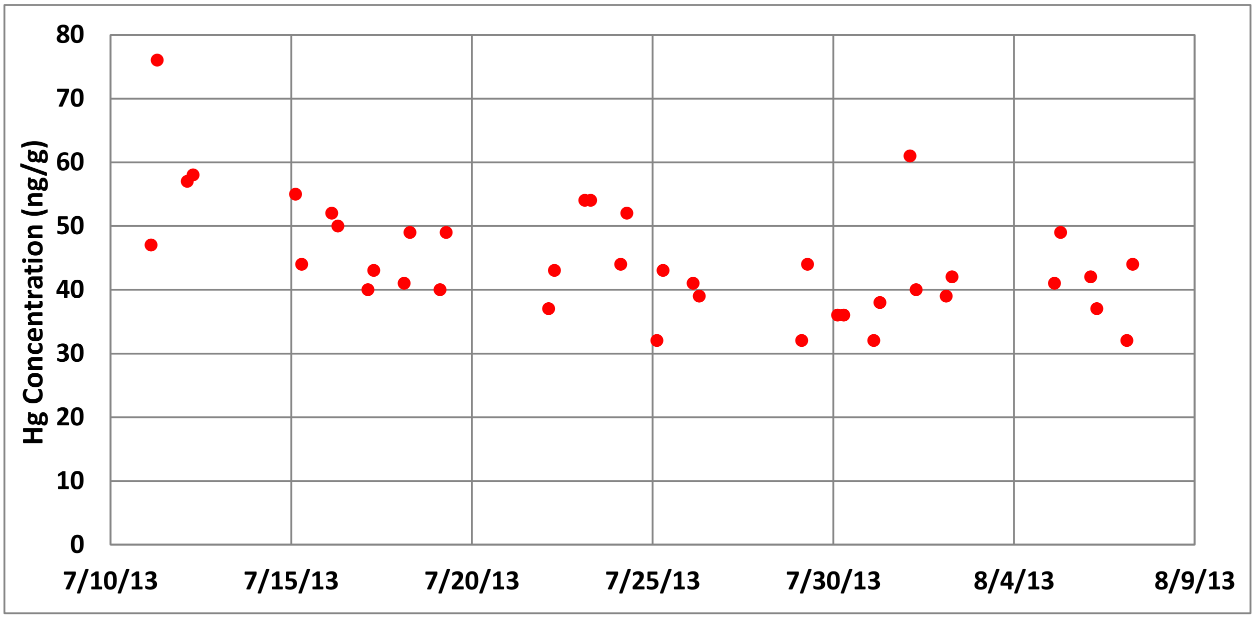

Figure 42. Independent Phase II Testing Fine Tailings Hg Analysis

Figure 43 shows the ADA measured Hg concentration in the fired Pellets. The figure shows no significant change in the relatively small amount of measured Hg within the Pellets as compared to the two data points from before the ACI injection. Little mercury was expected in this sample because the mercury should volatilize at the high temperatures in the furnace. The independent lab results showed all non-detects so the data is not presented.

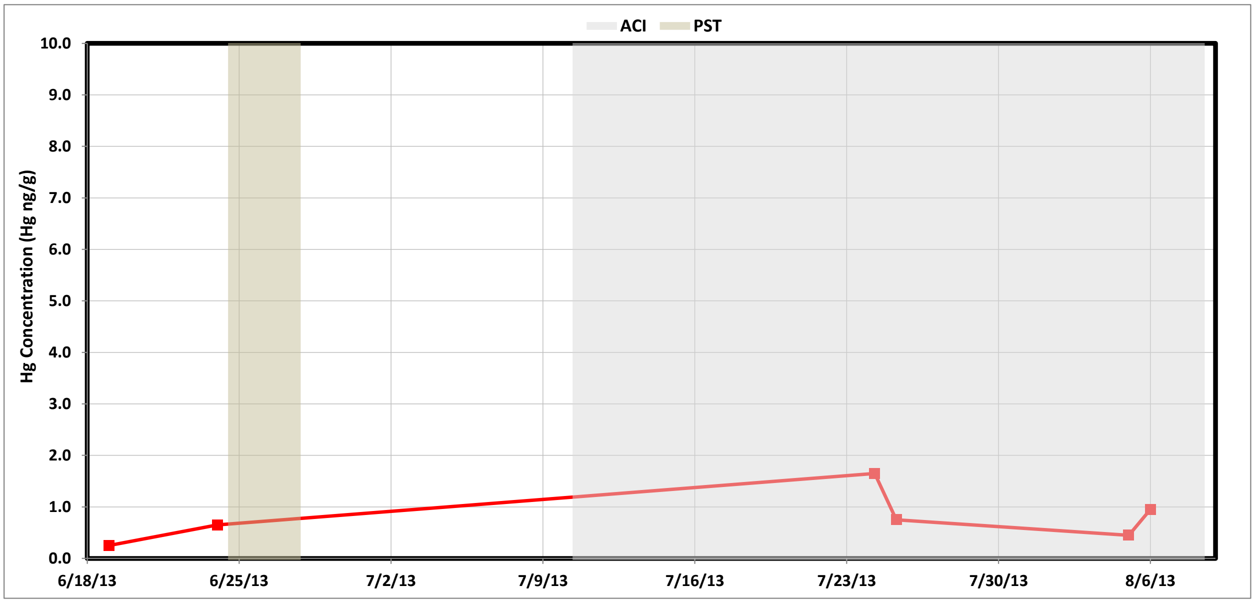

Figure 43. ADA Fired Pellets Hg Analysis

4.3 QA/QC

4.3.1 Sample Calculations

Modified Method 30B QA/QC Procedures

To provide assurance that the reported Hg-CEMS concentrations are accurate, ADA uses sorbent trap measurements as a quality control check. As a reference method, the paired sorbent trap measurements must meet a self-consistency criterion, and the average Hg-CEMS measurement must satisfy a relative accuracy criterion compared to the MM30B results. The criteria described below are derived from Title 40, CFR Part 75.

The paired sorbent trap results shall agree with each other according to Table 6.

Table 6. M30B Relative Deviation

Concentration Range	Criteria
C > 1 µg/dscm	Relative Deviation shall not exceed 10%
C < 1 µg/dscm	Relative Deviation shall not exceed 20%

To determine the concentration range for selecting the appropriate criteria, the average of the two sorbent trap concentrations, C, results shall be used.

Relative Deviation (RD) is defined in Title 40, CFR Part 75, Appendix K as:

$$RD = 100 \times \frac{|C_a - C_b|}{C_a + C_b}$$

Where: C_a and C_b are the paired MM30B concentrations of a sample run.

The average Hg-CEMS concentration shall agree with the average MM30B concentration, C, according to Table 7.

Table 7. Hg-CEMS Relative Accuracy

Concentration Range	Criteria
C > 5 µg/dscm	Relative Accuracy shall not exceed 20%
C < 5 µg/dscm	Absolute Mean Difference shall not exceed 1 µg/dscm

To determine the concentration range for selecting the appropriate criteria, average MM30B concentration, C, shall be used.

Relative Accuracy (RA) is defined as:

$$RA = 100 \times \frac{\left| C \ - C_{CEM,ave} \right|}{C}$$

Absolute Mean Difference (AMD) is defined as:

$$AMD = \left| C \ - C_{CEM,ave} \right|$$

The average Hg-CEMS concentration, $C_{CEM,ave}$, shall be determined by numerically averaging the available concentration data from the period during which the MM30B measurements were obtained.

4.3.2 MM30B and Hg-CEMS Comparison

Appendix D contains all of the MM30B data obtained during the test at Minorca. The table also shows the average Hg-CEMS data at the stacks and the results of the comparison to corresponding MM30B data.

This comparison was done with one significant exception to the QA/QC procedure described above. The RA/AMD procedure assumes that there is no significant HgP in the stack gas. However, ADA discovered that with ACI operating at Minorca, HgP was a significant portion of the total mercury. This was determined by analyzing the first glass wool section of the sorbent trap, which is assumed to contain all of the particulate, separately from the other two sorbent sections. This allowed ADA to calculate a value for MM30B gas phase mercury (HgG=HgT-HgP) which was then used to perform the RA/AMD calculations. It is important to note that Hg-CEMS can only measure HgG. As Figure 27 shows, the MM30B HgG compared well with Hg-CEMS, but the MM30B HgT did not; indicating a significant amount of HgP.

The gas moisture at the Hood Exhaust was 6.1% and at the Windbox Exhaust was 8.5%. The moisture at stacks A, B, C, and D was 11.5%, 12.2%, 13.6%, and 14.9% respectively based on stack measurements by Barr during testing.

5.0 CONCLUSIONS

The Screening Test was conducted by injecting three different PACs at three rates into the Windbox Exhaust via an injection grid with 8 lances. Phase II testing ran for 30 days, injecting BPAC into only the Wind Box Exhaust at a rate of 3 lb/mmacf. Various solids samples were collected and analyzed for carbon and Hg to assess the fate of mercury recycled back to the process with the scrubber water.

The following conclusions can be drawn from the ACI tests at Minorca:

- Albemarle's BPAC performed well in the Screening Test and was selected for Phase II testing due to its performance and relatively low cost.

- The coarser ground PAC did not perform as well as the standard PACs in Stack D. The results of the PM tests with this material will be presented by Barr in a separate report.

- MM30B results, using the modified M30B procedure, show that total Hg reduction at 3 lb/mmacf of ACI was 54%; and therefore, the goal of 75% **total Hg reduction** is not obtainable at Minorca with the current system configuration.

- The Hg-CEMS showed the **gas phase Hg reduction** was 76% at 3 lb/mmacf.

- Particulate phase HgP in the stack gas significantly increased with ACI in Stacks C and D. Sorbent traps can be analyzed in such a way to give an estimate of HgP whereas the Hg-CEMS cannot. The Hg-CEMS values (HgG) agreed well with HgG MM30B data, but not with the total MM30B HgT values due to the particulate mercury (HgP).

- Mercury concentrations measured in the process samples during the 30-day trial provide an initial indication that most of the Hg recycled back to the process with the scrubber water does not end up in the green balls.

- Multiclone solids showed an increase in Hg with ACI.

- A three to four week period is not sufficient to determine the effects of all the external processes of ore type, green ball composition, plant operations, holding basin water recycle, etc. A longer period of time with a more rigorous effluent sampling plan would be required to determine the ultimate fate of mercury captured by the PAC.

6.0 APPENDIX A - HG-CEMS DATA (ELECTRONIC)

All Hg-CEMS data was sent to the ArcelorMittal Minorca Project Manager electronically with the Final Report.

7.0 APPENDIX B - HG-CEMS CALIBRATION DATA

FULL RAK CEMS CALIBRATION RECORD																
DATE	TIME	TYPE	LEVEL	SPAN	ELEM ZERO		ELEM SPAN		TOTAL ZERO		TOTAL SPAN		OCOEF	TCOEF	OBKG	TBKG	DILF
6/19	8:26	iMCAL	5.0	10	--	--	--	--					1.000	1.000	0.00	0.00	1.00
6/19	9:00	iMUP	--	--	--	--	--	--	--	--	--	--	1.000	1.000	0.04	0.04	1.00
6/19	9:00	iCALC	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
6/19	9:01	iMCAL	10.0	10	--	--	--	--					1.000	1.000	0.04	0.04	1.00
6/19	9:37	iMUP	--	--	--	--	--	--	--	--	--	--	1.014	1.002	0.04	0.04	1.00
6/19	9:37	iCALC	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
6/19	9:38	iCHK	10.0	10	0.00	0.0%	9.98	-0.2%	0.00	0.0%	10.01	0.1%	1.014	1.002	0.04	0.04	1.00
6/19	10:05	iCALC	--	--	--	--	--	--	--	--	--	--	1.016	0.999	0.04	0.04	1.00
6/19	10:06	iCHK	9.0	10	0.00	0.0%	9.04	0.4%	0.00	0.0%	9.04	0.4%	1.014	1.002	0.04	0.04	1.00
6/19	10:52	iCALC	--	--	--	--	--	--	--	--	--	--	1.009	1.003	0.04	0.04	1.00
6/19	11:00	CHG	--	--	--	--	--	--	--	--	--	--	0.989	0.934	1.19	0.98	29.50
6/19	13:07	MCAL	10.0	10	0.47	4.7%	7.66	-23%	0.94	9.4%	7.45	-26%	1.000	1.000	0.00	0.00	29.50
6/19	13:41	MUP	--	--	--	--	--	--	--	--	--	--	1.000	1.000	1.42	1.49	29.50
6/19	13:41	CALC	--	--	--	--	--	--	--	--	--	--	1.374	1.032	1.70	2.95	29.50
6/19	13:43	MCAL	10.0	10	0.10	1.0%	9.94	-0.6%	0.48	4.8%	10.22	2.2%	1.000	1.000	1.42	1.49	37.70
6/19	14:16	MUP	--	--	--	--	--	--	--	--	--	--	1.011	0.996	1.48	1.81	37.70
6/19	14:16	CALC	--	--	--	--	--	--	--	--	--	--	1.015	1.012	1.54	2.03	37.70
6/19	14:18	CHK	10.0	10	0.06	0.6%	10.18	1.8%	0.15	1.5%	10.24	2.4%	1.011	0.996	1.48	1.81	37.70
6/19	14:49	CALC	--	--	--	--	--	--	--	--	--	--	0.999	0.999	1.52	1.94	37.70
6/19	16:00	CHK	9.0	10	-0.02	-0.2%	8.54	-4.6%	-0.03	-0.3%	8.64	-3.6%	1.011	0.996	1.48	1.81	37.70
6/19	16:29	CALC	--	--	--	--	--	--	--	--	--	--	1.063	0.983	1.54	1.84	37.70
6/19	17:11	oCHK	10.0	10	-0.12	-1.2%	20.08	101%	-0.48	-4.8%	19.15	92%	1.011	0.996	1.48	1.81	37.70
6/19	17:40	oCALC	--	--	--	--	--	--	--	--	--	--	0.500	1.025	0.68	0.68	37.70
6/20	6:00	CHK	9.0	10	-0.04	-0.4%	8.59	-4.1%	-0.20	-2.0%	8.68	-3.2%	1.011	0.996	1.48	1.81	37.70
6/20	6:29	CALC	--	--	--	--	--	--	--	--	--	--	1.053	0.969	1.50	1.63	37.70
6/20	10:31	LIN	3.0	--	--	--	2.84	-6.1%	--	--	2.89	-4.7%	1.011	0.996	1.48	1.81	37.70
6/20	10:46	LIN	5.0	--	--	--	4.90	-2.1%	--	--	4.87	-2.7%	1.011	0.996	1.48	1.81	37.70
6/20	11:10	LIN	9.0	--	--	--	9.18	2.0%	--	--	9.11	1.2%	1.011	0.996	1.48	1.81	37.70
6/21	8:15	CHK	9.0	10	-0.12	-1.2%	9.37	3.7%	-0.41	-4.1%	9.12	1.2%	1.011	0.996	1.48	1.81	37.70
6/21	8:44	CALC	--	--	--	--	--	--	--	--	--	--	0.959	0.991	1.29	1.32	37.70
6/22	6:00	CHK	9.0	10	-0.07	-0.7%	9.75	7.5%	-0.32	-3.2%	9.57	5.7%	1.011	0.996	1.48	1.81	37.70
6/22	6:29	CALC	--	--	--	--	--	--	--	--	--	--	0.927	0.989	1.30	1.35	37.70
6/22	7:22	CHG	--	--	--	--	--	--	--	--	--	--	0.927	0.989	1.30	1.35	37.70
6/23	6:00	CHK	9.0	10	0.03	0.3%	8.86	-1.4%	0.06	0.6%	9.12	1.2%	0.927	0.989	1.30	1.35	37.70
6/23	6:29	CALC	--	--	--	--	--	--	--	--	--	--	0.945	0.964	1.35	1.40	37.70
6/24	6:00	CHK	9.0	10	0.05	0.5%	9.79	7.9%	0.06	0.6%	9.74	7.4%	0.927	0.989	1.30	1.35	37.70
6/24	6:29	CALC	--	--	--	--	--	--	--	--	--	--	0.856	0.995	1.24	1.31	37.70
6/24	7:11	CHG	--	--	--	--	--	--	--	--	--	--	0.856	0.995	1.24	1.31	37.70
6/24	21:52	DILP	CHANGE FROM 44 psi — DOWN TO 40 psi AT 6/24 22:02 — STABLE TO 43 psi AT 6/24 22:08														
6/25	3:45	DILP	CHANGE FROM 43 psi — STABLE TO 45 psi AT 6/25 03:51														
6/25	6:00	CHK	9.0	10	0.02	0.2%	9.12	1.2%	0.06	0.6%	9.35	3.5%	0.856	0.995	1.24	1.31	37.70
6/25	6:29	CALC	--	--	--	--	--	--	--	--	--	--	0.847	0.974	1.25	1.33	37.70
6/25	14:24	DILP	CHANGE FROM 43 psi — DOWN TO 43 psi AT — STABLE TO 46 psi AT 6/25 14:30														
6/25	23:50	DILP	CHANGE FROM 46 psi — STABLE TO 44 psi AT 6/25 23:56														
6/26	6:00	CHK	9.0	10	0.04	0.4%	9.19	1.9%	0.08	0.8%	9.44	4.4%	0.856	0.995	1.24	1.31	37.70
6/26	6:29	CALC	--	--	--	--	--	--	--	--	--	--	0.842	0.973	1.26	1.34	37.70
6/26	7:18	DILP	CHANGE FROM 46 psi — DOWN TO 43 psi AT 6/26 07:22 — STABLE TO 46 psi AT 6/26 07:31														
6/27	6:00	CHK	9.0	10	0.04	0.4%	9.12	1.2%	0.05	0.5%	9.36	3.6%	0.856	0.995	1.24	1.31	37.70
6/27	6:29	CALC	--	--	--	--	--	--	--	--	--	--	0.848	0.971	1.27	1.31	37.70
6/28	6:00	CHK	9.0	10	0.04	0.4%	9.52	5.2%	0.01	0.1%	9.49	4.9%	0.856	0.995	1.24	1.31	37.70
6/28	6:29	CALC	--	--	--	--	--	--	--	--	--	--	0.812	0.996	1.21	1.26	37.70
6/28	14:51	CHG	--	--	--	--	--	--	--	--	--	--	0.812	0.996	1.21	1.26	37.70
6/29	6:00	CHK	9.0	10	0.00	0.0%	9.24	2.4%	0.04	0.4%	9.31	3.1%	0.812	0.996	1.21	1.26	37.70
6/29	6:29	CALC	--	--	--	--	--	--	--	--	--	--	0.791	0.993	1.18	1.27	37.70
6/29	13:59	CNVT	CHANGE FROM 760°C — UP TO 771°C AT 6/29 13:59 — STABLE TO 761°C AT 6/29 14:05														
6/30	6:00	CHK	9.0	10	0.05	0.5%	9.27	2.7%	0.09	0.9%	9.16	1.6%	0.812	0.996	1.21	1.26	37.70
6/30	6:29	CALC	--	--	--	--	--	--	--	--	--	--	0.792	1.014	1.23	1.34	37.70
7/1	6:00	CHK	9.0	10	0.06	0.6%	8.85	-1.5%	0.18	1.8%	8.91	-0.9%	0.812	0.996	1.21	1.26	37.70

7/1	6:29	CALC	--	--	--	--	--	--	--	--	--	--	0.832	1.002	1.30	1.48	37.70
7/2	6:00	CHK	9.0	10	0.10	1.0%	9.39	3.9%	0.16	1.6%	9.28	2.8%	0.812	0.996	1.21	1.26	37.70
7/2	6:29	CALC	--	--	--	--	--	--	--	--	--	--	0.787	1.014	1.27	1.40	37.70
7/3	6:00	CHK	9.0	10	0.08	0.8%	9.40	4.0%	0.11	1.1%	9.21	2.1%	0.812	0.996	1.21	1.26	37.70
7/3	6:29	CALC	--	--	--	--	--	--	--	--	--	--	0.784	1.020	1.25	1.36	37.70
7/3	20:39	DILP	CHANGE FROM 46 psi — DOWN TO 44 psi AT 7/3 20:41 — STABLE TO 45 psi AT 7/3 20:48														
7/3	23:13	DILP	CHANGE FROM 45 psi — DOWN TO 43 psi AT 7/3 23:14 — STABLE TO 47 psi AT 7/3 23:20														
7/4	6:00	CHK	9.0	10	0.10	1.0%	9.46	4.6%	0.11	1.1%	9.36	3.6%	0.812	0.996	1.21	1.26	37.70
7/4	6:29	CALC	--	--	--	--	--	--	--	--	--	--	0.781	1.008	1.26	1.33	37.70
7/5	6:00	CHK	9.0	10	0.08	0.8%	9.36	3.6%	0.13	1.3%	9.26	2.6%	0.812	0.996	1.21	1.26	37.70
7/5	6:29	CALC	--	--	--	--	--	--	--	--	--	--	0.787	1.013	1.25	1.37	37.70
7/6	6:00	CHK	9.0	10	0.06	0.6%	9.43	4.3%	0.12	1.2%	9.25	2.5%	0.812	0.996	1.21	1.26	37.70
7/6	6:29	CALC	--	--	--	--	--	--	--	--	--	--	0.780	1.022	1.22	1.36	37.70
7/7	6:00	CHK	9.0	10	0.04	0.4%	8.85	-1.5%	0.13	1.3%	8.79	-2.1%	0.812	0.996	1.21	1.26	37.70
7/7	6:29	CALC	--	--	--	--	--	--	--	--	--	--	0.829	1.013	1.28	1.44	37.70
7/7	10:52	CNVT	CHANGE FROM 752°C — UNSTABLE 728°C TO 779°C — STABLE TO 758°C AT 7/7 11:04														
7/7	11:59	DILP	CHANGE FROM 47 psi — DOWN TO 42 psi AT 7/7 12:28 — STABLE TO 47 psi AT 7/7 12:43														
7/7	14:46	DILP	CHANGE FROM 47 psi — DOWN TO 44 psi AT 7/7 14:58 — STABLE TO 46 psi AT 7/7 15:04														
7/8	6:00	CHK	9.0	10	0.06	0.6%	9.29	2.9%	0.10	1.0%	9.17	1.7%	0.812	0.996	1.21	1.26	37.70
7/8	6:29	CALC	--	--	--	--	--	--	--	--	--	--	0.791	1.014	1.23	1.35	37.70
7/9	6:00	CHK	9.0	10	0.11	1.1%	9.71	7.1%	0.17	1.7%	9.49	4.9%	0.812	0.996	1.21	1.26	37.70
7/9	6:29	CALC	--	--	--	--	--	--	--	--	--	--	0.761	1.027	1.23	1.38	37.70
7/9	8:05	CHG	--	--	--	--	--	--	--	--	--	--	0.761	1.027	1.23	1.38	37.70
7/10	0:28	CNVT	CHANGE FROM 759°C — UNSTABLE 554°C TO 770°C — STABLE TO 759°C AT 7/10 00:45														
7/10	1:18	CNVT	CHANGE FROM 759°C — UNSTABLE 584°C TO 786°C — STABLE TO 739°C AT 7/10 01:33														
7/10	1:45	CNVT	CHANGE FROM 739°C — UNSTABLE 618°C TO 770°C — STABLE TO 755°C AT 7/10 01:57														
7/10	1:58	CNVT	CHANGE FROM 755°C — UNSTABLE 636°C TO 763°C — STABLE TO 750°C AT 7/10 02:09														
7/10	6:00	CHK	9.0	10	0.07	0.7%	8.85	-1.5%	0.07	0.7%	8.97	-0.3%	0.761	1.027	1.23	1.38	37.70
7/10	6:29	CALC	--	--	--	--	--	--	--	--	--	--	0.780	1.014	1.33	1.47	37.70
7/11	8:00	CHK	9.0	10	0.04	0.4%	7.88	-11%	-0.01	-0.1%	8.40	-6.0%	0.761	1.027	1.23	1.38	37.70
7/11	8:29	CALC	--	--	--	--	--	--	--	--	--	--	0.874	0.957	1.46	1.46	37.70
7/11	9:40	MCAL	9.0	10	-0.26	-2.6%	5.60	-34%	-0.32	-3.2%	6.34	-27%	0.761	1.027	1.23	1.38	37.70
7/11	9:49	DILP	CHANGE FROM 47 psi — DOWN TO 41 psi AT 7/11 09:56 — STABLE TO 48 psi AT 7/11 10:06														
7/11	10:14	MUP	--	--	--	--	--	--	--	--	--	--	0.761	1.027	0.93	1.05	37.70
7/11	10:14	CALC	--	--	--	--	--	--	--	--	--	--	1.169	0.903	1.48	1.43	37.70
7/11	10:36	iCHK	9.0	10	0.01	0.1%	10.31	13%	0.01	0.1%	10.41	14%	1.014	1.002	0.04	0.04	1.00
7/11	10:47	iCALC	--	--	--	--	--	--	--	--	--	--	0.886	0.992	0.04	0.04	1.00
7/11	10:53	CHG	--	--	--	--	--	--	--	--	--	--	0.761	1.027	0.93	1.05	37.70
7/11	11:58	MCAL	9.0	10	0.04	0.4%	6.06	-29%	0.01	0.1%	6.36	-26%	0.761	1.027	0.93	1.05	37.70
7/11	12:27	MUP	--	--	--	--	--	--	--	--	--	--	1.136	0.974	1.43	1.49	37.70
7/11	12:27	CALC	--	--	--	--	--	--	--	--	--	--	1.138	0.973	1.45	1.50	37.70
7/11	12:30	CHK	9.0	10	-0.01	-0.1%	8.99	-0.1%	0.00	0.0%	9.15	1.5%	1.136	0.974	1.43	1.49	37.70
7/11	12:59	CALC	--	--	--	--	--	--	--	--	--	--	1.136	0.957	1.42	1.46	37.70
7/12	7:30	CHK	9.0	10	0.00	0.0%	7.86	-11%	0.09	0.9%	8.13	-8.7%	1.136	0.974	1.43	1.49	37.70
7/12	7:59	CALC	--	--	--	--	--	--	--	--	--	--	1.299	0.952	1.64	1.76	37.70
7/12	9:38	MCAL	9.0	10	-0.02	-0.2%	8.35	-6.5%	0.05	0.5%	8.54	-4.6%	1.136	0.974	1.43	1.49	37.70
7/12	10:10	MUP	--	--	--	--	--	--	--	--	--	--	1.221	0.959	1.50	1.58	37.70
7/12	10:10	CALC	--	--	--	--	--	--	--	--	--	--	1.221	0.960	1.52	1.63	37.70
7/12	10:15	CHK	9.0	10	0.00	0.0%	9.14	1.4%	0.02	0.2%	9.13	1.3%	1.221	0.959	1.50	1.58	37.70
7/12	10:44	CALC	--	--	--	--	--	--	--	--	--	--	1.203	0.961	1.48	1.58	37.70
7/12	15:02	PRBT	CHANGE FROM 220°C — DOWN TO 117°C AT 7/12 15:21 — STABLE TO 220°C AT 7/12 15:49														
7/12	15:02	DILP	CHANGE FROM 48 psi — DOWN TO 1.4 psi AT 7/12 15:37 — STABLE TO 48 psi AT 7/12 15:45														
7/12	17:20	CHK	9.0	10	0.00	0.0%	9.23	2.3%	0.06	0.6%	9.32	3.2%	1.221	0.959	1.50	1.58	37.70
7/12	17:49	CALC	--	--	--	--	--	--	--	--	--	--	1.191	0.956	1.47	1.59	37.70
7/13	7:30	CHK	9.0	10	0.03	0.3%	9.67	6.7%	0.06	0.6%	9.52	5.2%	1.221	0.959	1.50	1.58	37.70
7/13	7:59	CALC	--	--	--	--	--	--	--	--	--	--	1.140	0.977	1.43	1.56	37.70
7/13	8:16	CHG	--	--	--	--	--	--	--	--	--	--	1.140	0.977	1.43	1.56	37.70
7/13	18:00	CHK	9.0	10	-0.13	-1.3%	7.03	-20%	-0.15	-1.5%	7.24	-18%	1.140	0.977	1.43	1.56	37.70
7/13	18:29	CALC	--	--	--	--	--	--	--	--	--	--	1.433	0.946	1.64	1.71	37.70
7/13	18:41	MCAL	9.0	10	0.92	9.2%	6.95	-21%	0.81	8.1%	7.13	-19%	1.140	0.977	1.43	1.56	37.70

ArcelorMittal
Minorca Mine
ACI Test

7/13	18:47	iCHK	5.0	10	0.01	0.1%	4.91	-0.9%	0.01	0.1%	4.89	-1.1%	1.014	1.002	0.04	0.04	1.00
7/13	19:01	iCALC	--	--	--	--	--	--	--	--	--	--	1.034	1.006	0.04	0.04	1.00
7/13	19:27	MUP	--	--	--	--	--	--	--	--	--	--	1.000	1.000	1.65	1.80	37.70
7/13	19:27	CALC	--	--	--	--	--	--	--	--	--	--	1.703	0.931	3.51	3.38	37.70
7/13	19:29	MCAL	9.0	10	0.03	0.3%	9.08	0.8%	-0.04	-0.4%	9.49	4.9%	1.000	1.000	1.65	1.80	54.00
7/13	19:58	MUP	--	--	--	--	--	--	--	--	--	--	0.993	0.953	1.65	1.68	54.00
7/13	19:58	CALC	--	--	--	--	--	--	--	--	--	--	0.994	0.950	1.67	1.66	54.00
7/13	20:15	CHK	9.0	10	0.01	0.1%	8.92	-0.8%	0.03	0.3%	8.93	-0.7%	0.993	0.953	1.65	1.68	54.00
7/13	20:44	CALC	--	--	--	--	--	--	--	--	--	--	1.003	0.954	1.68	1.73	54.00
7/14	7:30	CHK	9.0	10	-0.01	-0.1%	8.85	-1.5%	0.08	0.8%	9.16	1.6%	0.993	0.953	1.65	1.68	54.00
7/14	7:59	CALC	--	--	--	--	--	--	--	--	--	--	1.008	0.930	1.67	1.74	54.00
7/15	7:30	CHK	9.0	10	-0.02	-0.2%	8.80	-2.0%	-0.01	-0.1%	8.93	-0.7%	0.993	0.953	1.65	1.68	54.00
7/15	7:59	CALC	--	--	--	--	--	--	--	--	--	--	1.012	0.942	1.66	1.68	54.00
7/16	7:30	CHK	9.0	10	-0.24	-2.4%	8.90	-1.0%	-0.20	-2.0%	9.08	0.8%	0.993	0.953	1.65	1.68	54.00
7/16	7:59	CALC	--	--	--	--	--	--	--	--	--	--	0.978	0.939	1.39	1.43	54.00
7/17	3:05	CNVT	CHANGE FROM 746°C — UNSTABLE 568°C TO 777°C — STABLE TO 759°C AT 7/17 03:17														
7/17	5:11	CNVT	CHANGE FROM 759°C — DOWN TO 681°C AT 7/17 05:16 — STABLE TO 752°C AT 7/17 05:24														
7/17	7:30	CHK	9.0	10	-0.23	-2.3%	8.47	-5.3%	-0.18	-1.8%	8.81	-1.9%	0.993	0.953	1.65	1.68	54.00
7/17	7:59	CALC	--	--	--	--	--	--	--	--	--	--	1.026	0.923	1.47	1.49	54.00
7/17	8:11	CHG	--	--	--	--	--	--	--	--	--	--	1.026	0.923	1.47	1.49	54.00
7/18	7:25	CNVT	CHANGE FROM 760°C — UNSTABLE 390°C TO 811°C — STABLE TO 735°C AT 7/18 07:42														
7/18	8:24	CNVT	CHANGE FROM 735°C — UNSTABLE 233°C TO 821°C — STABLE TO 734°C AT 7/18 08:39														
7/18	9:00	CHK	9.0	10	0.02	0.2%	9.28	2.8%	-0.05	-0.5%	9.22	2.2%	1.026	0.923	1.47	1.49	54.00
7/18	9:29	CALC	--	--	--	--	--	--	--	--	--	--	0.997	0.923	1.45	1.40	54.00
19-Jul	8:30	CHK	9	10	0.02	0.20%	9.64	6.40%	-0.04	-0.40%	9.24	2.40%	1.026	0.923	1.47	1.49	54
19-Jul	8:59	CALC	--	--	--	--	--	--	--	--	--	--	0.959	0.957	1.39	1.4	54
20-Jul	7:30	CHK	9	10	0.04	0.40%	8.84	-1.60%	0.07	0.70%	9.1	1.00%	0.959	0.957	1.39	1.4	54
20-Jul	7:59	CALC	--	--	--	--	--	--	--	--	--	--	0.981	0.933	1.46	1.47	54
7/21	8:30	CHK	9.0	10	0.08	0.8%	9.21	2.1%	0.09	0.9%	9.33	3.3%	0.959	0.957	1.39	1.40	54.00
7/21	8:59	CALC	--	--	--	--	--	--	--	--	--	--	0.945	0.945	1.45	1.45	54.00
7/22	7:30	CHK	9.0	10	0.06	0.6%	8.93	-0.7%	0.05	0.5%	9.11	1.1%	0.959	0.957	1.39	1.40	54.00
7/22	7:59	CALC	--	--	--	--	--	--	--	--	--	--	0.973	0.937	1.47	1.45	54.00
7/23	7:30	CHK	9.0	10	0.06	0.6%	9.00	0.0%	0.04	0.4%	9.13	1.3%	0.959	0.957	1.39	1.40	54.00
7/23	7:59	CALC	--	--	--	--	--	--	--	--	--	--	0.966	0.941	1.46	1.43	54.00
24-Jul	8:30	CHK	9	10	0.09	0.90%	9.06	0.60%	0.08	0.80%	9.23	2.30%	0.959	0.957	1.39	1.4	54
24-Jul	8:59	CALC	--	--	--	--	--	--	--	--	--	--	0.962	0.939	1.48	1.46	54
7/25	7:30	CHK	9.0	10	0.08	0.8%	9.33	3.3%	0.08	0.8%	9.41	4.1%	0.959	0.957	1.39	1.40	54.00
7/25	7:59	CALC	--	--	--	--	--	--	--	--	--	--	0.933	0.949	1.43	1.43	54.00
7/26	6:40	CHK	9.0	10	0.08	0.8%	9.62	6.2%	0.07	0.7%	9.67	6.7%	0.959	0.957	1.39	1.40	54.00
7/26	7:09	CALC	--	--	--	--	--	--	--	--	--	--	0.905	0.950	1.38	1.37	54.00
7/26	7:41	CHG	--	--	--	--	--	--	--	--	--	--	0.905	0.950	1.38	1.37	54.00
7/26	21:39	CNVT	CHANGE FROM 758°C — UNSTABLE 732°C TO 775°C — STABLE TO 758°C AT 7/26 21:48														
7/27	6:40	CHK	9.0	10	0.04	0.4%	8.91	-0.9%	0.02	0.2%	8.81	-1.9%	0.905	0.950	1.38	1.37	54.00
7/27	7:09	CALC	--	--	--	--	--	--	--	--	--	--	0.919	0.959	1.44	1.43	54.00
7/28	3:47	CNVT	CHANGE FROM 760°C — UNSTABLE 747°C TO 773°C — STABLE TO 760°C AT 7/28 03:54														
7/28	5:40	CNVT	CHANGE FROM 760°C — UNSTABLE 733°C TO 768°C — STABLE TO 758°C AT 7/28 05:48														
7/28	6:40	CHK	9.0	10	0.08	0.8%	9.04	0.4%	0.06	0.6%	9.09	0.9%	0.905	0.950	1.38	1.37	54.00
7/28	7:09	CALC	--	--	--	--	--	--	--	--	--	--	0.909	0.942	1.47	1.42	54.00
7/29	6:40	CHK	9.0	10	0.09	0.9%	9.46	4.6%	0.05	0.5%	9.46	4.6%	0.905	0.950	1.38	1.37	54.00
7/29	7:09	CALC	--	--	--	--	--	--	--	--	--	--	0.870	0.946	1.42	1.36	54.00
7/30	6:40	CHK	9.0	10	0.06	0.6%	9.63	6.3%	0.06	0.6%	9.64	6.4%	0.905	0.950	1.38	1.37	54.00
7/30	7:09	CALC	--	--	--	--	--	--	--	--	--	--	0.851	0.949	1.36	1.34	54.00
7/30	9:12	CHG	--	--	--	--	--	--	--	--	--	--	0.851	0.949	1.36	1.34	54.00
7/30	9:49	CNVT	CHANGE FROM 760°C — STABLE TO 757°C AT 7/30 09:55														
7/30	23:06	RFINT	CHANGE FROM 50933 Hz — DOWN TO 49502 Hz AT 7/30 23:10 — STABLE TO 50858 Hz AT 7/30 23:16														
7/31	5:00	CHK	9.0	10	0.01	0.1%	8.95	-0.5%	0.01	0.1%	9.01	0.1%	0.851	0.949	1.36	1.34	54.00
7/31	5:29	CALC	--	--	--	--	--	--	--	--	--	--	0.857	0.942	1.38	1.35	54.00
8/1	5:00	CHK	9.0	10	0.03	0.3%	9.11	1.1%	0.03	0.3%	9.04	0.4%	0.851	0.949	1.36	1.34	54.00
8/1	5:29	CALC	--	--	--	--	--	--	--	--	--	--	0.843	0.957	1.37	1.37	54.00
8/2	5:00	CHK	9.0	10	0.03	0.3%	9.15	1.5%	0.07	0.7%	9.09	0.9%	0.851	0.949	1.36	1.34	54.00

8/2	5:29	CALC	--	--	--	--	--	--	--	--	--	--	0.840	0.960	1.37	1.41	54.00
8/2	10:28	CNVT	CHANGE FROM 760°C — UNSTABLE 736°C TO 783°C — STABLE TO 755°C AT 8/2 10:36														
8/2	16:25	CNVT	CHANGE FROM 755°C — UP TO 795°C AT 8/2 16:26 — STABLE TO 762°C AT 8/2 16:32														
8/3	5:00	CHK	9.0	10	0.07	0.7%	9.21	2.1%	0.08	0.8%	9.23	2.3%	0.851	0.949	1.36	1.34	54.00
8/3	5:29	CALC	--	--	--	--	--	--	--	--	--	--	0.838	0.949	1.40	1.40	54.00
8/4	7:05	CHK	9.0	10	0.08	0.8%	9.36	3.6%	0.13	1.3%	9.36	3.6%	0.851	0.949	1.36	1.34	54.00
8/4	7:34	CALC	--	--	--	--	--	--	--	--	--	--	0.825	0.955	1.39	1.44	54.00
8/5	5:00	CHK	9.0	10	0.08	0.8%	9.28	2.8%	0.09	0.9%	9.32	3.2%	0.851	0.949	1.36	1.34	54.00
8/5	5:29	CALC	--	--	--	--	--	--	--	--	--	--	0.833	0.946	1.41	1.40	54.00
8/6	5:00	CHK	9.0	10	0.06	0.6%	9.36	3.6%	0.09	0.9%	9.49	4.9%	0.851	0.949	1.36	1.34	54.00
8/6	5:29	CALC	--	--	--	--	--	--	--	--	--	--	0.823	0.940	1.38	1.37	54.00
8/7	5:00	CHK	9.0	10	0.06	0.6%	9.28	2.8%	0.11	1.1%	9.28	2.8%	0.851	0.949	1.36	1.34	54.00
8/7	5:29	CALC	--	--	--	--	--	--	--	--	--	--	0.830	0.954	1.38	1.42	54.00
8/8	5:00	CHK	9.0	10	0.09	0.9%	9.58	5.8%	0.16	1.6%	9.59	5.9%	0.851	0.949	1.36	1.34	54.00
8/8	5:29	CALC	--	--	--	--	--	--	--	--	--	--	0.807	0.955	1.38	1.43	54.00
8/8	7:42	CHG	--	--	--	--	--	--	--	--	--	--	0.807	0.955	1.38	1.43	54.00
8/9	5:00	CHK	9.0	10	0.04	0.4%	9.50	5.0%	0.03	0.3%	9.18	1.8%	0.807	0.955	1.38	1.43	54.00
8/9	5:29	CALC	--	--	--	--	--	--	--	--	--	--	0.768	0.988	1.35	1.44	54.00

MODRAK CEMS CALIBRATION RECORD

DATE	TIME	TYPE	LEVEL	SPAN	ELEM ZERO		ELEM SPAN		TOTAL ZERO		TOTAL SPAN		OCOEF	TCOEF	OBKG	TBKG	DILF
6/18	17:09	CHG	--	--	--	--	--	--	--	--	--	--	1.028	0.987	10.29	10.12	52.50
6/18	18:13	VAC	CHANGE FROM 21 inHg — DOWN TO 2.2 inHg AT 6/18 18:18 — STABLE TO 22 inHg AT 6/18 18:39														52.50
6/18	18:14	ORFP	CHANGE FROM 0.4 psi — UP TO 0.5 psi AT 6/18 18:29 — STABLE TO 0.4 psi AT 6/18 18:37														
6/18	22:35	PMTV	CHANGE FROM 586V — STABLE TO 569V AT 6/18 22:53														
6/19	8:26	iMCAL	5.0	10	--	--	--	--					1.000	1.000	0.00	0.00	52.50
6/19	9:10	iMUP	--	--	--	--	--	--	--	--	--	--	1.000	1.000	0.18	0.18	52.50
6/19	9:10	iCALC	--	--	--	--	--	--	--	--	--	--	--	--	--	--	
6/19	9:11	iMCAL	10.0	10	--	--	--	--					1.000	1.000	0.18	0.18	
6/19	10:29	iMUP	--	--	--	--	--	--	--	--	--	--	0.960	1.000	0.14	0.14	
6/19	10:29	iCALC	--	--	--	--	--	--	--	--	--	--	--	--	--	--	
6/19	10:30	iCHK	10.0	10	0.00	0.0%	9.93	-0.7%	0.00	0.0%	9.90	-1.0%	0.960	1.001	0.14	0.14	
6/19	10:53	iCALC	--	--	--	--	--	--	--	--	--	--	0.967	1.003	0.14	0.14	
6/19	10:54	iCHK	9.0	10	0.00	0.0%	8.83	-1.7%	0.00	0.0%	8.81	-1.9%	0.960	1.001	0.14	0.14	
6/19	11:30	iCALC	--	--	--	--	--	--	--	--	--	--	0.978	1.003	0.14	0.14	
6/19	11:35	CHG	--	--	--	--	--	--	--	--	--	--	1.028	0.987	10.29	10.12	
6/19	13:09	iMCAL	5.0	10	--	--	--	--					0.960	1.001	0.14	0.14	
6/19	13:29	iMUP	--	--	--	--	--	--	--	--	--	--	1.003	1.003	0.14	0.14	
6/19	13:29	iCALC	--	--	--	--	--	--	--	--	--	--	--	--	--	--	
6/19	13:30	iCHK	10.0	10	0.00	0.0%	10.30	3.0%	0.00	0.0%	10.30	3.0%	1.003	1.003	0.14	0.14	
6/19	14:12	iCALC	--	--	--	--	--	--	--	--	--	--	0.974	1.003	0.14	0.14	
6/19	14:18	MCAL	10.0	10	2.01	20%	12.17	22%	3.74	37%	12.34	23%	1.000	1.000	0.00	0.00	
6/19	14:52	MUP	--	--	--	--	--	--	--	--	--	--	1.000	1.000	7.24	7.13	
6/19	14:52	CALC	--	--	--	--	--	--	--	--	--	--	0.993	1.171	13.82	12.90	
6/19	14:54	MCAL	10.0	10	0.02	0.2%	10.07	0.7%	0.00	0.0%	10.39	3.9%	1.000	1.000	7.24	7.13	
6/19	15:26	MUP	--	--	--	--	--	--	--	--	--	--	0.994	0.968	7.20	6.86	
6/19	15:26	CALC	--	--	--	--	--	--	--	--	--	--	0.995	0.967	7.22	6.86	
6/19	16:15	CHK	10.0	10	0.01	0.1%	9.79	-2.1%	-0.02	-0.2%	9.83	-1.7%	0.994	0.968	7.20	6.86	
6/19	16:44	CALC	--	--	--	--	--	--	--	--	--	--	1.016	0.961	7.36	6.94	
6/19	17:11	oCHK	10.0	10	-0.01	-0.1%	16.87	69%	-0.01	-0.1%	16.80	68%	0.994	0.968	7.20	6.86	
6/19	17:41	oCALC	--	--	--	--	--	--	--	--	--	--	0.588	0.973	4.25	4.08	
6/20	6:00	CHK	9.0	10	-0.05	-0.5%	8.67	-3.3%	0.01	0.1%	8.78	-2.2%	0.994	0.968	7.20	6.86	
6/20	6:29	CALC	--	--	--	--	--	--	--	--	--	--	1.026	0.963	7.37	7.06	
6/20	10:18	LIN	3.0	--	--	--	3.04	1.3%	--	--	3.21	7.1%	0.994	0.968	7.20	6.86	
6/20	10:31	LIN	3.0	--	--	--	2.82	-6.2%	--	--	2.90	-3.7%	0.994	0.968	7.20	6.86	
6/20	10:46	LIN	5.0	--	--	--	4.74	-5.2%	--	--	4.86	-2.8%	0.994	0.968	7.20	6.86	
6/20	11:11	LIN	9.0	--	--	--	8.81	-2.1%	--	--	8.85	-1.7%	0.994	0.968	7.20	6.86	
6/20	11:46	LIN	9.0	--	--	--	8.73	-3.0%	--	--	8.81	-2.1%	0.994	0.968	7.20	6.86	
6/20	18:15	PMTV	CHANGE FROM 569V — UNSTABLE 568V TO 570V — STABLE TO 569V AT 6/20 18:22														
6/21	8:45	CHK	9.0	10	0.01	0.1%	8.64	-3.6%	-0.02	-0.2%	8.75	-2.5%	0.994	0.968	7.20	6.86	52.50
6/21	9:14	CALC	--	--	--	--	--	--	--	--	--	--	1.036	0.954	7.51	7.03	52.50
6/21	15:47	DILP	CHANGE FROM 44.2 psi — STABLE TO -11.1 psi AT 6/21 15:53														
6/21	17:10	DILP	CHANGE FROM -11 psi — STABLE TO 45 psi AT 6/21 17:16														
6/22	11:30	CHK	9.0	10	0.00	0.0%	8.79	-2.1%	0.06	0.6%	8.91	-0.9%	0.994	0.968	7.20	6.86	52.50
6/22	11:59	CALC	--	--	--	--	--	--	--	--	--	--	1.017	0.962	7.37	7.04	52.50
6/23	6:00	CHK	9.0	10	-0.12	-1.2%	8.64	-3.6%	0.04	0.4%	8.73	-2.7%	0.994	0.968	7.20	6.86	52.50
6/23	6:29	CALC	--	--	--	--	--	--	--	--	--	--	1.022	0.975	7.28	7.14	52.50
6/23	11:47	PRBT	CHANGE FROM 220°C — DOWN TO 186°C AT 6/23 11:54 — STABLE TO 220°C AT 6/23 12:41														
6/23	11:48	DILP	CHANGE FROM 45 psi — DOWN TO 1.2 psi AT 6/23 11:55 — STABLE TO 45 psi AT 6/23 12:02														
6/24	6:00	CHK	9.0	10	0.01	0.1%	8.79	-2.1%	0.05	0.5%	8.85	-1.5%	0.994	0.968	7.20	6.86	52.50
6/24	6:29	CALC	--	--	--	--	--	--	--	--	--	--	1.019	0.965	7.39	7.06	52.50
6/24	7:10	CHG	--	--	--	--	--	--	--	--	--	--	1.019	0.965	7.39	7.01	52.50
6/25	6:00	CHK	9.0	10	0.00	0.0%	8.96	-0.4%	0.07	0.7%	9.09	0.9%	1.019	0.965	7.39	7.01	52.50
6/25	6:29	CALC	--	--	--	--	--	--	--	--	--	--	1.023	0.958	7.42	7.06	52.50
6/26	6:00	CHK	9.0	10	-0.05	-0.5%	8.98	-0.2%	0.03	0.3%	9.07	0.7%	1.019	0.965	7.39	7.01	52.50
6/26	6:29	CALC	--	--	--	--	--	--	--	--	--	--	1.015	0.965	7.31	7.02	52.50
6/26	17:04	DILP	CHANGE FROM 44 psi — DOWN TO 1.2 psi AT 6/26 17:11 — STABLE TO 44 psi AT 6/26 17:18														
6/27	6:00	CHK	9.0	10	-0.03	-0.3%	8.85	-1.5%	0.05	0.5%	9.08	0.8%	1.019	0.965	7.39	7.01	52.50
6/27	6:29	CALC	--	--	--	--	--	--	--	--	--	--	1.032	0.950	7.45	7.04	52.50

6/28	6:00	CHK	9.0	10	0.05	0.5%	8.69	-3.1%	0.05	0.5%	9.14	1.4%	1.019	0.965	7.39	7.01	52.50
6/28	6:29	CALC	--	--	--	--	--	--	--	--	--	--	1.062	0.917	7.75	6.99	52.50
6/28	19:26	DILP	CHANGE FROM 45 psi — DOWN TO 37 psi AT 6/28 19:31 — STABLE TO 44 psi AT 6/28 19:42														
6/29	6:00	CHK	9.0	10	0.01	0.1%	8.76	-2.4%	0.08	0.8%	9.11	1.1%	1.019	0.965	7.39	7.01	52.50
6/29	6:29	CALC	--	--	--	--	--	--	--	--	--	--	1.048	0.935	7.61	7.07	52.50
6/30	6:00	CHK	9.0	10	0.08	0.8%	8.92	-0.8%	0.14	1.4%	9.18	1.8%	1.019	0.965	7.39	7.01	52.50
6/30	6:29	CALC	--	--	--	--	--	--	--	--	--	--	1.037	0.944	7.60	7.12	52.50
7/1	6:00	CHK	9.0	10	0.05	0.5%	9.08	0.8%	0.13	1.3%	9.31	3.1%	1.019	0.965	7.39	7.01	52.50
7/1	6:29	CALC	--	--	--	--	--	--	--	--	--	--	1.016	0.949	7.42	7.00	52.50
7/2	6:00	CHK	9.0	10	0.04	0.4%	9.11	1.1%	0.10	1.0%	9.36	3.6%	1.019	0.965	7.39	7.01	52.50
7/2	6:29	CALC	--	--	--	--	--	--	--	--	--	--	1.012	0.944	7.38	6.91	52.50
7/3	6:00	CHK	9.0	10	-0.03	-0.3%	8.93	-0.7%	0.06	0.6%	9.05	0.5%	1.019	0.965	7.39	7.01	52.50
7/3	6:29	CALC	--	--	--	--	--	--	--	--	--	--	1.024	0.961	7.40	7.08	52.50
7/4	6:00	CHK	9.0	10	0.02	0.2%	8.85	-1.5%	0.12	1.2%	9.22	2.2%	1.019	0.965	7.39	7.01	52.50
7/4	6:29	CALC	--	--	--	--	--	--	--	--	--	--	1.038	0.937	7.54	7.05	52.50
7/5	6:00	CHK	9.0	10	0.10	1.0%	8.91	-0.9%	0.16	1.6%	9.23	2.3%	1.019	0.965	7.39	7.01	52.50
7/5	6:29	CALC	--	--	--	--	--	--	--	--	--	--	1.041	0.937	7.65	7.11	52.50
7/6	6:00	CHK	9.0	10	0.11	1.1%	8.96	-0.4%	0.15	1.5%	9.25	2.5%	1.019	0.965	7.39	7.01	52.50
7/6	6:29	CALC	--	--	--	--	--	--	--	--	--	--	1.035	0.940	7.62	7.09	52.50
7/7	6:00	CHK	9.0	10	0.06	0.6%	8.91	-0.9%	0.17	1.7%	9.16	1.6%	1.019	0.965	7.39	7.01	52.50
7/7	6:29	CALC	--	--	--	--	--	--	--	--	--	--	1.037	0.949	7.58	7.19	52.50
7/8	1:49	PMTV	CHANGE FROM 568V — UP TO 571V AT — STABLE TO 569V AT 7/8 01:55														
7/8	6:00	CHK	9.0	10	0.13	1.3%	8.86	-1.4%	0.21	2.1%	9.06	0.6%	1.019	0.965	7.39	7.01	52.50
7/8	6:29	CALC	--	--	--	--	--	--	--	--	--	--	1.050	0.952	7.74	7.34	52.50
7/8	16:56	PRBT	CHANGE FROM 220°C — DOWN TO 190°C AT 7/8 17:08 — STABLE TO 220°C AT 7/8 17:41														
7/8	17:02	DILP	CHANGE FROM 44 psi — DOWN TO 1.3 psi AT 7/8 17:08 — STABLE TO 44 psi AT 7/8 17:14														
7/9	6:00	CHK	9.0	10	0.24	2.4%	8.97	-0.3%	0.22	2.2%	9.18	1.8%	1.019	0.965	7.39	7.01	52.50
7/9	6:29	CALC	--	--	--	--	--	--	--	--	--	--	1.050	0.941	7.86	7.26	52.50
7/9	17:31	PRBT	CHANGE FROM 220°C — DOWN TO 193°C AT 7/9 17:39 — STABLE TO 220°C AT 7/9 18:20														
7/10	6:00	CHK	8900.0	8900	-0.08	0.0%	16.23	-100%	-0.05	0.0%	16.69	-100%	1.019	0.965	7.39	7.01	52.50
7/10	6:29	CALC	--	--	--	--	--	--	--	--	--	--	556.018	0.940	3988.37	3701.95	52.50
7/10	9:30	CHK	9.0	10	0.14	1.4%	8.94	-0.6%	0.23	2.3%	9.29	2.9%	1.019	0.965	7.39	7.01	52.50
7/10	9:59	CALC	--	--	--	--	--	--	--	--	--	--	1.042	0.938	7.70	7.20	52.50
7/11	8:00	CHK	9.0	10	0.11	1.1%	9.05	0.5%	0.24	2.4%	9.36	3.6%	1.019	0.965	7.39	7.01	52.50
7/11	8:29	CALC	--	--	--	--	--	--	--	--	--	--	1.026	0.945	7.56	7.16	52.50
7/12	7:30	CHK	9.0	10	0.20	2.0%	8.99	-0.1%	0.26	2.6%	9.35	3.5%	1.019	0.965	7.39	7.01	52.50
7/12	7:59	CALC	--	--	--	--	--	--	--	--	--	--	1.043	0.933	7.77	7.20	52.50
7/12	14:48	PRBT	CHANGE FROM 220°C — DOWN TO 161°C AT 7/12 14:56 — STABLE TO 220°C AT 7/12 15:47														
7/12	14:48	DILP	CHANGE FROM 44 psi — DOWN TO 1.2 psi AT 7/12 15:02 — STABLE TO 44 psi AT 7/12 15:17														
7/13	7:30	CHK	9.0	10	0.21	2.1%	8.94	-0.6%	0.31	3.1%	9.59	5.9%	1.019	0.965	7.39	7.01	52.50
7/13	7:59	CALC	--	--	--	--	--	--	--	--	--	--	1.051	0.907	7.85	7.10	52.50
7/13	8:25	CHG	--	--	--	--	--	--	--	--	--	--	1.051	0.907	7.85	7.10	52.50
7/13	18:00	CHK	9.0	10	-0.09	-0.9%	8.84	-1.6%	-0.07	-0.7%	8.89	-1.1%	1.051	0.907	7.85	7.10	52.50
7/13	18:29	CALC	--	--	--	--	--	--	--	--	--	--	1.060	0.904	7.83	7.07	52.50
7/14	7:30	CHK	9.0	10	-0.06	-0.6%	8.76	-2.4%	-0.04	-0.4%	8.84	-1.6%	1.051	0.907	7.85	7.10	52.50
7/14	7:59	CALC	--	--	--	--	--	--	--	--	--	--	1.073	0.900	7.96	7.15	52.50
7/14	14:12	PRBT	CHANGE FROM 220°C — DOWN TO 163°C AT 7/14 14:21 — STABLE TO 220°C AT 7/14 15:07														
7/14	14:12	DILP	CHANGE FROM 44 psi — DOWN TO 1.1 psi AT 7/14 14:29 — STABLE TO 44 psi AT 7/14 14:42														
7/15	7:30	CHK	9.0	10	-0.06	-0.6%	7.19	-18%	-0.07	-0.7%	8.70	-3.0%	1.051	0.907	7.85	7.10	52.50
7/15	7:59	CALC	--	--	--	--	--	--	--	--	--	--	1.304	0.751	9.66	7.22	52.50
7/15	8:25	MCAL	9.0	10	-0.84	-8.4%	5.33	-37%	-0.38	-3.8%	6.92	-21%	1.051	0.907	7.85	7.10	52.50
7/15	8:58	MUP	--	--	--	--	--	--	--	--	--	--	1.501	0.741	9.85	7.37	52.50
7/15	8:58	CALC	--	--	--	--	--	--	--	--	--	--	1.533	0.766	10.23	8.28	52.50
7/15	9:00	CHG	--	--	--	--	--	--	--	--	--	--	1.501	0.741	9.85	7.37	52.50
7/15	9:05	CHK	9.0	10	0.07	0.7%	8.51	-4.9%	-0.06	-0.6%	8.97	-0.3%	1.501	0.741	9.85	7.37	52.50
7/15	9:34	CALC	--	--	--	--	--	--	--	--	--	--	1.599	0.693	10.56	7.29	52.50
7/15	9:58	CHG	--	--	--	--	--	--	--	--	--	--	1.599	0.693	10.56	7.29	52.50
7/15	16:05	DILP	CHANGE FROM 44 psi — DOWN TO 8.4 psi AT 7/15 16:12 — STABLE TO 44 psi AT 7/15 16:19														
7/16	7:30	CHK	9.0	10	-0.03	-0.3%	10.42	14%	-0.04	-0.4%	9.01	0.1%	1.599	0.693	10.56	7.29	52.50
7/16	7:59	CALC	--	--	--	--	--	--	--	--	--	--	1.377	0.800	9.07	7.21	52.50

7/16	8:30	MCAL	9.0	10	-0.06	-0.6%	10.19	12%	-0.06	-0.6%	8.96	-0.4%	1.599	0.693	10.56	7.29	52.50
7/16	9:01	MUP	--	--	--	--	--	--	--	--	--	--	1.407	0.788	9.25	7.25	52.50
7/16	9:01	CALC	--	--	--	--	--	--	--	--	--	--	1.404	0.788	9.21	7.22	52.50
7/16	9:03	CHG	--	--	--	--	--	--	--	--	--	--	1.407	0.788	9.25	7.25	52.50
7/16	9:05	CHK	9.0	10	0.02	0.2%	8.92	-0.8%	0.06	0.6%	9.03	0.3%	1.407	0.788	9.25	7.25	52.50
7/16	9:34	CALC	--	--	--	--	--	--	--	--	--	--	1.424	0.782	9.38	7.34	52.50
7/16	15:43	PRBT	CHANGE FROM 220°C — DOWN TO 128°C AT 7/16 15:55 — STABLE TO 221°C AT 7/16 16:41														
7/16	15:43	DILP	CHANGE FROM 44.1 psi — STABLE TO 5.5 psi AT 7/16 15:51														
7/16	16:20	DILP	CHANGE FROM 5.5 psi — STABLE TO 44.2 psi AT 7/16 16:28														
7/17	7:30	CHK	9.0	10	0.01	0.1%	9.97	9.7%	0.02	0.2%	9.08	0.8%	1.407	0.788	9.25	7.25	52.50
7/17	7:59	CALC	--	--	--	--	--	--	--	--	--	--	1.271	0.867	8.36	7.23	52.50
7/17	8:14	CHG	--	--	--	--	--	--	--	--	--	--	1.271	0.867	8.36	7.23	52.50
7/18	9:00	CHK	9.0	10	0.02	0.2%	9.07	0.7%	0.05	0.5%	8.86	-1.4%	1.271	0.867	8.36	7.23	52.50
7/18	9:29	CALC	--	--	--	--	--	--	--	--	--	--	1.265	0.889	8.34	7.43	52.50
19-Jul	8:30	CHK	9	10	0.05	0.50%	9.27	2.70%	0.07	0.70%	8.92	-0.80%	1.271	0.867	8.36	7.23	52.5
19-Jul	8:59	CALC	--	--	--	--	--	--	--	--	--	--	1.24	0.904	8.21	7.43	52.5
20-Jul	7:30	CHK	9	10	-0.02	-0.20%	8.84	-1.60%	-0.02	-0.20%	8.83	-1.70%	1.271	0.867	8.36	7.23	52.5
20-Jul	7:59	CALC	--	--	--	--	--	--	--	--	--	--	1.291	0.868	8.47	7.33	52.5
7/21	8:30	CHK	9.0	10	-0.02	-0.2%	8.87	-1.3%	-0.01	-0.1%	8.93	-0.7%	1.271	0.867	8.36	7.23	52.50
7/21	8:59	CALC	--	--	--	--	--	--	--	--	--	--	1.287	0.862	8.45	7.26	52.50
7/22	7:30	CHK	9.0	10	0.06	0.6%	8.54	-4.6%	0.07	0.7%	8.65	-3.5%	1.271	0.867	8.36	7.23	52.50
7/22	7:59	CALC	--	--	--	--	--	--	--	--	--	--	1.349	0.856	8.95	7.65	52.50
7/22	16:49	DILP	CHANGE FROM 44 psi — DOWN TO 1.1 psi AT 7/22 16:56 — STABLE TO 44 psi AT 7/22 17:34														
7/22	16:51	PRBT	CHANGE FROM 221°C — DOWN TO 85°C AT 7/22 17:15 — STABLE TO 220°C AT 7/22 18:07														
7/22	17:09	CNVT	CHANGE FROM 756°C — DOWN TO 720°C AT 7/22 17:10 — STABLE TO 757°C AT 7/22 17:21														
7/23	7:30	CHK	9.0	10	-0.01	-0.1%	8.47	-5.3%	-0.04	-0.4%	8.90	-1.0%	1.271	0.867	8.36	7.23	52.50
7/23	7:59	CALC	--	--	--	--	--	--	--	--	--	--	1.349	0.822	8.86	7.23	52.50
24-Jul	8:30	CHK	9	10	0.13	1.30%	9.17	1.70%	0.1	1.00%	9.15	1.50%	1.349	0.822	8.86	7.23	52.5
24-Jul	8:59	CALC	--	--	--	--	--	--	--	--	--	--	1.344	0.821	8.96	7.29	52.5
7/25	3:12	INTT	CHANGE FROM 28°C — UP TO 30°C AT 7/25 03:16 — STABLE TO 28°C AT 7/25 03:31														
7/25	7:30	CHK	9.0	10	0.18	1.8%	9.29	2.9%	0.18	1.8%	9.15	1.5%	1.349	0.822	8.86	7.23	52.50
7/25	7:59	CALC	--	--	--	--	--	--	--	--	--	--	1.333	0.835	8.94	7.44	52.50
7/25	15:02	PRBT	CHANGE FROM 220°C — DOWN TO 183°C AT 7/25 15:11 — STABLE TO 220°C AT 7/25 15:53														
7/25	15:04	DILP	CHANGE FROM 44 psi — DOWN TO 1.2 psi AT 7/25 15:12 — STABLE TO 44 psi AT 7/25 15:20														
7/26	6:40	CHK	9.0	10	0.07	0.7%	9.41	4.1%	0.07	0.7%	8.98	-0.2%	1.349	0.822	8.86	7.23	52.50
7/26	7:09	CALC	--	--	--	--	--	--	--	--	--	--	1.300	0.862	8.61	7.38	52.50
7/27	6:40	CHK	9.0	10	-0.05	-0.5%	7.24	-18%	-0.01	-0.1%	6.76	-22%	1.349	0.822	8.86	7.23	52.50
7/27	7:09	CALC	--	--	--	--	--	--	--	--	--	--	1.666	0.885	10.88	9.61	52.50
7/27	7:17	MCAL	9.0	10	-0.49	-4.9%	6.45	-26%	-0.32	-3.2%	6.11	-29%	1.349	0.822	8.86	7.23	52.50
7/27	7:52	MUP	--	--	--	--	--	--	--	--	--	--	1.774	0.881	11.09	9.78	52.50
7/27	7:52	CALC	--	--	--	--	--	--	--	--	--	--	1.748	0.887	10.85	9.67	52.50
7/27	8:10	CHK	9.0	10	0.18	1.8%	8.53	-4.7%	0.12	1.2%	8.91	-0.9%	1.774	0.881	11.09	9.78	52.50
7/27	8:39	CALC	--	--	--	--	--	--	--	--	--	--	1.912	0.837	12.14	10.14	52.50
7/28	6:40	CHK	9.0	10	0.14	1.4%	9.21	2.1%	0.03	0.3%	9.41	4.1%	1.774	0.881	11.09	9.78	52.50
7/28	7:09	CALC	--	--	--	--	--	--	--	--	--	--	1.760	0.852	11.14	9.41	52.50
7/28	8:52	DILP	CHANGE FROM 45 psi — DOWN TO 39 psi AT — STABLE TO 45 psi AT 7/28 08:58														
7/28	14:24	PRBT	CHANGE FROM 220°C — STABLE TO 220°C AT 7/28 14:30														
7/29	6:40	CHK	9.0	10	0.25	2.5%	9.59	5.9%	0.19	1.9%	9.90	9.0%	1.774	0.881	11.09	9.78	52.50
7/29	7:09	CALC	--	--	--	--	--	--	--	--	--	--	1.708	0.848	10.91	9.24	52.50
7/29	7:23	CHG	--	--	--	--	--	--	--	--	--	--	1.708	0.848	10.91	9.24	52.50
7/29	22:55	INTT	CHANGE FROM 28°C — UP TO 30°C AT 7/29 23:02 — STABLE TO 28°C AT 7/29 23:17														
7/30	5:43	INTT	CHANGE FROM 28°C — UP TO 30°C AT 7/30 05:48 — STABLE TO 29°C AT 7/30 05:54														
7/30	6:40	CHK	9.0	10	-0.01	-0.1%	8.79	-2.1%	0.05	0.5%	8.72	-2.8%	1.708	0.848	10.91	9.24	52.50
7/30	7:09	CALC	--	--	--	--	--	--	--	--	--	--	1.748	0.860	11.16	9.64	52.50
7/30	7:59	DILP	CHANGE FROM 45 psi — DOWN TO 1.2 psi AT 7/30 08:06 — STABLE TO 44 psi AT 7/30 08:15														
7/30	8:21	CHK	9.0	10	-0.02	-0.2%	10.99	20%	0.02	0.2%	11.30	23%	1.708	0.848	10.91	9.24	52.50
7/30	8:50	CALC	--	--	--	--	--	--	--	--	--	--	1.397	0.827	8.91	7.38	52.50
7/30	9:16	MCAL	9.0	10	-0.13	-1.3%	11.28	23%	-0.15	-1.5%	11.29	23%	1.708	0.848	10.91	9.24	52.50
7/30	9:50	MUP	--	--	--	--	--	--	--	--	--	--	1.346	0.849	8.49	7.21	52.50
7/30	9:50	CALC	--	--	--	--	--	--	--	--	--	--	1.347	0.846	8.50	7.15	52.50

7/30	10:00	CHK	9.0	10	0.02	0.2%	8.91	-0.9%	0.01	0.1%	8.97	-0.3%	1.346	0.849	8.49	7.21	52.50
7/30	10:29	CALC	--	--	--	--	--	--	--	--	--	--	1.363	0.843	8.62	7.25	52.50
7/31	5:00	CHK	9.0	10	0.07	0.7%	9.06	0.6%	0.06	0.6%	8.89	-1.1%	1.346	0.849	8.49	7.21	52.50
7/31	5:29	CALC	--	--	--	--	--	--	--	--	--	--	1.349	0.863	8.59	7.40	52.50
7/31	13:42	DILP	CHANGE FROM 44.2 psi — STABLE TO 1.2 psi AT 7/31 13:50														
7/31	13:43	PRBT	CHANGE FROM 220°C — DOWN TO 108°C AT 7/31 14:07 — STABLE TO 221°C AT 7/31 15:04														
7/31	14:07	CNVT	CHANGE FROM 748°C — DOWN TO 724°C AT — STABLE TO 756°C AT 7/31 14:13														
7/31	14:44	DILP	CHANGE FROM 1.2 psi — STABLE TO 44.2 psi AT 7/31 14:52														
8/1	5:00	CHK	9.0	10	0.05	0.5%	8.69	-3.1%	0.04	0.4%	8.84	-1.6%	1.346	0.849	8.49	7.21	52.50
8/1	5:29	CALC	--	--	--	--	--	--	--	--	--	--	1.403	0.834	8.90	7.42	52.50
8/2	5:00	CHK	9.0	10	0.06	0.6%	8.71	-2.9%	0.01	0.1%	8.84	-1.6%	1.346	0.849	8.49	7.21	52.50
8/2	5:29	CALC	--	--	--	--	--	--	--	--	--	--	1.401	0.832	8.90	7.35	52.50
8/3	5:00	CHK	9.0	10	0.13	1.3%	8.88	-1.2%	0.04	0.4%	8.99	-0.1%	1.346	0.849	8.49	7.21	52.50
8/3	5:29	CALC	--	--	--	--	--	--	--	--	--	--	1.384	0.831	8.87	7.30	52.50
8/3	13:32	DILP	CHANGE FROM 44.2 psi — STABLE TO 1.2 psi AT 8/3 13:40														
8/3	13:33	PRBT	CHANGE FROM 220°C — DOWN TO 122°C AT 8/3 13:50 — STABLE TO 221°C AT 8/3 14:55														
8/3	14:28	DILP	CHANGE FROM 1.2 psi — STABLE TO 44.2 psi AT 8/3 14:36														
8/4	5:00	CHK	9.0	10	0.08	0.8%	9.25	2.5%	0.07	0.7%	8.85	-1.5%	1.346	0.849	8.49	7.21	52.50
8/4	5:29	CALC	--	--	--	--	--	--	--	--	--	--	1.321	0.887	8.41	7.46	52.50
8/5	5:00	CHK	9.0	10	0.11	1.1%	9.58	5.8%	0.07	0.7%	8.88	-1.2%	1.346	0.849	8.49	7.21	52.50
8/5	5:29	CALC	--	--	--	--	--	--	--	--	--	--	1.281	0.912	8.19	7.43	52.50
8/5	7:51	CHG	--	--	--	--	--	--	--	--	--	--	1.281	0.912	8.19	7.43	52.50
8/6	5:00	CHK	9.0	10	0.06	0.6%	8.92	-0.8%	0.05	0.5%	8.92	-0.8%	1.281	0.912	8.19	7.43	52.50
8/6	5:29	CALC	--	--	--	--	--	--	--	--	--	--	1.302	0.911	8.39	7.60	52.50
8/7	5:00	CHK	9.0	10	-0.05	-0.5%	12.56	36%	-0.06	-0.6%	12.57	36%	1.281	0.912	8.19	7.43	52.50
8/7	5:29	CALC	--	--	--	--	--	--	--	--	--	--	0.914	0.910	5.81	5.25	52.50
8/7	8:16	CHK	9.0	10	-0.06	-0.6%	12.23	32%	0.01	0.1%	13.27	43%	1.281	0.912	8.19	7.43	52.50
8/7	8:49	CALC	--	--	--	--	--	--	--	--	--	--	0.938	0.845	5.96	5.05	52.50
8/7	12:14	PRBT	CHANGE FROM 221°C — DOWN TO 205°C AT 8/7 12:21 — STABLE TO 220°C AT 8/7 12:51														
8/8	5:00	CHK	9.0	10	0.06	0.6%	10.24	12%	0.09	0.9%	12.40	34%	1.281	0.912	8.19	7.43	52.50
8/8	5:29	CALC	--	--	--	--	--	--	--	--	--	--	1.132	0.754	7.29	5.50	52.50

8.0 APPENDIX C - OHIO LUMEX DATA

No	Description: 6/22/13	M, mg	C, ng/g	Area	Maximum	Time
1	Std__10	1	9.8	7340	820	2:47:19 PM
2	Std__50	1	49	36600	3350	2:51:07 PM
3	Std__100	1	100	75100	6450	2:55:47 PM
4	Std__150	1	148	111000	14400	3:00:28 PM
5	Std__200	1	199	149000	19300	3:04:04 PM
6	Std__250	1	250	187000	15700	3:08:10 PM
7	Std__100 QA, RL = 3%	1	103	77300	6510	3:23:18 PM
	Standard__100, R = 0%		103			
8	Std__100 SS, RL = 4%	1	104	77800	9330	3:29:01 PM
9	172276 FP	1	217	162000	17900	3:37:52 PM
13	172276 Section 1	1	243	182000	18400	3:52:05 PM
14	172276 Section 2	1	10	7540	280	3:53:59 PM
20	173282 FP	1	74	55900	4170	4:15:21 PM
21	173282 Section 1	1	361	270000	29600	4:18:55 PM
22	173282 Section 2	1	15	11200	505	4:21:30 PM
23	172358 FP	1	120	89700	7350	4:42:16 PM
24	172358 Section 1	1	222	166000	16500	4:44:56 PM
25	172358 Section 2	1	10	7970	298	4:47:24 PM
26	172485 FP	1	166	124000	7060	5:02:21 PM
27	Std__100 QA, RL = 1%	1	101	75900	5730	5:05:00 PM
28	172485 Section 1	1	207	155000	18100	5:08:27 PM
29	172485 Section 2	1	14	10800	453	5:13:08 PM
30	172458 FP	1	6.1	4570	327	5:26:58 PM
31	172458 Section 1	1	116	86700	10000	5:29:53 PM
32	172458 Section 2	1	1.2	920	40	5:31:57 PM
33	172474 FP	1	5.1	3840	339	5:42:53 PM
35	12474 Section 1	1	132	99200	12300	5:46:10 PM
36	12474 Section 2	1	1.0	750	62	5:48:25 PM
37	173272 FP	1	22	16600	1310	5:58:25 PM
38	173272 Section 1	1	120	90200	12100	6:00:42 PM
39	Std__100 QA, RL = 5%	1	105	78600	7090	6:04:53 PM
40	173272 Section 2	1	7.3	5430	294	6:07:36 PM
41	173281 FP	1	20	15500	1010	6:17:06 PM
42	173281 Section 1	1	125	94000	12500	6:19:35 PM
43	173281 Section 2	1	7.4	5510	244	6:21:19 PM
44	173296FP	1	42	31600	2410	6:31:13 PM
45	173296 Section 1	1	644	481000	51300	6:34:31 PM
46	173296 Section 2	1	6.6	4930	343	6:39:03 PM
47	173273 FP	1	38	28800	2640	6:48:26 PM

48	173273 Section 1	1	633	473000	53600	6:51:48 PM
49	173273 Section 2	1	7.9	5920	351	6:56:11 PM
50	Std__100 QA, RL = 3%	1	103	77500	7070	6:59:50 PM
51	173262 FP	1	0.7	550	32	7:10:58 PM
52	173262 Section 1	1	167	125000	13500	7:13:09 PM
53	173262 Section 2	1	0.3	202	14	7:16:19 PM
54	173265 FP	1	0.9	684	35	7:28:18 PM
55	173265 Section 1	1	191	143000	16300	7:30:26 PM
56	173265 Section 2	1	0.4	326	17	7:32:22 PM
57	172122 FP	1	6.5	4850	403	7:40:08 PM
58	172122 Section 1	1	451	337000	41900	7:43:05 PM
59	172122 Section 2	1	2.3	1700	144	7:45:23 PM
61	173268 FP	1	4.3	3220	199	7:52:46 PM
62	173268 Section 1	1	478	357000	43000	7:56:05 PM
63	173268 Section 2	1	3.5	2590	213	7:58:00 PM
65	172205 FP	1	80	60000	3680	8:06:46 PM
67	172205 Section 1	1	686	512000	51400	8:10:44 PM
68	172205 Section 2	1	3.4	2560	102	8:13:30 PM
69	172341 FP	1	79	59000	4680	8:20:20 PM
71	172341 Section 1	1	781	583000	51600	8:24:00 PM
73	172341 Section 2	1	5.4	4040	193	8:26:16 PM
74	Std__100 QC, RL = 7%	1	107	80100	8430	8:29:04 PM
No	Description: 6/23/13	M, mg	C, ng/g	Area	Maximum	Time
1	Std__10	1	9.8	7340	820	2:47:19 PM
2	Std__50	1	49	36600	3350	2:51:07 PM
3	Std__100	1	100	75100	6450	2:55:47 PM
4	Std__150	1	148	111000	14400	3:00:28 PM
5	Std__200	1	199	149000	19300	3:04:04 PM
6	Std__250	1	250	187000	15700	3:08:10 PM
7	Std__100 QA, RL = 3%	1	103	77300	6510	3:23:18 PM
	Standard__100, R = 0%		103			
8	Std__100 SS, RL = 4%	1	104	77800	9330	3:29:01 PM
9	172276 FP	1	217	162000	17900	3:37:52 PM
13	172276 Section 1	1	243	182000	18400	3:52:05 PM
14	172276 Section 2	1	10	7540	280	3:53:59 PM
20	173282 FP	1	74	55900	4170	4:15:21 PM
21	173282 Section 1	1	361	270000	29600	4:18:55 PM
22	173282 Section 2	1	15	11200	505	4:21:30 PM
23	172358 FP	1	120	89700	7350	4:42:16 PM

24	172358 Section 1	1	222	166000	16500	4:44:56 PM
25	172358 Section 2	1	10	7970	298	4:47:24 PM
26	172485 FP	1	166	124000	7060	5:02:21 PM
27	Std__100 QA, RL = 1%	1	101	75900	5730	5:05:00 PM
28	172485 Section 1	1	207	155000	18100	5:08:27 PM
29	172485 Section 2	1	14	10800	453	5:13:08 PM
30	172458 FP	1	6.1	4570	327	5:26:58 PM
31	172458 Section 1	1	116	86700	10000	5:29:53 PM
32	172458 Section 2	1	1.2	920	40	5:31:57 PM
33	172474 FP	1	5.1	3840	339	5:42:53 PM
35	12474 Section 1	1	132	99200	12300	5:46:10 PM
36	12474 Section 2	1	1.0	750	62	5:48:25 PM
37	173272 FP	1	22	16600	1310	5:58:25 PM
38	173272 Section 1	1	120	90200	12100	6:00:42 PM
39	Std__100 QA, RL = 5%	1	105	78600	7090	6:04:53 PM
40	173272 Section 2	1	7.3	5430	294	6:07:36 PM
41	173281 FP	1	20	15500	1010	6:17:06 PM
42	173281 Section 1	1	125	94000	12500	6:19:35 PM
43	173281 Section 2	1	7.4	5510	244	6:21:19 PM
44	173296FP	1	42	31600	2410	6:31:13 PM
45	173296 Section 1	1	644	481000	51300	6:34:31 PM
46	173296 Section 2	1	6.6	4930	343	6:39:03 PM
47	173273 FP	1	38	28800	2640	6:48:26 PM
48	173273 Section 1	1	633	473000	53600	6:51:48 PM
49	173273 Section 2	1	7.9	5920	351	6:56:11 PM
50	Std__100 QA, RL = 3%	1	103	77500	7070	6:59:50 PM
51	173262 FP	1	0.7	550	32	7:10:58 PM
52	173262 Section 1	1	167	125000	13500	7:13:09 PM
53	173262 Section 2	1	0.3	202	14	7:16:19 PM
54	173265 FP	1	0.9	684	35	7:28:18 PM
55	173265 Section 1	1	191	143000	16300	7:30:26 PM
56	173265 Section 2	1	0.4	326	17	7:32:22 PM
57	172122 FP	1	6.5	4850	403	7:40:08 PM
58	172122 Section 1	1	451	337000	41900	7:43:05 PM
59	172122 Section 2	1	2.3	1700	144	7:45:23 PM
61	173268 FP	1	4.3	3220	199	7:52:46 PM
62	173268 Section 1	1	478	357000	43000	7:56:05 PM
63	173268 Section 2	1	3.5	2590	213	7:58:00 PM
65	172205 FP	1	80	60000	3680	8:06:46 PM
67	172205 Section 1	1	686	512000	51400	8:10:44 PM

68	172205 Section 2	1	3.4	2560	102	8:13:30 PM
69	172341 FP	1	79	59000	4680	8:20:20 PM
71	172341 Section 1	1	781	583000	51600	8:24:00 PM
73	172341 Section 2	1	5.4	4040	193	8:26:16 PM
74	Std__100 QC, RL = 7%	1	107	80100	8430	8:29:04 PM
75	Std__100 QC, RL = 5%	1	105	78500	6950	2:09:12 PM
76	173255 FP	1	5.7	4250	322	2:37:17 PM
77	173255 Section 1	1	82	61400	5550	2:40:04 PM
78	173255 Section 2	1	3.5	2600	155	2:43:06 PM
79	173288 FP	1	2.6	1910	115	2:52:51 PM
80	173288 Section 1	1	98	73200	5360	2:55:15 PM
81	173288 Section 2	1	4.4	3250	177	2:57:25 PM
82	173267 FP	1	15	11800	808	3:06:57 PM
83	173267 Section 1	1	115	85900	8120	3:09:29 PM
84	173267 Section 2	1	5.2	3910	174	3:11:31 PM
85	173274 FP	1	17	13000	764	3:23:39 PM
86	173274 Section 1	1	116	87100	11600	3:26:44 PM
88	Std__100 QA, RL = 5%	1	105	78900	7980	3:35:34 PM
90	173274 Section 2	1	5.8	4320	167	3:38:35 PM
91	173259 FP	1	36	27100	1180	3:49:39 PM
92	173259 Section 1	1	205	153000	17300	3:52:52 PM
93	173259 Section 2	1	7.1	5270	214	3:55:13 PM
94	173261 FP	1	30	22800	1680	4:03:46 PM
96	173261 Section 1	1	215	161000	18400	4:07:43 PM
97	173261 Section 2	1	7.9	5860	199	4:10:39 PM
98	Std__100 QA, RL = 5%	1	105	78800	8280	4:17:16 PM
No	Description: 7/12/13	M, mg	C, ng/g	Area	Maximum	Time
1	Std__5, RL = -11%	1	4.4	1560	177	11:47:51 AM
2	Std__10, RL = -13%	1	8.7	3070	324	11:49:42 AM
3	Std__100, RL = -2%, RL = -2%	1	98	34900	3510	11:51:34 AM
4	Std__50, RL = -2%, RL = -2%	1	49	17600	2160	11:53:49 AM
5	Std__500, RL = 0%, RL = 0%	1	500	177000	18400	11:56:06 AM
6	Std__5, RL = 0%	1	5.0	1760	161	12:10:58 PM
7	Std__10, RL = -1%	1	9.8	3450	389	12:12:43 PM
8	Std__250 SS, RL = 0%	1	249	88300	9360	12:16:41 PM
9	OL 173271 Sec 1 Plug Stack A	1	20	7350	387	12:24:06 PM
10	OL 173271 Sec 1	1	82	29200	2990	12:26:08 PM
11	OL 173271 Sec 2 and Plug	1	4.5	1600	85	12:28:07 PM
12	OL 173300 Sec 1 Plug Stack A	1	24	8550	640	12:32:35 PM

13	OL 173300 Sec 1	1	79	28000	3820	12:34:15 PM
14	OL 173300 Sec 2 and Plug	1	4.6	1640	80	12:36:05 PM
15	OL 173276 Sec 1 Plug Stack D	1	158	56200	6250	12:40:47 PM
16	OL 173276 Sec 1	1	7.5	2670	291	12:42:20 PM
17	OL 173276 Sec 2 and Plug	1	6.1	2150	113	12:44:25 PM
18	OL 173284 Sec 1 Plug Stack D	1	150	53400	3620	12:47:23 PM
19	OL 173284 Sec 1	1	8.6	3060	422	12:49:45 PM
20	OL 173284 Sec 2 and Plug	1	8.0	2840	179	12:52:01 PM
21	OL 173257 Sec 1 Plug Inlet	1	33	11700	1020	12:54:28 PM
22	OL 173257 Sec 1	1	460	163000	18900	12:56:46 PM
23	OL 173257 Sec 2 and Plug	1	10	3820	287	12:58:24 PM
24	OL 173275 Sec 1 Plug Inlet	1	35	12500	773	1:02:15 PM
25	OL 173275 Sec 1	1	494	175000	21800	1:04:22 PM
26	OL 173275 Sec 2 and Plug	1	13	4720	304	1:06:10 PM
27	Std__300 Chk, RL = 1%	1	305	108000	13500	1:10:15 PM
No	Description: 7/14/13	M, mg	C, ng/g	Area	Maximum	Time
1	Std__5, RL = -4%	1	4.8	1550	165	11:24:33 AM
2	Std__10, RL = 0%	1	10	3290	307	11:26:58 AM
3	Std__100, RL = 3%	1	103	33300	2830	11:29:00 AM
4	Std__500, RL = 0%	1	499	161000	17700	11:31:38 AM
5	Std__500 SS, RL = 4%	1	520	168000	13200	11:34:27 AM
6	OL 165245 Sec 1 Plug	1	42	13600	1530	11:48:53 AM
7	OL 165245 Sec 1	1	613	198000	20100	11:50:58 AM
8	OL 165345 Sec 2 and Plug	1	12	4100	178	11:52:36 AM
9	OL 165389 Sec 1 Plug	1	45	14800	1510	11:59:42 AM
10	OL 165389 Sec 1	1	688	222000	31500	12:01:35 PM
11	OL 165389 Sec 2	1	17	5640	440	12:03:07 PM
12	OL 165482 Sec 1 Plug	1	131	42500	3090	12:17:01 PM
13	OL 165482 Sec 1	1	9.1	2920	278	12:18:31 PM
14	OL 165482 Sec 2	1	8.4	2700	175	12:19:57 PM
15	OL 165484 Sec 1 Plug	1	133	43000	4680	12:29:10 PM
16	OL 165484 Sec 1	1	8.6	2790	321	12:30:53 PM
17	OL 165484 Sec 2	1	7.4	2380	124	12:32:25 PM
18	OL 165385 Sec 1 Plug	1	40	13200	782	12:39:59 PM
19	OL 165385 Sec 1	1	38	12400	1400	12:41:43 PM
20	OL 165385 Sec 2	1	4.7	1530	83	12:43:29 PM
21	OL 165726 Sec 1 Plug	1	43	14000	1160	12:45:18 PM
22	OL 165726 Sec 1	1	34	11200	1430	12:47:02 PM
23	OL 165726 Sec 2	1	4.4	1410	71	12:48:19 PM

24	Std__700 Chk, RL = 1%	1	713	230000	24100	12:52:53 PM
No	Description: 7/17/13	M, mg	C, ng/g	Area	Maximum	Time
1	Std__5, RL = 8%	1	5.4	1690	135	9:13:56 AM
2	Std__10, RL = 0%, RL = 0%	1	10	3430	381	9:15:58 AM
3	Std__5, RL = 5%, RL = 5%	1	5.3	1660	207	9:19:14 AM
4	Std__100, RL = 8%, RL = 8%	1	108	34000	3360	9:22:26 AM
5	Std__1000, RL = 0%, RL = 0%	1	999	313000	33700	9:24:56 AM
6	Std__1000 SS, RL = 2%	1	1020	320000	35100	9:30:26 AM
7	OL 173258 Sec 1 Plug	1	161	50700	3940	9:36:52 AM
8	OL 173258 Sec 1	1	7.9	2490	260	9:38:50 AM
9	OL 173258 Sec 2 and Plug	1	8.0	2510	175	9:40:11 AM
10	OL 173292 Sec 1 Plug	1	166	52200	2560	9:43:53 AM
11	OL 173292 Sec 1	1	7.5	2340	221	9:45:44 AM
12	OL 173292 Sec and Plug	1	8.3	2590	189	9:47:39 AM
13	OL 171696 Sec 1 Plug	1	112	35100	2900	9:51:09 AM
14	OL 171696 Sec 1	1	19	5960	768	9:52:43 AM
15	OL 171696 Sec 2 and Plug	1	7.6	2380	182	9:54:04 AM
16	OL 171706 Sec 1 Plug	1	109	34200	2670	9:58:26 AM
17	OL 171706 Sec 1	1	18	5810	704	10:00:26 AM
18	OL 171706 Sec 2 and Plug	1	7.3	2290	164	10:02:12 AM
19	OL 173264 Sec 1 Plug	1	43	13500	1280	10:05:39 AM
20	OL 173264 Sec 1	1	663	208000	22500	10:08:09 AM
21	OL 173264 Sec 2 and Plug	1	23	7240	601	10:10:21 AM
22	OL 171680 Sec 1 Plug	1	25	8030	523	10:12:59 AM
23	OL 171680 Sec 1	1	648	203000	22900	10:15:18 AM
24	Ol 171680 Sec 2 and Plug	1	17	5340	381	10:17:02 AM
25	Std__700 Chk, RL = 7%	1	753	236000	27000	10:21:11 AM
No	Description: 7/20/13	M, mg	C, ng/g	Area	Maximum	Time
1	Std__100, RL = 5%	50	105	1820	221	8:06:47 PM
2	Std__100, RL = -2%	100	98	3410	410	8:09:43 PM
3	Std__1000, RL = 0%	50	999	17300	2290	8:11:53 PM
4	GB-202 - 1	1066	14	5250	248	9:24:49 PM
5	GB-202 - 2	1387	13	6400	314	9:28:17 PM
6	GB-203 - 1	1838	15	9760	441	9:31:20 PM
7	GB-203 - 2	1093	16	6280	347	9:34:37 PM
8	GB-204 - 1	1295	13	6050	309	10:03:28 PM
9	GB-204 - 2	1621	15	8540	371	10:06:35 PM
10	GB-205 - 1	1120	18	7240	323	10:09:10 PM

11	GB-205 - 2	1276	13	5970	300	10:12:43 PM
12	GB-206 - 1	1264	11	4880	250	10:23:23 PM
13	GB-206 - 2	1329	11	5130	227	10:26:23 PM
14	Std__100, RL = 1%	100	101	3500	463	10:33:05 PM
No	Description: 7/21/13	M, mg	C, ng/g	Area	Maximum	Time
1	Std__5, RL = -4%	1	4.8	1650	190	11:47:26 PM
2	Std__10, RL = 0%	1	9.9	3410	366	12:23:41 AM
3	Std__50, RL = 0%	1	50	17400	1930	12:25:47 AM
4	Std__100, RL = 1%	1	101	35000	3870	12:28:25 AM
5	Std__250, RL = 2%	1	257	89100	10800	12:42:23 AM
6	Std__500, RL = 2%	1	511	177000	19500	12:45:20 AM
7	Std__1000, RL = 0%	1	991	343000	29200	12:48:19 AM
8	Std__30, RL = 0%	1	30	10500	1310	12:55:34 AM
9	171708 FP	1	24	8430	597	1:06:36 AM
10	171708 Section 1	1	45	15700	1930	1:08:45 AM
11	171708 Section 2	1	3.6	1240	59	1:11:01 AM
12	172004 FP	1	24	8630	662	1:18:06 AM
13	172004 Section 1	1	43	15000	1800	1:19:56 AM
14	172004 Section 2	1	4.1	1430	60	1:21:50 AM
15	172187 FP	1	121	42200	4510	1:31:45 AM
16	172187 Section 1	1	5.7	1980	234	1:33:48 AM
17	172187 Section 2	1	4.8	1660	84	1:35:26 AM
18	172200 FP	1	112	39000	3670	1:37:32 AM
20	Std__30, RL = 0%	1	30	10600	1290	1:42:40 AM
21	172200 Section 1	1	6.8	2370	327	1:44:40 AM
22	172200 Section 2	1	5.9	2030	77	1:48:06 AM
23	171596 FP	1	32	11100	1090	1:56:28 AM
24	171596 Section 1	1	525	182000	19000	1:58:52 AM
25	171596 Section 2	1	13	4550	364	2:01:20 AM
26	172073 FP	1	33	11600	1510	2:15:33 AM
27	172073 Section 1	1	540	187000	20400	2:18:58 AM
28	172073 Section 2	1	11	3860	331	2:21:10 AM
29	171590 FP	1	32	11300	1100	2:23:54 AM
30	171590 Section 1	1	29	10300	1250	2:28:21 AM
31	Std__30, RL = 0%	1	30	10500	1200	2:30:54 AM
32	171590 Section 2	1	3.2	1090	53	2:42:56 AM
33	172237 FP	1	31	10800	966	2:44:44 AM
34	172237 Section 1	1	30	10600	1300	2:46:40 AM
35	172237 Section 2	1	3.0	1050	35	2:49:02 AM

36	171682 FP	1	115	39800	3460	2:57:35 AM
37	171682 Section 1	1	7.5	2610	298	2:59:58 AM
38	171682 Section 2	1	6.0	2080	93	3:02:04 AM
39	171683 FP	1	115	39900	3570	3:07:43 AM
40	171683 Section 1	1	6.8	2350	283	3:10:47 AM
41	171683 Section 2	1	5.8	1990	90	3:12:42 AM
42	Std__30, RL = 0%	1	30	10600	1220	3:14:56 AM
No	Description: 7/25/13	M, mg	C, ng/g	Area	Maximum	Time
1	Std__5, RL = -4%	1	4.8	1560	161	10:53:08 AM
2	Std__10, RL = 0%	1	10	3370	281	10:54:51 AM
3	Std__100, RL = 2%	1	102	33200	3020	10:56:51 AM
4	Std__500, RL = 3%	1	517	167000	13300	10:58:47 AM
5	Std__1000, RL = 0%	1	992	320000	32400	11:02:30 AM
6	Std__1000 SS, RL = -3%	1	964	311000	26800	11:04:41 AM
7	OL 172080 Sec 1 Plug	1	95	30900	1870	11:19:08 AM
8	OL 172080 Sec 1	1	26	8610	913	11:20:50 AM
9	OL 172080 Sec 2 and Plug	1	7.2	2310	145	11:22:50 AM
10	OL 171698 Sec 1 Plug	1	103	33400	2950	11:25:02 AM
11	OL 171698 Sec 1	1	24	7770	940	11:28:02 AM
12	OL 171698 Sec 2 and Plug	1	5.4	1730	113	11:29:58 AM
13	OL 171679 Sec 1 Plug	1	134	43300	2950	11:33:28 AM
14	OL 171679 Sec 1	1	9.9	3180	354	11:35:57 AM
15	OL 171679 Sec 2 and Plug	1	6.7	2160	130	11:37:15 AM
16	OL 173013 Sec 1 Plug	1	133	43000	4110	11:42:15 AM
17	OL 173013 Sec 1	1	10	3300	349	11:44:32 AM
18	OL 173013 Sec 2 and Plug	1	6.8	2190	94	11:46:19 AM
19	OL 171689 Sec 1 Plug	1	48	15600	838	11:49:34 AM
20	OL 171689 Sec 1	1	595	192000	22200	11:51:21 AM
21	OL 171689 Sec 2 and Plug	1	17	5520	325	11:54:09 AM
22	OL 172182 Sec 1 Plug	1	59	19200	832	11:57:52 AM
23	OL 172182 Sec 1	1	604	195000	19900	11:59:28 AM
24	OL 172182 Sec 2 and Plug	1	19	6350	453	12:01:11 PM
25	Std__600, RL = 4%	1	626	202000	18200	12:06:21 PM
No	Description: 7/26/13	M, mg	C, ng/g	Area	Maximum	Time
1	Std__100, RL = 5%	50	105	1670	167	8:01:14 AM
2	Std__100, RL = 4%	100	104	3290	333	8:03:10 AM
3	Std__1000, RL = 5%	50	1050	16600	1650	8:05:33 AM
4	Std__1000, RL = 3%	100	1030	32600	3500	8:07:39 AM

5	Std__10000, RL = 5%	50	10500	167000	14500	8:12:51 AM
6	Std__10000, RL = -1%	100	9850	311000	34000	8:15:35 AM
7	Pellets 7-24-2013 A	655	1.1	235	13	8:28:56 AM
8	Pellets 7-24-2013 B	1029	1.3	438	20	8:31:27 AM
9	Fine Tailings AM 7-24-2013 A	881	51	14400	867	8:33:57 AM
10	Fine Tailings AM 7-24-2013 B	847	40	10900	572	8:36:30 AM
11	Multiclone AM 7-24-2013 A	406	552	70800	4010	8:48:36 AM
12	Multiclone AM 7-24-2013 B	445	554	77800	4620	8:51:03 AM
13	Green Balls AM 7-24-2013 A	1091	16	5660	309	8:53:37 AM
14	Green Balls AM 7-24-2013 B	531	19	3340	211	8:55:26 AM
15	Conc Thick Overflow W AM 7-24-2013 A	420	353	46800	3500	9:09:26 AM
16	Conc Thick Overflow W AM 7-24-2013 B	652	354	72900	5100	9:12:51 AM
17	Multiclone PM 7-24-2013 A	655	362	74900	4350	9:17:02 AM
18	Multiclone PM 7-24-2013 B	700	360	79600	4630	9:19:36 AM
19	Pellets PM 7-24-2013 A	497	3.1	487	24	10:06:47 AM
20	Pellets PM 7-24-2013 B	855	2.4	655	29	10:08:55 AM
21	Green Balls PM 7-24-2013 A	646	19	3880	209	10:11:22 AM
22	Green Balls PM 7-24-2013 B	1206	25	9680	510	10:13:31 AM
23	Fine Tailings PM 7-24-2013 A	676	42	9120	543	10:26:11 AM
24	Fine Tailings PM 7-24-2013 B	522	43	7170	481	10:28:23 AM
25	Conc Thick Overflow W PM 7-24-2013 A	458	816	118000	7420	10:31:06 AM
26	Conc Thick Overflow W PM 7-24-2013 B	515	824	134000	8750	10:34:29 AM
27	Green Balls AM 7-25-2013 A	637	20	4110	275	10:52:40 AM
28	Green Balls AM 7-25-2013 B	716	16	3640	219	10:54:49 AM
29	Fine Tailings AM 7-25-2013 A	885	41	11600	627	10:57:09 AM
30	Fine Tailings AM 7-25-2013 B	867	41	11300	596	11:00:00 AM
31	Conc Thick Overflow W AM 7-25-2013 A	701	290	64300	4420	11:10:33 AM
32	Conc Thick Overflow W AM 7-25-2013 B	507	285	45700	3010	11:13:15 AM
33	Pellets AM 7-25-2013 A	1163	0.7	273	10	11:15:27 AM
34	Pellets AM 7-25-2013 B	923	0.5	141	8	11:16:58 AM
35	Multiclone AM 7-25-2013 A	689	667	145000	8680	12:19:02 PM
36	Multiclone AM 7-25-2013 B	932	666	196000	10300	12:22:10 PM
37	Pellets PM 7-25-2013 A	1033	0.3	111	7	12:24:13 PM
38	Pellets PM 7-25-2013 B	741	0.9	215	7	12:30:03 PM
39	Green Balls PM 7-25-2013 A	917	16	4810	266	12:40:58 PM
40	Green Balls PM 7-25-2013 B	862	14	4030	211	12:44:24 PM
41	Conc Thick Overflow W PM 7-25-2013 A	622	708	139000	8260	12:47:00 PM
42	Conc Thick Overflow W PM 7-25-2013 B	424	696	93200	5840	12:49:38 PM
43	Multiclone PM 7-25-2013 A	698	177	39000	2750	1:01:05 PM
44	Multiclone PM 7-25-2013 B	705	173	38600	2490	1:03:24 PM

45	Fine Tailings PM 7-25-2013 A	537	54	9270	576	1:05:59 PM
46	Fine Tailings PM 7-25-2013 B	1011	33	10800	566	1:08:28 PM
47	Std__1000, RL = 9%	100	1090	34400	3770	1:13:54 PM
No	Description: 7/27/13	M, mg	C, ng/g	Area	Maximum	Time
1	Std__100, RL = 1%	50	101	1770	184	9:35:50 PM
2	Std__100, RL = -1%	100	99	3480	428	9:37:55 PM
3	Std__1000, RL = 0%	50	1000	17500	2060	9:40:56 PM
4	GB-207-1	1497	11	6000	331	10:06:47 PM
5	GB-207-2	1217	13	5650	357	10:08:58 PM
6	GB-208-1	1371	13	6430	368	10:12:10 PM
7	GB-208-2	1683	19	11200	544	10:15:32 PM
8	GB-209-1	1563	18	9900	672	10:28:14 PM
9	GB-209-2	1656	15	8960	512	10:31:12 PM
10	GB-210-1	1442	14	7530	443	10:33:56 PM
11	GB-210-2	1216	13	5900	335	10:37:05 PM
12	GB-212-1	977	13	4770	246	10:53:59 PM
13	GB-212-2	1253	53	23400	2340	10:56:58 PM
14	GB-211-1	1537	14	7710	459	10:59:35 PM
15	GB-211-2	1277	14	6310	387	11:02:47 PM
16	GB-213-1	1786	11	7160	394	11:09:13 PM
17	GB-213-2	791	13	3740	206	11:11:57 PM
18	GB-214-1	1399	11	5580	302	11:14:55 PM
19	GB-214-2	1383	10	5250	291	11:18:38 PM
No	Description: 7/28/13	M, mg	C, ng/g	Area	Maximum	Time
1	Std__5, RL = 8%, RL = 8%	1	5.4	1800	156	9:59:54 AM
2	Std__50, RL = 10%	1	55	18400	1590	10:01:42 AM
3	Std__500, RL = 5%, RL = 5%	1	526	175000	19300	10:03:57 AM
4	Std__1000, RL = -1%, RL = -1%	1	986	328000	32300	10:06:34 AM
5	Std__50, RL = 2%	1	51	17200	1660	10:12:16 AM
	Std__1000 SS, RL = -1%	1	989	329000	30500	10:14:26 AM
1	OL 171676 Sec 1 Plug	1	45	15100	811	10:20:09 AM
2	OL 171676 Sec 1	1	622	207000	16400	10:22:16 AM
3	OL 171676 Sec 2 and Plug	1	17	5790	235	10:24:31 AM
4	OL 172483 Sec 1 Plug	1	53	17900	1040	10:28:03 AM
5	OL 172483 Sec 1	1	613	204000	25600	10:30:10 AM
6	OL 172483 Sec 2 and Plug	1	19	6600	350	10:32:02 AM
7	OL 171588 Sec 1 Plug	1	101	33900	3030	10:35:58 AM
8	OL 171588 Sec 1	1	17	5840	569	10:38:17 AM

9	OL 171588 Sec 2 and Plug	1	7.1	2360	135	10:40:56 AM
10	OL 171710 Sec 1 Plug	1	118	39400	3070	10:44:38 AM
11	OL 171710 Sec 1	1	11	3930	411	10:46:57 AM
12	OL 171710 Sec 2 and Plug	1	3.9	1280	76	10:48:59 AM
13	OL 171621 Sec 1 Plug	1	27	9160	441	10:52:39 AM
14	OL 171621 Sec 1	1	48	16200	1580	10:55:30 AM
15	OL 171621 Sec 2 and Plug	1	4.8	1580	103	10:57:12 AM
16	OL 171707 Sec 1 Plug	1	24	8180	525	10:59:39 AM
17	OL 171707 Sec 1	1	48	16200	1760	11:01:20 AM
18	OL 171707 Sec 2 and Plug	1	4.3	1430	129	11:02:58 AM
19	Std__650 Chk, RL = 4%	1	676	225000	23300	11:07:46 AM

No	Description: 8/2/13	M, mg	C, ng/g	Area	Maximum	Time
1	Std__10, RL = -1%	1	9.8	3390	378	8:45:16 AM
2	Std__100, RL = -1%	1	99	34600	3550	8:48:51 AM
3	Std__50, RL = -2%	1	49	17000	1980	8:57:10 AM
4	Std__250, RL = 0%	1	251	87100	10800	9:01:42 AM
5	Std__500, RL = 0%	1	499	173000	19000	9:06:26 AM
6	Std__250 SS, RL = -2%	1	245	85100	10800	9:12:38 AM
7	171685 S1	1	10	3800	585	9:21:07 AM
8	171685 P1	1	95	33200	2650	9:24:29 AM
9	171685 S2 P2	1	3.7	1270	54	9:31:19 AM
10	173001 S1	1	12	4380	668	9:37:34 AM
11	173001 P1	1	92	32100	2140	9:40:28 AM
12	173001 S2 P2	1	4.5	1550	85	9:45:03 AM
13	172111 S1	1	30	10500	1560	9:51:41 AM
14	172111 P1	1	21	7390	425	9:54:17 AM
15	172111 S2 P2	1	2.7	947	61	9:59:34 AM
16	Std__100, RL = -2%	1	98	34000	3740	10:04:46 AM
17	172235 S1	1	29	10200	1470	10:14:57 AM
18	172235 P1	1	20	7050	442	10:17:32 AM
19	172235 S2 P2	1	2.8	986	74	10:21:49 AM
20	172241 S1	1	450	156000	20100	10:30:25 AM
21	172241 P1	1	35	12200	1250	10:34:40 AM
22	172241 S2 P2	1	14	5190	477	10:39:20 AM
23	172495 S1	1	453	157000	21100	10:44:46 AM
24	172495 P1	1	54	18800	1180	10:48:50 AM
25	172495 S2 P2	1	14	5170	460	10:52:47 AM
26	Std__100	1	96	33500	3510	10:57:56 AM

No	Description: 8/4/13	M, mg	C, ng/g	Area	Maximum	Time
1	Std__10, RL = 0%	1	10	3400	402	1:26:06 PM
2	Std__100, RL = -1%	1	99	33500	3800	1:29:23 PM
3	Std__50, RL = -2%	1	49	16800	1840	1:34:19 PM
4	Std__500, RL = 0%	1	497	168000	17800	1:38:06 PM
5	Std__250, RL = 2%	1	257	87000	10400	1:44:23 PM
6	Std__SS 250	1	248	83900	10300	1:49:09 PM
7	K 173016 s1	1	192	65000	8340	1:56:01 PM
8	K 173016 P1	1	13	4600	261	1:58:03 PM
9	K 173016 S2 P2	1	0.2	67	8	2:01:31 PM
10	K 172496 S1	1	199	67300	8930	2:32:37 PM
11	K 172496 P1	1	8.9	3000	186	2:35:57 PM
12	K 172496 S2 P2	1	0.3	92	7	2:39:35 PM
13	K 171717 S1	1	180	60900	7770	2:46:01 PM
14	K 171717 P1	1	7.6	2560	157	2:51:21 PM
15	K 171717 S2 P2	1	0.3	102	9	2:54:58 PM
16	K 172231 S1	1	181	61400	8680	2:59:22 PM
17	Std__100	1	101	34400	3470	3:04:58 PM
18	K 172231 P1	1	9.9	3350	191	3:10:54 PM
19	K172231 S2 P2	1	0.3	89	9	3:14:39 PM
20	172217 S1	1	11	3820	504	3:18:55 PM
21	172217 P1	1	107	36400	2360	3:22:38 PM
22	172217 S2 P2	1	4.8	1630	99	3:27:25 PM
23	171693 S1	1	22	7590	989	3:33:36 PM
24	171693 P1	1	69	23500	1400	3:36:00 PM
25	171693 S2 P2	1	5.4	1810	86	3:39:49 PM
26	171684 S1	1	20	6930	1000	3:46:22 PM
27	171684 P1	1	71	24100	1730	3:48:51 PM
28	Std__100	1	102	34500	3690	3:53:15 PM
29	171684 S2 P2	1	5.9	2000	85	4:01:28 PM
30	171686 S1	1	586	198000	27300	4:07:24 PM
31	171686 P1	1	68	23300	1300	4:13:07 PM
32	171686 S2 P2	1	4.9	1670	134	4:17:44 PM
33	173009 S1	1	589	199000	23700	4:22:20 PM
34	173009 P1	1	85	29000	1450	4:25:42 PM
35	173009 S2 P2	1	4.1	1380	98	4:29:50 PM
36	Std__1000, RL = -8%	1	911	308000	36900	4:34:02 PM
No	Description: 8/7/13	M, mg	C, ng/g	Area	Maximum	Time
1	Std__100, RL = -4%	50	96	1600	180	5:44:13 PM

2	Std__100, RL = -4%	100	96	3200	369	5:46:46 PM
3	Std__1000	50	1000	16800	1800	5:49:31 PM
4	Std__1000, RL = 0%	50	1000	16600	1560	5:54:35 PM
	GB 8-2	970	11	3620	197	6:22:31 PM
1	GB 8-2	1338	13	5910	257	6:25:33 PM
2	GB 8-5	727	13	3350	166	6:27:56 PM
3	GB 8-5	678	11	2620	123	6:30:18 PM
4	GB 8-6	1102	35	12800	796	6:48:19 PM
5	GB 8-6	1096	9.1	3300	134	6:51:10 PM
6	GB 8-7	863	9.2	2630	102	6:53:35 PM
7	GB 8-7	1104	9.7	3530	127	6:56:34 PM
8	GB-SS 317	562	13	2570	110	7:04:38 PM
9	GB-SS 317	761	12	3050	141	7:07:08 PM
10	Std__100, RL = -3%	100	97	3230	214	7:10:00 PM
11	GB-SS 322	793	13	3640	161	7:28:01 PM
12	GB-SS 322	439	13	1910	91	7:30:28 PM
13	GB-SS 320	1120	0.5	203	8	7:32:24 PM
14	GB-SS 320	1702	0.4	211	8	7:34:32 PM
15	P-SS 325	1179	0.9	357	10	7:46:00 PM
16	P-SS 325	599	1.0	193	9	7:47:59 PM
17	FT-SS 323	888	36	10800	405	7:50:56 PM
18	FT-SS 323	388	38	4960	193	7:53:25 PM
19	FT-SS 318	355	33	3920	159	8:01:22 PM
20	FT-SS 318	840	40	11200	429	8:04:35 PM
21	Std__100, RL = -5%	100	95	3160	261	8:07:06 PM
No	Description: 8/8/13	M, mg	C, ng/g	Area	Maximum	Time
1	Std__10, RL = 0%	1	10.0	3310	344	2:00:24 PM
2	Std__100, RL = 0%	1	100	33500	3480	2:03:39 PM
3	Std__50, RL = 0%	1	50	16800	1620	2:07:04 PM
4	Std__500, RL = 0%	1	496	165000	15700	2:10:33 PM
5	Std__250, RL = 2%	1	255	84800	8940	2:14:56 PM
6	Std__250 SS, RL = 0%	1	250	83300	9160	2:18:34 PM
7	184732 s1	1	6.7	2210	322	2:25:22 PM
8	184732 p1	1	86	28900	2190	2:28:42 PM
9	184732 s2 p2	1	3.7	1230	70	2:33:45 PM
10	184920 s1	1	8.0	2670	384	2:38:44 PM
11	184920 p1	1	85	28300	2570	2:42:17 PM
12	184920 s2 p2	1	4.2	1410	59	2:46:10 PM
13	184627 s1	1	35	11800	1500	2:50:06 PM

14	184627 p1	1	28	9450	693	2:52:44 PM
15	184627 s2 p2	1	3.9	1280	84	2:56:07 PM
16	184853 s1	1	35	11700	1330	3:00:19 PM
17	Std__100	1	102	34200	3360	3:36:12 PM
18	184853 p1	1	27	9150	610	3:46:51 PM
19	184853 s2 p2	1	4.4	1460	61	3:50:24 PM
20	171585 s1	1	44	14800	1910	4:09:31 PM
21	171585 p1	1	25	8590	939	4:12:01 PM
22	171585 s2 p2	1	3.8	1270	82	4:16:25 PM
23	172500 s1	1	36	12000	1860	4:19:35 PM
24	172500 p1	1	33	11200	1040	4:22:31 PM
25	172500 s2 p2	1	3.0	1010	43	4:25:20 PM
26	184614 s1	1	29	9820	1310	4:29:36 PM
27	184614 p1	1	25	8360	638	4:31:10 PM
28	Std__100	1	104	34700	3130	4:34:42 PM
29	184614 s2 p2	1	2.6	874	42	4:40:19 PM
30	184821 s1	1	28	9550	1340	4:43:32 PM
31	184821 p1	1	23	7940	665	4:45:37 PM
32	184821 s2 p2	1	2.7	904	39	4:48:31 PM
33	171678 s1	1	9.3	3090	424	4:53:49 PM
34	171678 p2	1	102	34100	3160	4:56:22 PM
35	171678 s2 p2	1	4.2	1410	63	5:00:37 PM
36	172218 s1	1	7.7	2550	286	5:03:47 PM
37	172218 p1	1	98	32600	3300	5:05:42 PM
38	172218 s2 p2	1	4.5	1490	60	5:08:29 PM
39	Std__100	1	101	33800	3950	5:14:47 PM
40	184646 s1	1	385	128000	17100	5:21:37 PM
41	184646 p1	1	59	19800	1990	5:25:26 PM
42	184646 s2 p2	1	13	4510	296	5:30:08 PM
43	184871 s1	1	409	136000	17100	5:34:58 PM
44	184871 p1	1	73	24300	1990	5:40:02 PM
45	184871 s2 p2	1	11	3890	290	5:43:50 PM
46	Std__100	1	102	34000	3130	5:47:32 PM
1	Std__100, RL = -3%	100	97	3340	342	5:57:10 PM
2	Std__100, RL = -2%	50	98	1680	175	5:59:36 PM
3	Std__1000, RL = 0%	50	1000	17100	2010	6:01:55 PM
4	8-6 1	1140	10	4030	205	6:09:37 PM
5	8-6 2	518	10	1800	97	6:13:59 PM
6	ss319 1	574	592	116000	8040	6:17:53 PM
7	ss319 2	336	583	66900	4740	6:21:08 PM

8	ss325 1	307	372	39000	2800	6:25:28 PM
9	ss325 2	394	371	50000	3420	6:29:03 PM
10	ss327 1	460	726	114000	8490	6:32:57 PM
11	ss327 2	277	741	70100	5900	6:37:17 PM
12	ss326 1	301	452	46500	3820	6:41:49 PM
13	ss326 2	511	454	79300	5000	6:47:16 PM
14	ss321 1	444	131	19900	1380	6:49:46 PM
15	ss321 2	393	129	17400	1140	6:53:10 PM
16	bad 1000	100	943	32200	3110	6:56:59 PM
17	Std__1000	100	978	33400	3570	6:59:41 PM

9.0 APPENDIX D - MM30B DATA

Table 8 shows the average Hg-CEMS data at the stack and the results of the comparison to corresponding MM30B data.

This comparison was done with one significant exception to the QA/QC procedure described in Section 4.3.1. The RA/AMD procedure assumes that there is no significant particulate mercury (HgP) in the stack gas. However, ADA discovered that with ACI operating at Minorca, HgP was a significant portion of the total mercury. This was determined by analyzing the first glass wool section of the sorbent trap, which is assumed to contain all of the particulate, separately from the other two sorbent sections. This allowed ADA to calculate a value for MM30B gas phase mercury (HgG=HgT-HgP) which was then used to perform the RA/AMD calculations. It is important to note that Hg-CEMS can only measure HgG. As Figure 27 shows, the MM30B HgG compared well with Hg-CEMS but the MM30B HgT did not.

Also, the gas moisture at the Hood Exhaust was 6.1% and at the Windbox Exhaust was 8.5%. The moisture at stacks A, B, C, and D was 11.5%, 12.2%, 13.6%, and 14.9% respectively based on stack measurements by Barr during testing.

Table 8. MM30B Data and RD, RA, AMD Calculations

Run	Sampling location	Trap ID	Date	Start Time	End Time	Flow Rate cc/min	DGMi L	DGMf L	Volume L actual	Initial Leak Test Pass/Fail	Final Leak Test Pass/Fail	DGM L (STP)	M Plug 1 ONLY ng	M Sect 1 ONLY ng	M Plug 2 and Sect 2 ng	H_2O %	STM (dry) µg/dscm	STM µg/wscm	Total STM Avg µg/wscm	Gas Phase STM Hg µg/wscm	Gas Phase STM Avg Hg	Particulate STM Hg µg/wscm	Particulate STM Hg Avg	RD %	Pass/Fail	CEM Avg µg/wscm	RA %	AMD µg/wscm	Pass/Fail
1	Stack B, STM 1064	173279	6/21/13	11:52	12:52	600	14538.2	14574.4	36.2	PASS	PASS	32.697		102	5.7	12.2	3.29	2.89	3.32		2.87		0.45	0.93	PASS				
		173291					12597.8	12633.0	35.2	PASS	PASS	31.886		99	4.1	12.2	3.23	2.84											
2	Stack C, STM 1064	172422	6/21/13	10:15	11:15	600	12561.9	12597.5	35.6	PASS	PASS	32.434		124	6.3	13.6	4.02	3.47	3.64					4.69	PASS	5.39	48.00	1.75	FAIL
		172107					14501.1	14538.0	36.9	PASS	PASS	33.29		140	6.9	13.6	4.41	3.81											
3	Duct A, STM 1062	172108	6/21/13	10:22	11:22	600	8219.2	8252.9	33.7	PASS	PASS	31.212		78	0.6	6.1	2.52	2.36	2.40					1.64	PASS				
		168921					110259.7	110293.0	33.3	PASS	PASS	29.742		77	0.4	6.1	2.60	2.44											
4	Duct C, STM 1062	173268	6/22/13	13:25	14:25	600	110352.0	110387.1	35.1	PASS	PASS	31.311	4.3	478	3.5	8.5	15.52	14.20	13.08	14.07	12.93	0.13	0.15	8.52	PASS				
		172122					8326.7	8365.0	38.3	PASS	PASS	35.155	6.5	451	2.3	8.5	13.08	11.97		11.80		0.17							
5	Duct A, STM 1062	172458	6/22/13	11:22	12:22	600	110314.3	110348.0	33.7	PASS	PASS	29.893	6.1	116	1.2	6.1	4.12	3.87	3.86	3.68	3.69	0.19	0.17	0.33	PASS				
		172474					8286.2	8323.1	36.9	PASS	PASS	33.703	5.1	132	1.0	6.1	4.10	3.85		3.71		0.14							
6	Stack D STM 1064	172358	6/22/13	08:21	09:21	600	14581.2	14616.0	34.8	PASS	PASS	32.823	120	222	10.0	14.9	10.72	9.13	9.62	6.02	5.90	3.11	3.72	5.14	PASS	8.41	42.65	2.51	FAIL
		172485					12641.2	12675.4	34.2	PASS	PASS	32.561	166	207	14.0	14.9	11.89	10.11		5.78		4.34							
7	Stack D, STM 1064	172276	6/22/13	09:52	10:52	600	14616.4	14650.6	34.2	PASS	PASS	31.271	217	243	10.0	14.9	15.03	12.79	12.60	6.89	8.63	5.91	3.97	1.52	PASS	8.73	1.21	0.10	PASS
		173282					12675.6	12709.4	33.8	PASS	PASS	30.865	74	361	15.0	14.9	14.58	12.41		10.37		2.04							
8	Stack A, STM 1064	173272	6/22/13	13:42	14:42	600	14690.0	14726.0	36.0	PASS	PASS	33.12	22	120	7.3	11.5	4.51	3.99	4.07	3.40	3.51	0.59	0.57	2.06	PASS	2.97	15.30	0.54	PASS
		173281					12749.0	12783.8	34.8	PASS	PASS	32.442	20	125	7.4	11.5	4.70	4.16		3.61		0.55							
9	Inlet MM30B Port, STM 1064	173273	6/22/13	17:14	18:14	600	14768.4	14804.9	36.5	PASS	PASS	32.708	38	633	7.9	8.5	20.76	18.99	19.52	17.93	18.38	1.06	1.14	2.70	PASS				
		173296					12825.0	12860.1	35.1	PASS	PASS	31.615	42	644	6.6	8.5	21.91	20.05		18.83		1.22							
10	Duct B, STM 1062	173262	6/22/13	16:47	17:47	600	110422.5	110454.8	32.3	PASS	PASS	31.669	0.7	167.0	0.3	8.5	5.30	4.85	4.90	4.83	4.88	0.02	0.02	0.99	PASS				
		173265					8403.8	8438.6	34.8	PASS	PASS	35.538	0.9	191.0	0.4	8.5	5.41	4.95		4.93		0.02							
11	Duct D, STM 1062	172205	6/22/13	15:06	16:06	600	110388.1	110422.3	34.2	PASS	PASS	29.986	80	686.0	3.4	8.5	25.66	23.48	23.47	21.04	21.18	2.44	2.29	0.03	PASS				
		172341					8366.3	8403.3	37.0	PASS	PASS	33.749	79	781.0	5.4	8.5	25.64	23.46		21.32		2.14							
12	Stack A, STM 1064	173255	6/23/13	10:28	11:28	600	14809.0	14846.2	37.2	PASS	PASS	36.236	5.7	82.0	3.5	11.5	2.52	2.23	2.50	2.09	2.40	0.14	0.10	10.98	FAIL	2.65	10.54	0.25	PASS
		173288					12864.5	12900.6	36.1	PASS	PASS	33.464	2.6	98.0	4.4	11.5	3.14	2.78		2.71		0.07							
13	Stack B, STM 1062	173267	6/23/13	13:13	14:13	600	110512.6	110549.2	36.6	PASS	PASS	33.256	15	115.0	5.2	12.2	4.07	3.57	3.60	3.17	3.18	0.40	0.42	0.86	PASS	3.58	12.58	0.40	PASS
		173274					8482.3	8518.2	35.9	PASS	PASS	33.558	17	116.0	5.8	12.2	4.14	3.63		3.19		0.44							
14	Stack C, STM 1062	173259	6/23/13	11:40	12:40	600	110473.4	110508.8	35.4	PASS	PASS	31.86	36	205	7.1	13.6	7.79	6.73	6.74	5.75	5.85	0.98	0.89	0.16	PASS				
		173261					8444.5	8479.0	34.5	PASS	PASS	32.374	30	215	7.9	13.6	7.81	6.75		5.95		0.80							
15	Inlet. 30B Port, STM 1062	173257	7/10/13	16:40	17:40	600	110553.2	110588.5	35.3	PASS	PASS	31.309	33	460	10.0	8.5	16.07	14.70	14.64	13.74	13.68	0.96	0.95	0.44	PASS				
		173275					8521.8	8558.9	37.1	PASS	PASS	34.034	35	494	13.0	8.5	15.93	14.57		13.63		0.94							
16	Stack A, STM 1064	173271	7/11/13	15:21	16:21	600	14850.5	14887.6	37.1	PASS	PASS	33.596	20	82	4.5	11.5	3.17	2.81	2.86	2.28	2.27	0.53	0.59	1.84	PASS	3.03	33.48	0.76	PASS
		173300					12905.0	12940.9	35.9	PASS	PASS	32.718	24	79	4.6	11.5	3.29	2.91		2.26		0.65							
17	Stack D, STM 1064	173276	7/11/13	18:06	19:06	600	14887.9	14925.4	37.5	PASS	PASS	33.513	158	7.5	6.1	14.9	5.12	4.36	4.38	0.35	0.39	4.01	3.98	0.43	PASS	0.55	40.43	0.16	PASS
		173284					12941.2	12977.1	35.9	PASS	PASS	32.255	150	8.6	8.0	14.9	5.17	4.40		0.44		3.96							
18	Stack D, STM 1064	165482	7/13/13	9:48	10:48	600	14927.6	14963.8	36.2	PASS	PASS	33.06	131	9.1	8.4	14.9	4.49	3.82	3.89	0.45	0.44	3.37	3.45	1.71	PASS	0.70	59.96	0.26	PASS
		165484					12979.4	13014.5	35.1	PASS	PASS	32.055	133	8.6	7.4	14.9	4.65	3.96		0.42		3.53							
19	Stack B, STM 1064	165385	7/13/13	11:16	12:16	600	14964.5	15002.0	37.5	PASS	PASS	33.92	40	38	4.7	12.2	2.44	2.14	2.16	1.11	1.07	1.04	1.10	1.08	PASS	1.41	31.95	0.34	PASS
		165726					13015.0	13051.4	36.4	PASS	PASS	32.675	43	34	4.4	12.2	2.49	2.19		1.03		1.16							
20	Inlet. 30B Port, STM 1062	165245	7/14/13	09:57	10:57	600	110589.0	110625.0	36.0	PASS	PASS	31.736	42	613	12.0	8.5	21.02	19.23	19.65	18.02	18.44	1.21	1.21	2.12	PASS				
		165389					8562.8	8599.0	36.2	PASS	PASS	34.204	45	688	17.0	8.5	21.93	20.06		18.86		1.20							
21	Stack D, STM 1064	173258	7/16/13	9:27	10:27	600	15005.0	15041.2	36.2	PASS	PASS	33.629	161	7.9	8.0	14.9	5.26	4.48	4.58	0.40	0.40	4.07	4.17	2.21	PASS	0.74	82.94	0.34	PASS
		173292					13054.9	13090.5	35.6	PASS	PASS	33.065	166	7.5	8.3	14.9	5.50	4.68		0.41		4.27							
22	Stack C, STM 1062	171696	7/16/13	10:55	11:55	600	15041.8	15078.8	37.0	PASS	PASS	33.816	112	19	7.6	13.6	4.10	3.54	3.52	0.68	0.67	2.86	2.85	0.48	PASS	1.05	56.68	0.38	PASS
		171706					13090.8	13126.8	36.0	PASS	PASS	33.085	109	18	7.3	13.6	4.06	3.51		0.66		2.85							
23	Inlet. 30B Port, STM 1062	171680	7/17/13	07:39	08:39	600	110625.8	110661.8	36.0	PASS	PASS	31.701	25	648.0	17.0	8.5	21.77	19.92	19.59	19.19	18.66	0.72	0.93	1.66	PASS				
		173264					8602.4	8640.0	37.6	PASS	PASS	34.624	43	663.0	23.0	8.5	21.05	19.27		18.13		1.14							
24	Stack A, STM 1064	171708	7/18/13	14:50	15:50	600	15082.7	15119.0	36.3	PASS	PASS	32.471	24	45.0	3.6	11.5	2.24	1.98	1.99	1.32	1.32	0.65	0.66	0.32	PASS	1.80	36.17	0.48	PASS
		172004					13130.7	13166.1	35.4	PASS	PASS	31.597	24	43.0	4.1	11.5	2.25	1.99		1.32		0.67							

ArcelorMittal
Minorca Mine
ACI Test

Run	Sampling location	Trap ID	Date	Start Time	End Time	Flow Rate cc/min	DGMi L	DGMf L	Volume L actual	Initial Leak Test Pass/Fail	Final Leak Test Pass/Fail	DGM L (STP)	M Plug 1 ONLY ng	M Sect 1 ONLY ng	M Plug 2 and Sect 2 ng	H_2O %	STM (dry) µg/dscm	STM µg/wscm	Total STM Avg µg/wscm	Gas Phase STM Hg µg/wscm	Gas Phase STM Avg Hg	Particulate STM Hg µg/wscm	Particulate STM Hg Avg	RD %	Pass/Fail	CEM Avg µg/wscm	RA %	AMD µg/wscm	Pass/Fail
25	Stack D, STM 1064	172187	7/18/13	16:20	17:20	600	15123.0	15160.1	37.1	PASS	PASS	32.66	121	5.7	4.8	14.9	4.03	3.43	3.41	0.27	0.31	3.15	3.10	0.48	PASS	0.66	113.18	0.35	PASS
		172200					13169.7	13205.1	35.4	PASS	PASS	31.271	112	6.8	5.9	14.9	3.99	3.39		0.35		3.05							
26	Inlet. 30B Port, STM 1062	171596	7/21/13	10:38	11:38	600	110662.4	110697.6	35.2	PASS	PASS	31.657	32	525.0	13.0	8.5	18.01	16.48	16.48	15.55	15.55	0.92	0.93	0.03	PASS				
		172073					8642.9	8677.7	34.8	PASS	PASS	32.417	33	540.0	11.0	8.5	18.02	16.48		15.55		0.93							
27	Stack B, STM 1064	171590	7/21/13	11:09	12:09	600	15164.1	15198.5	34.4	PASS	PASS	32.036	32	29.0	3.2	12.2	2.00	1.76	1.77	0.88	0.90	0.88	0.87	0.76	PASS	1.05	16.43	0.15	PASS
		172237					13208.6	13242.2	33.6	PASS	PASS	31.456	31	30.0	3.0	12.2	2.03	1.79		0.92		0.87							
28	Stack D, STM 1064	171682	7/21/13	12:55	13:55	600	15202.6	15238.4	35.8	PASS	PASS	32.137	115	7.5	6.0	14.9	4.00	3.40	3.43	0.36	0.35	3.05	3.08	0.83	PASS	0.71	103.12	0.36	PASS
		171683					13245.7	13280.6	34.9	PASS	PASS	31.388	115	6.8	5.8	14.9	4.07	3.46		0.34		3.12							
29	Inlet. 30B Port, STM 1062	171689	7/24/13	12:08	13:08	600	110702.2	110737.7	35.5	PASS	PASS	31.779	48	595	17.0	8.5	20.77	19.00	18.96	17.62	17.45	1.38	1.51	0.24	PASS				
		172182					8682.3	8717.9	35.6	PASS	PASS	32.995	59	604	19.0	8.5	20.67	18.91		17.28		1.64							
30	Stack D, STM 1064	171679	7/24/13	12:37	13:37	600	15241.5	15277.9	36.4	PASS	PASS	32.689	134	9.9	6.7	14.9	4.61	3.92	3.96	0.43	0.44	3.49	3.52	0.95	PASS	0.95	115.84	0.51	PASS
		173013					13284.1	13319.4	35.3	PASS	PASS	31.904	133	10	6.8	14.9	4.70	4.00		0.45		3.55							
31	Stack C, STM 1062	171698	7/24/13	14:08	15:08	600	15281.5	15318.5	37.0	PASS	PASS	33.394	103	24	5.4	13.6	3.96	3.43	3.42	0.76	0.82	2.66	2.60	0.19	PASS	1.72	109.19	0.90	PASS
		172080					13323.0	13358.7	35.7	PASS	PASS	32.456	95	26	7.2	13.6	3.95	3.41		0.88		2.53							
32	Inlet. 30B Port, STM 1062	171676	7/27/13	9:10	10:10	600	110738.0	110774.8	36.8	PASS	PASS	34.172	45	622	17.0	8.5	20.02	18.31	18.35	17.11	17.04	1.20	1.31	0.19	PASS				
		172483					8721.1	8757.0	35.9	PASS	PASS	34.092	53	613	19.0	8.5	20.09	18.38		16.96		1.42							
33	Stack D, STM 1064	171588	7/27/13	09:37	10:37	600	15324.5	15358.6	34.1	PASS	PASS	32.683	101	17	7.1	14.9	3.83	3.26	3.41	0.63	0.51	2.63	2.90	4.46	PASS	0.90	75.30	0.39	PASS
		171710					13364.6	13397.4	32.8	PASS	PASS	31.757	118	11	3.9	14.9	4.18	3.56		0.40		3.16							
34	Stack A, STM 1064	171621	7/27/13	11:03	12:03	600				PASS	PASS	34.033	27	48	4.8	11.5	2.34	2.08	2.04	1.37	1.38	0.70	0.67	1.52	PASS	1.82	32.23	0.44	PASS
		171707								PASS	PASS	33.546	24	48	4.3	11.5	2.27	2.01		1.38		0.63							
35	Stack B, STM 1064	172111	7/30/13	14:20	15:20	600	15404.2	15442.2	38.0	PASS	PASS	34.239	21	30	2.7	12.2	1.57	1.38	1.36	0.84	0.83	0.54	0.53	0.91	PASS	1.01	21.06	0.18	PASS
		172235					13442.2	13479.2	37.0	PASS	PASS	33.634	20	29	2.8	12.2	1.54	1.35		0.83		0.52							
36	Inlet. 30B Port, STM 1062	172241	7/30/13	14:43	15:43	600	110776.8	110811.8	35.0	PASS	PASS	31.321	35	450	14.0	8.5	15.93	14.58	14.63	13.56	13.36	1.02	1.27	0.35	PASS				
		172495					8760.6	8795.6	35.0	PASS	PASS	32.474	54	453	14.0	8.5	16.04	14.68		13.16		1.52							
37	Stack D, STM 1064	171685	7/31/13	12:11	13:11	600	15445.2	15480.6	35.4	PASS	PASS	32.64	95	10	3.7	14.9	3.33	2.83	2.86	0.36	0.40	2.48	2.46	1.00	PASS	0.71	78.19	0.31	PASS
		173001					13482.1	13516.7	34.6	PASS	PASS	31.934	92	12	4.5	14.9	3.40	2.89		0.44		2.45							
38	Stack D, STM 1064	172217	8/2/13	17:27	18:27	600	15485.3	15523.8	38.5	PASS	PASS	34.288	107	11	4.8	14.9	3.58	3.05	3.05	0.39	0.39	2.66	2.66			0.71	81.06	0.32	PASS
																14.9													
39	Stack C, STM 1062	171684	8/2/13	18:42	19:42	600	15526.4	15565.6	39.2	PASS	PASS	34.539	71	20	5.9	13.6	2.81	2.42	2.45	0.65	0.68	1.78	1.77	1.05	PASS	1.42	110.14	0.74	PASS
		171693					13528.8	13560.5	31.7	PASS	PASS	33.648	69	22	5.4	13.6	2.86	2.48		0.70		1.77							
40	Inlet. 30B Port, STM 1062	171686	8/4/13	14:10	15:10	600	110966.3	111004.9	38.6	PASS	PASS	34.755	68	586	4.9	8.5	18.96	17.35	17.51	15.56	15.51	1.79	2.00	0.94	PASS				
		173009					8945.5	8982.9	37.4	PASS	PASS	35.1	85	589	4.1	8.5	19.32	17.68		15.46		2.22							
41	Stack A, STM 1064	171585	8/5/13	12:57	13:57	600	15568.7	15603.2	34.5	PASS	PASS	32.173	25	44	3.8	11.5	2.26	2.00	2.01	1.31	1.21	0.69	0.81	0.58	PASS				
		172500					13569.0	13602.8	33.8	PASS	PASS	31.45	33	36	3.0	11.5	2.29	2.03		1.10		0.93							
42	Stack D, STM 1064	171678	8/5/13	14:39	15:39	600	15607.0	15642.8	35.8	PASS	PASS	32.681	102	9.3	4.2	14.9	3.53	3.01	2.98	0.35	0.34	2.66	2.64	1.05	PASS	0.80	136.13	0.46	PASS
		172218					13606.4	13641.2	34.8	PASS	PASS	31.842	98	7.7	4.5	14.9	3.46	2.95		0.33		2.62							
43	Stack B, STM 1064	184614	8/7/13	15:56	16:56	600	15646.2	15681.2	35.0	PASS	PASS	32.583	25	29	2.6	12.2	1.74	1.53	1.50	0.85	0.85	0.67	0.65	1.83	PASS	0.91	7.56	0.06	PASS
		184821					13644.8	13679.1	34.3	PASS	PASS	32.069	23	28	2.7	12.2	1.67	1.47		0.84		0.63							
44	Inlet. 30B Port, STM 1062	184646	8/7/13	16:30	17:30	600	111008.8	111044.9	36.1	PASS	PASS	31.815	59	385	13.0	8.5	14.36	13.14	13.21	11.45	11.38	1.70	1.83	0.53	PASS				
		184871					8988.6	9025.6	37.0	PASS	PASS	33.957	73	409	11.0	8.5	14.52	13.28		11.32		1.97							
45	Stack B, STM 1064	184627	8/8/13	8:32	09:32	600	15685.1	15719.5	34.4	PASS	PASS	32.399	28	35	3.9	12.2	2.06	1.81	1.82	1.05	1.07	0.76	0.75	0.50	PASS	0.65	39.27	0.42	PASS
		184853					13682.2	13716.2	34.0	PASS	PASS	31.836	27	35	4.4	12.2	2.09	1.83		1.09		0.74							
46	Stack D, STM 1064	184732	8/8/13	10:04	11:04	600	15723.1	15758.0	34.9	PASS	PASS	32.167	86	6.7	3.7	14.9	3.00	2.55	2.59	0.28	0.30	2.28	2.29	1.68	PASS	0.68	124.35	0.38	PASS
		184920					13719.7	13753.4	33.7	PASS	PASS	31.361	85	8	4.2	14.9	3.10	2.64		0.33		2.31							

Attachment B

MPCA Phase II ACI Testing Review

Phase II ACI Testing Review (DRAFT)

Hongming Jiang and Marc Severin
Minnesota Pollution Control Agency
November 21, 2014

Summary

The Minnesota Pollution Control Agency (MPCA) has reviewed the five test reports from the taconite industry on its evaluation of the effectiveness of using activated carbon injection (ACI) technology to reduce mercury emissions from taconite indurating furnaces. In summary, the MPCA cannot determine the exact reduction in total mercury emissions capable by ACI due to the measurement methodologies used, lack of access to underlying data, and certain operating conditions during testing.

Total mercury (HgT) emissions are a sum of gas phase mercury (HgG) and particulate-bound mercury (HgP). Quantification of the total mercury capture efficiency relies on accurate measurement of both HgG and HgP. For HgG for four of the five indurating furnaces, the selected sorbent, at injection rates specifically selected for each indurating operation, has achieved 80% HgG reduction. The ACI tests confirmed qualitatively that improved downstream particulate control is needed for a comparable level of HgP reduction.

Why did the MPCA review the Phase II test reports?

The MPCA developed a state-wide mercury Total Maximum Daily Load (TMDL) to address mercury concentrations in Minnesota's lakes and streams, which was approved by the U.S. Environmental Protection Agency (EPA) in March 2007. The TMDL addresses impaired waters by evaluating the sources of mercury pollution, pollutant reduction necessary to meet water quality standards, and the allowable levels of future pollution. In Minnesota, mercury is primarily introduced to surface waters through atmospheric deposition.

In 2009, the Minnesota Taconite Mercury Control Advisory Committee was formed, with technical experts from industry, state, and academia, to help the taconite industry achieve a 75% reduction in industry-wide stack gas mercury emissions by 2025. Research conducted by this group from 2010 to 2012 focused on testing activated and brominated carbon sorbents to improve mercury capture in existing indurating furnaces. The project, also known as Phase I of the taconite mercury emission reduction research, was funded through various federal, state, and industry sources.[1] The Phase I research reports provided valuable information to the reader, along with test methods used – for example, the Ontario Hydro method (OHM) and continuous mercury monitoring system (Hg-CEMS) – and how raw data were processed, analyzed, and reported. As a result of this research, Activated Carbon Injection was selected by the industry as potentially viable and worthy of additional investigation termed Phase II testing. ACI is well established in other industries including power generation but, because the exhaust gas of a boiler differs from that of an indurating furnace, it needs to be further validated with more furnaces for mercury capture in the taconite industry.

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[1] "Minnesota Taconite Mercury Control Advisory Committee: Summary of Phase One Research Results (2010-2012)," a final report submitted to the EPA (Grant No. GL00E00655-0) by M.E. Berndt, Minnesota DNR, St. Paul, MN 55155, November 29, 2012.

Phase II testing included screening tests of several activated carbon products at five furnaces (U.S. Steel Minntac's Line 7, Hibbing Taconite's Line 3, ArcelorMittal Minorca's furnace, U.S. Steel Keetac's furnace, and United Taconite's Line 2) and 15-30 days of the most promising product (Albemarle's brominated powdered activated carbon). Because of the importance of the Phase II test results to understanding the potential design and operation of mercury reduction technologies, the MPCA reviewed the five Phase II ACI test reports for the five indurating furnaces. While the MPCA review was of the final Phase II ACI test reports, which were prepared by ADA-Environmental Solutions (ADA) in portable document format (pdf),[2] the MPCA also used the Phase I reports as a complementary information source. In addition, Minnesota Department of Natural Resources (DNR) Division of Lands and Minerals provided comments included in this document. See the attached DNR letter.

What is known about mercury captured with the ACI deployment from Phase II ACI testing?

Total mercury (HgT) emissions are a sum of emissions of gas phase mercury (HgG)[3] and particulate-bound mercury (HgP). Greater than 80% of HgG was captured with ACI deployed upstream of the furnace scrubber for the first four furnaces. See Table 1. The tests confirm *qualitatively* that ACI, as a mercury capture technology, needs to have improved particulate control downstream to achieve 75 to 80% control of HgT.

In a Phase I report by Benson, *et al.*[4], a *quantitative* account was presented of HgT, HgG, and HgP at baseline condition (no use of sorbent, ESORB-HG-11) and at two sorbent injection rates. At the high sorbent injection rate, 71.2% capture of HgT and 83.7% capture of HgG were achieved. See Figure 1.

Table 1. Phase II ACI test results: Gas phase mercury reduction determined with Hg-CEMS

Facility*	Minntac Line 7	Hibtac Line 3	ArcelorMittal	Keetac	United Line 2
ACI, lb/million ft^3	9	3	3	7	5-8
ADA: % HgG reduction	82	81	~~76~~	82	48
MPCA notes			Should be[5]: 81		See text later

* The ADA Phase II ACI test reports can be made available. For staff at the MPCA, follow the hyperlink of M, H, A, K, or U for the selected facility's test report.

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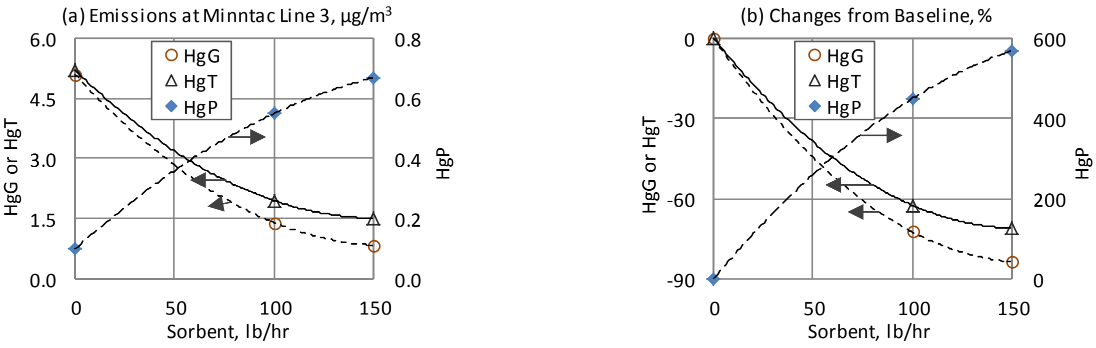
[2] U.S. Steel did answer over the telephone some scrubber sampling questions raised by M.E. Berndt of the DNR.

[3] Gas phase mercury (HgG) has two parts, oxidized mercury (Hg^{2+}) and elemental mercury (Hg^0 or Hg0). The reader will encounter HgG most often in this review document and Hg0 in Figures 2 and 3 only.

[4] "Evaluation of Scrubber Additives and Carbon Injection to Increase Mercury Capture," by S.A. Benson, J. Nasah, C. Thumbi, S. Patwardhan, L. Yarbrough, H. Feilen, S.F. Korom, and S. Srinivasachar. Phase I Project 1 Final Report, Aug. 17, 2012.

[5] At ArcelorMittal, 19.64 μg/m^3 was found for baseline with all 4 stacks' data combined; for ACI, it was 3.77 μg/m^3; thus, (19.64 – 3.77) × 100% / 3.77 = 81%. This would be similar to how ADA got 81% for Hibtac. The ADA value of 76% above is the average of 51% reduction for Stack A, 69% for Stack B, 88% for Stack C, and 95% for Stack D.



(c) 3-way split of HgG (µg/m³) at low sorbent injection rate: Baseline vs. 100 lb/hr of sorbent

(d) 3-way split of HgG (µg/m³) at high sorbent injection rate: Baseline vs. 150 lb/hr of sorbent

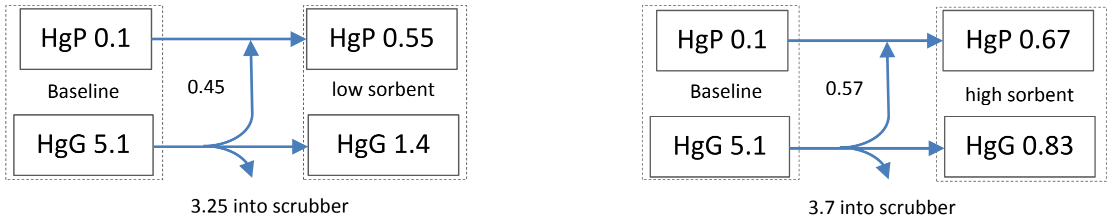


Figure 1. Phase I ACI test results at U.S. Steel Minntac's Line 3:[4] at baseline, HgT = 5.2 µg/m³; at low sorbent, HgT = 1.95 µg/m³; at high sorbent, HgT = 1.5 µg/m³. At each sorbent injection rate, most HgG was capture in scrubber blowdown, some HgG was emitted as HgG, and the least of HgG was adsorbed to the sorbent powder then emitted as HgP. From (c) and (d), HgP is 1.9% of HgT for baseline (resulted from 0.1×100%/5.2), but 28.2% at low sorbent injection rate and 44.7% at high sorbent injection rate.

Why is the particulate-bound mercury information for Phase II ACI considered merely qualitative?

The five Phase II ACI tests show the increase presence of HgP in the stack gas when ACI was deployed to treat the gas upstream of the existing wet scrubber. Method 30B,[6] an EPA approved method for determining gas phase mercury, was modified by ADA in an attempt to determine particulate mercury based on a fraction of mercury captured in the sorbent trap.

Approved methods for determining particulate mercury such as Method 29 and the OHM employ isokinetic sampling procedures to ensure sample gas is collected at a representative rate. This is accomplished by sampling at multiple points along intersecting cross sectional travers lines within an exhaust stack while adjusting the sample rates to match the flow rates of the stack gas at each individual point. The modified 30B method used a fixed sample rate and at a single location within the stack disregarding the dynamic inter-stack flow field. Without either having the modified 30B method approved by the EPA or conducting stack tests using both the modified 30B method and an approved method simultaneously to quantify a useful relationship between the two resultant data sets, the modified 30B method can bring out only qualitative information.

Since "the filter bag essentially removes all of the particulate from the gas," as stated by ADA, HgT = HgG, which allows the Method 30B results to enter the reduction calculation for HgT for ADA's Mini

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[6] "Method 30B is only supposed to be applied in low particulate locations (see Section 1.2 of the method) and all mercury in the sorbent trap is supposed to be reported as gaseous mercury," wrote Robin R. Segall, of the EPA to Hongming Jiang, in an e-mail received on August 26, 2014 (for staff at the MPCA, follow this link).

Fabric Filter (MFF) ACI optimization test at Keetac. This test shows a 95% reduction in HgT at the sorbent injection rate of 7 lb/million ft^3 of stack gas. It is worth noting that a slipstream testing of ACI with a baghouse was researched at the same indurating furnace in Phase I.[7]

Potential mercury feedback loops and their impacts on mercury capture estimates

Previous studies have indicated that at least some mercury captured by wet scrubbers (at Minntac except its Line 3, United Taconite, and ArcelorMittal) is attached to the dust particles and are returned eventually to the balling mills.[8,9,10,11,12] Although some mention of this potential was provided in the Phase II ACI test reports, it was not addressed with the rigor needed to allow determination of the quantitative impacts on the reduction estimates in any of the reports. It is reasonable to assume that removing the feedback loops while deploying ACI would greatly improve mercury capture compared to the estimates provided in the reports.

Insufficient scrubber measurements to facilitate mercury balance checks

A previous study performed at a taconite plant indicated that a considerable fraction of HgG was lost somewhere within the plant and ducts when $CaBr_2$ was injected into process gases.[13] Mercury lost in the ducts or plant would not show up in the scrubber at first but could ultimately appear somewhere else later. Thus, tests involving brominated carbons should measure the total load of mercury that is captured by the scrubbers before and after the method is applied. Ideally, one would hope that the load captured and "blown down" by the scrubbers would balance mercury in the feed, fuel, product, and stack. Without such tests, the MPCA cannot determine what fraction of the mercury decreases occurred as a result of temporary hold-ups within the furnace (*e.g.*, non-steady state) and that which was caused by increased capture in the scrubber. Although ADA made some attempt to evaluate materials in the scrubbers before and during the tests, the methods used to evaluate the effluent fell short of allowing quantification. In order to quantify, more information is needed on scrubber flow rates, and the concentrations of mercury in the scrubber solids and liquids would need to be analyzed using more refined methods.

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[7] "Evaluation of a slipstream baghouse for the taconite industry," by D.L. Laudal. Phase I Project 4 Final Report, Jan., 2012, which also offers advice on making the control technology viable for further plant-scale testing.

[8] "Bench scale tests to separate mercury from wet-scrubber solids from taconite plants," by B.R. Benner, Coleraine Minerals Research Laboratory, University of Minnesota, Duluth, MN 55811, January 7, 2008.

[9] "Mercury transport in taconite processing facilities: (I) Release and capture during induration," by M.E. Berndt and J. Engesser, Iron Ore Cooperative Research Final Report, Minnesota DNR, August 15, 2005.

[10] "Mercury transport in taconite processing facilities: (II) Fate of mercury captured by wet scrubbers," by M.E. Berndt and J. Engesser, Iron Ore Cooperative Research Final Report, Minnesota DNR, December 31, 2005.

[11] "Mercury chemistry and Mössbauer spectroscopy of iron oxides during taconite processing on Minnesota's Iron Range," by M.E. Berndt, J. Engesser, and T.S. Berquó, a poster paper shown at Air Quality V, a conference held in Washington, DC, organized by Energy and Environmental Research Center, September 18-21, 2005.

[12] United Taconite Line 2 was using a setting to allow scrubber captured dust particles to return to the balling mills during Phase II ACI testing, even though it could have been set to let the dust particles exit the feedback loop.

[13] "On the measurement of stack emissions at taconite processing plants – a progress report submitted to MPCA," by M.E. Berndt, of Minnesota DNR, May 30, 2008, page 23.

Problems observed in the test results reported for United Taconite Line 2

In Table 1, while one sorbent injection rate is reported for each of other four furnaces along with the respective values of HgG reduction, a set of sorbent injection rates (5-8 lb/million ft^3 of stack gas) were reported for United Taconite with a much lower reported value of HgG reduction. To provide illustration of this point, Figure 2 shows an image from the ADA test report for United Taconite.

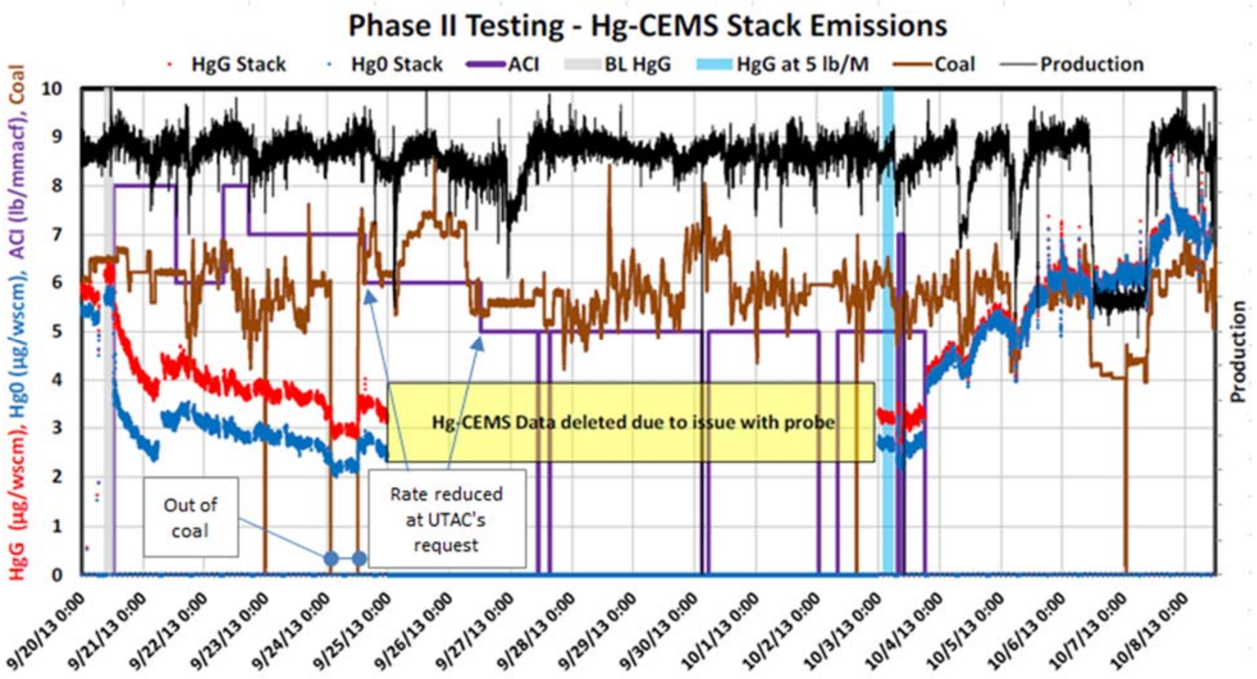

Figure 2. Figure 16 from the ADA Phase II ACI test report for United Taconite – with the text boxes, “Out of coal” and “Rate reduced at UTAC’s request,” inserted by the MPCA.

Phase II ACI was planned as a longer-term test. One would expect ADA to keep the selected sorbent injection rate for a longer duration – such as 98 hours – to see how low HgG could go and to evaluate HgG reduction accordingly. Instead, ADA alternated the sorbent injection rate several times – 8 lb/million ft^3 for 24.5 hours, 6 lb/million ft^3 for 18.5 hours, 8 lb/million ft^3 for 10 hours, and finally at 7 lb/million ft^3.

An outage of coal occurred and lasted 10 hours 50 minutes. At the same time, mercury concentrations[3] decreased while the sorbent injection rate was still at 7 lb/million ft^3. At 14:45, on 9/24/2013, at United Taconite’s request, ADA lowered the injection rate to 6 lb/million ft^3 (after 45.25 hours at 7 lb/million ft^3), which brought a prompt increase in mercury concentrations. About 9.25 hours later, a yellow-shaded text box appears to note “Hg-CEMS Data deleted due to issue with probe.” Still early in the data deletion duration, at United Taconite’s request again, ADA set the final injection rate to to 5 lb/million ft^3 (after 45.58 hours at 6 lb/million ft^3).

With the setting chosen[12] for Line 2 and the sorbent – brominated carbons – selected, the MPCA is concerned about non-steady state conditions, as discussed in previous sections. The frequent sorbent injection rate changes do not ease this concern. But, more importantly, deletion of a long duration of Hg-CEMS data is a much more serious problem that impairs the MPCA’s ability to evaluate the ADA test report and its conclusions.

Benson, *et al.,* also encountered questionable data points in their Phase I project.[4] Figure 3 is how they reported the OHM results and Hg-CEMS data (or CMM, in their notation for continuous mercury monitoring); Hg^{VT} – for total vapor-phase mercury – is HgG in our terminology.[3]

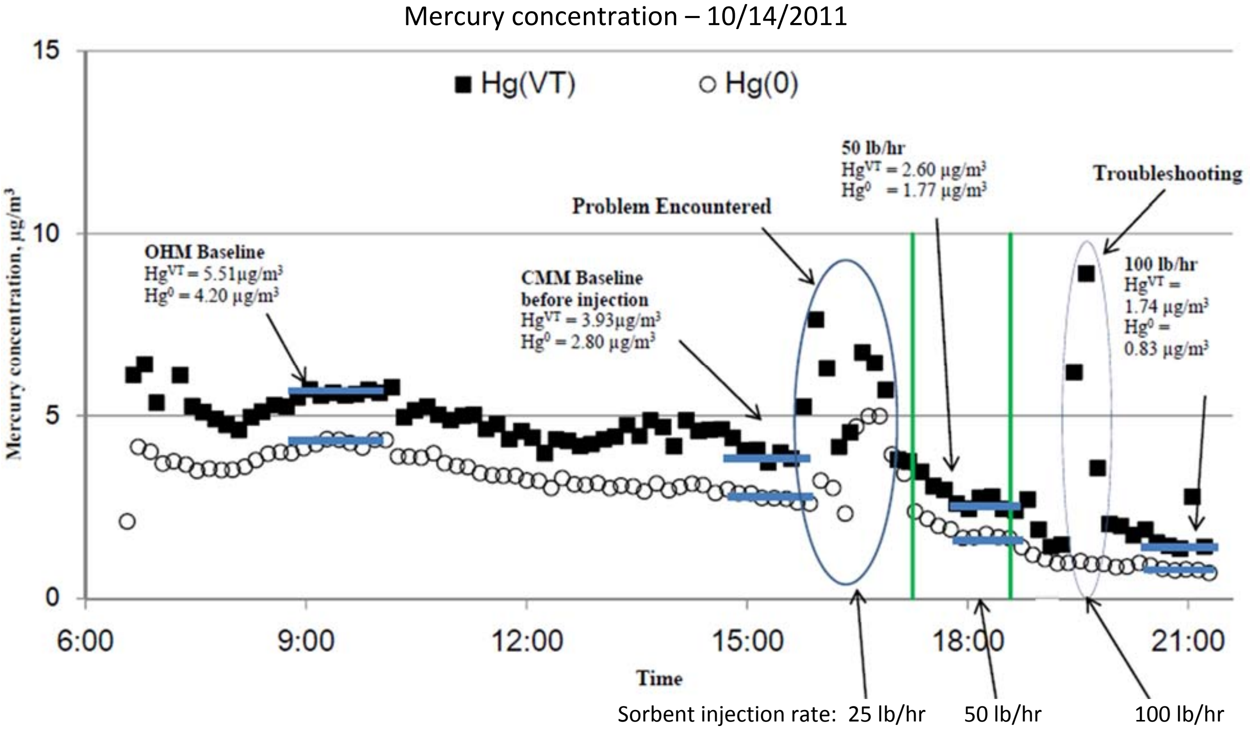

Figure 3. How to present and discuss questionable data? This is an example – Figure 8 from the Benson report and the original caption:[4] "CMM data for Day 1 of ESORB-HG-11 injection. The average CMM mercury concentrations during OHM sampling are shown. It can be observed that the baseline decreased by approximately 1.50 µg/m³ during the time from baseline OHM to start of injection at 16:10. However, when injection started, a problem occurred on the CMM. As soon as the problem was corrected, injection was increased to 50 lb/hr."

Including both the questionable data and the explanation about why the data should be treated differently would reflect greater transparency and improve the MPCA's confidence in the reported results.[14]

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[14] To provide a comprehensive technical review, the MPCA requires the data that were actually used to generate plots and graphs in the Phase II ACI test reports.

Concluding Remarks

Overall, the industry-initiated Phase II ACI testing confirms that the selected sorbent, Albemarle's Brominated, Powdered Activated Carbon, when injected into the furnace exhaust gas upstream of the existing particulate control wet scrubber, captured mercury in gas phase by more than 80%; that total mercury capture is indeterminate, but it potentially could be increased to approach 80% with better particulate control. Because of the complex interactions of mercury inside the dynamic pellet indurating process, with the brominated activated carbon particulate, as well as the scrubbing water loaded with reactive iron particles, if the ACI technology were to be examined further, more data must be collected to fully characterize the ACI technology in connection with the selected particulate control – either the existing wet scrubber or any other option – and to develop $PM_{2.5}$ emission data for purpose of fully evaluating the feasibility of the technology. The MPCA also encourages the industry to involve the MPCA when planning testing to address issues related to modifying performance test methods, treatment of apparent outliers, and other technical issues that may develop in the course of conducting field trials.

Attachment: DNR letter from Michael E. Berndt, 10/31/2014 (for staff at the MPCA, use this link)

10/31/2014

Minnesota Department of Natural Resources
500 Lafayette Road • St. Paul, MN • 55155-40_

Minnesota
DEPARTMENT OF
NATURAL RESOURCES

Hongming Jiang
Pollution Control Agency
520 Lafayette Road North
St Paul, MN 55155

RE: Review of Phase II Hg Control Reports

Five taconite mining companies recently submitted reports to the Minnesota Pollution Control Agency evaluating activated and brominated carbon injection to control Hg in stack emissions. Subsequently, your agency made a request to the DNR that I review these documents. It was agreed that I would provide a general, less detailed analyses of the reports, but that MPCA would provide more in-depth detailed analyses. This letter provides my overall assessment of the five reports that were originally submitted by ADA-ES to each of the companies conducting the tests.

My general findings are as follows:

M30B analysis indicates capture is much less than what is analyzed by CMS, however, the sampling method used for M30B was not done iso-kinetically and so may not be quantitative. Two primary methods were used for the analysis of stack gases during the five studies: M30B and CEMS. M30B is a method that relies on the sampling of stack gases through a tube containing glass wool and a sorbent material while CEMS is a continuous monitoring method that only analyzes mercury in the gaseous phase. The former has the advantage that Hg bound to particulates that is trapped in the glass wool can be quantified and added to the estimation of total mercury in any sample passing through the tube. The latter only analyzes what is present in the gas phase, but has the advantage that it provides continuous monitoring rather than just a periodic "spot check".

Ultimately, the M30B method results show that ACI reduces gaseous mercury but that a substantial amount of particulate bound mercury is formed during ACI injection and some of this particulate fraction escapes the wet scrubber and is emitted at the stack. I will defer to those with more experience in measuring particulates in stack emissions to determine how much weight to place on the HgP and HgT measurements that were made using the M30B method.

Potential Hg feedback loops likely provided an additional interference for making reduction estimates at Minntac, Utac, and ArcelorMittal. Previous studies have indicated that at least some Hg captured by wet scrubbers at these plants is attached to the dust particles that are returned eventually to the balling mills (Benner, 2008; Berndt and Engesser, 2005a; Berndt and Engesser, 2005b; Berndt et al., 2005). Although some mention of this potential was provided in the reports, it was not addressed with the rigor needed to allow determination of the quantitative impacts on reduction estimates in any of the reports. It is reasonable to assume, however, that removing the feedback loops during ACI injection would greatly improve the percentages of mercury captured compared to the estimates provided in the reports.

Measurements provided for the scrubbers were inadequate to allow Hg balance checks to be conducted during any of the tests. Thus, we don't really know the fate of the captured mercury or how permanent (or ephemeral) the mercury reductions are. A previous study performed at a taconite processing plant indicated that a considerable fraction of the gas-phase Hg was lost somewhere within the plant and ducts when CaBr2 was injected into process gases (Berndt, 2008). Mercury lost in the ducts or plant would not show up in the scrubber at first but could ultimately show up somewhere else later. Thus, tests involving brominated carbons should measure the total load of Hg that is captured by the scrubbers before and after the method is applied. Ideally, one would hope that the load captured and "blown down" by the scrubbers would balance Hg in the feed, fuel, product, and stack. Without such tests, we cannot determine what fraction of the Hg decreases occurred as a result of temporary hold-ups within the furnace (e.g., non-steady state) and that which was caused by increased capture in the scrubber. Although ADA-ES made some attempt to evaluate materials in the scrubbers before and during the tests, the methods used to evaluate the effluent fell far short of allowing quantification. In order to do so, more information would be needed on scrubber flow rates and the concentrations of Hg in the scrubber solids and liquids would need to be analyzed using more refined methods.

These results need to be compared to results from other past studies. ACI testing was previously conducted at both Hibbing Taconite and US Steel, but results from those tests were not compared to results from the present tests (Benson et al., 2012; Miller et al., 2012). Also, as mentioned above, much work was done previously on scrubber water and scrubber solid characterization (Berndt and Engesser, 2005b). Measured correctly, the change in scrubber solid chemistry can be used as an alternative means to estimate or verify changes in Hg capture rates.

Despite the four criticisms mentioned above, the reports do provide relatively strong evidence that re-emission of particulate-bound mercury is a pervasive issue that must be solved before brominated activated carbon injection methods can be considered suitable for the taconite industry. This potential issue was also identified previously in Phase 1 (Benson et al., 2012). Please let me know if I can be of any further assistance as the MPCA finalizes its review of the industry's reports.

Regards,

Michael E. Berndt

References (all available at http://www.dnr.state.mn.us/lands_minerals/dnr_hg_research.html)

Benner, B.R., 2008. Bench scale tests to separate mercury from wet-scrubber solids from taconite plants. Report submitted to the Minnesota Department of Natural Resources, St. Paul, MN, p. 26.

Benson, S.A., Nasah, J., Thumbi, C., Patwardhan, S., Yarbrough, L., Feilen, H., Korom, S.F., Srinivasachar, S., 2012. Evaluation of Scrubber Additives and Carbon Injection to Increase Mercury Capture, Report submitted to the Minnesota Department of Natural Resources, St. Paul, MN, p. 67.

Berndt, M., Engesser, J., 2005a. Mercury Transport in Taconite Processing Facilities: (I) Release and Capture During Induration. An Iron Ore Cooperative Research Final Report, Report submitted to the Minnesota Department of Natural Resources, St. Paul, MN, p. 60.

Berndt, M., Engesser, J., 2005b. Mercury Transport in Taconite Processing Facilities: (II) Fate of Mercury Captured by Wet Scrubbers, Report submitted to the Minnesota Department of Natural Resources, St. Paul, MN, p. 32.

Berndt, M., Engesser, J., Berquo, T.S., 2005. Mercury chemistry and Mossbauer spectroscopy of iron oxides during taconite processing on Minnesota's Iron Range, Air Quality V. Energy and Environmental Research Center, Washington, D. C. , p. 15.

Berndt, M.E., 2008. On the measurement of stack emissions at taconite processing plants - a progress report submitted to MPCA, Report submitted to the Minnesota Department of Natural Resources, St. Paul, MN, St. Paul, MN, p. 23.

Miller, J., Zerangue, M., Tang, Z., Landreth, R., 2012. Mercury control for taconite plants using gas-phase brominated sorbents, Report submitted to the Minnesota Department of Natural Resources, St. Paul, MN, St. Paul, MN, p. 55.

CC Jennifer Engstrom

Attachment C

Minorca Extended ACI Test Plan

resourceful. naturally.
engineering and environmental consultants
BARR

Technical Memorandum

To: ArcelorMittal Minorca Mine
From: Barr Engineering Co.
Subject: Test Plan for Extended Testing of Activated Carbon Injection
Date: January 26, 2017
Project: 23691731.00

This document provides the test plan for extended testing of activated carbon injection (ACI) to analyze mercury emissions capture from the pellet induration process. This test plan has been developed specifically for ArcelorMittal Minorca Mine (Minorca).

1.0 Introduction

This document outlines the next phase of extended ACI testing at Minorca. Minorca had previously completed ACI testing in 2013 as part of an overall Minnesota taconite industry research effort. The previous ACI testing, called Phase II, was conducted to determine if ACI could meet the 75% reduction total maximum daily load (TMDL) goal set by the Minnesota Pollution Control Agency's (MPCA's) 2009 Implementation Plan. Since the Phase II testing, Minnesota has finalized state regulations (Minn. R. 7007.0502) that require Minorca to reduce mercury emissions by January 1, 2025 to no more than 28% of the mercury emitted in 2008 or 2010, whichever is greater. The state regulations also require Minorca to submit a mercury emissions reduction plan by December 30, 2018 to show how Minorca will achieve the 72% reduction, or propose an alternate plan if Minorca concludes that a 72% reduction is not technically or economically feasible, impairs pellet quality, and/or causes excessive corrosion to plant equipment. Minorca has conducted a thorough review of potential mercury reduction technologies and has determined that ACI is one potential option for Best Available Mercury Reduction Technology (BAMRT).

The purpose of this test plan is to define the strategy and protocol for extended ACI testing to determine what amount of mercury capture is possible with ACI at a lower injection in order to adjust for the increased particulate rate previously tested in 2013, while also monitoring other aspects of the process to determine the technical or economic feasibility for implementation of a full-scale ACI system.

2.0 Proposed Schedule

The 90-day test for Minorca is scheduled to start with mobilization of the ACI equipment on January 4, 2017. Screening tests will commence on January 10, 2017 and extended testing will start on January 20, 2017 and end on April 7, 2017 prior to April shutdown of the furnace. Minorca will also be conducting baseline stack testing the week of December 12, 2016 prior to any ACI and the week of April 10, 2017 after ACI.

A detailed schedule is provided along with this testing plan in Attachment A.

3.0 Goals of Test

- Determine % reduction in total Hg emissions using ACI at pre-determined injection rates.

- ☐ Determine final destination of Hg following capture by ACI.
- ☐ Evaluate scrubber performance with additional ACI loading via particulate stack testing.
- ☐ Determine baseline Hg concentration in the stack emissions without ACI and with ACI.
- ☐ Evaluate all forms of Hg stack emissions such as vapor and particulate as well as elemental/oxidized Hg (during stack tests conducted during ACI testing).
- ☐ Quantify operating and maintenance cost at a specified injection rate.
- ☐ Determine if the selected ACI is technically feasible to reduce Hg emissions by MPCA rule.
- ☐ Determine if the selected ACI is economically feasible to reduce Hg emissions by MPCA rule.
- ☐ Measure and analyze ACI impact on pellet quality.
- ☐ Measure and analyze maintenance and equipment issues associated with ACI.
- ☐ Document abnormal erosion/corrosion issues with plant equipment and ductwork during post shutdown visual inspections.
- ☐ Identify safety/hygiene issues with ACI.

4.0 ACI Selection

The activated carbons recommended for this phase of ACI testing are high temperature brominated powdered activated carbon (HPAC) and brominated powdered activated carbon (BPAC). These were chosen based on previous testing of these types of activated carbon during Phase II testing in which these carbons showed the greatest mercury reduction compared to other types of activated carbons.

During Phase II, Minorca conducted screening tests of various types of powdered activated carbon (PAC) and at different injection rates to determine which PAC type at what injection rate should be used for extended testing. The screening results at Minorca as part of Phase II determined that HPAC at a 1 lb/mmacfm injection rate achieved a 60% reduction in gas phase mercury (HgG), and BPAC achieved a 63% HgG reduction at 1 lb/mmacfm injection rate. The measurements of the screening tests were taken from Stack D.

During the Phase II testing, ADA-ES, Inc. (ADA) employed the ThermoFisher mercury continuous emission monitor system (Hg-CEMS) to measure gas phase mercury emission at the stack. However, Hg-CEMS cannot measure particulate-bound Hg (HgP). In order to estimate the amount of HgP, ADA used a modified Environmental Protection Agency (EPA) Method 30B (M30B) by periodically measuring the Hg concentration of the inlet gas (before ACI), and to validate the performance of the Hg-CEMS at the stack. However, the modified M30B measurements were only conducted during the extended testing, not during the screening tests. Therefore, the recommended performance tests according to this test plan (outlined below) will estimate the total Hg, HgT, as HgG + HgP, while Minorca conducts extended testing of PAC injection at a rate of 1lb/mmacfm.

Considering the past results, each PAC type is a good option to use during the 90-day test. Initial screening tests will be completed during a performance test (described in 7.1) for each PAC to determine which one should be used for long-term testing. Another main factor in determining the economic feasibility of a specific type of activated carbon is the cost associated with each.

5.0 Mercury Stack Test Method Applicability

It is important that the stack test mercury measurement method is most applicable to the type of source being measured. It is also important to note that mercury particulate issues identified during Phase II testing were a significant factor in determining the testing methods for this next round of testing.

The two methods that meet all the criteria for the mercury stack testing are the Ontario Hydro (O-H) ASTM D6784 and the EPA Method 29 (M29). M29 and O-H methods are recognized for their ability to accurately measure HgT and capture particulate emissions. The only difference in the two methods is that the O-H method can speciate the Hg (elemental and oxidized) in the samples, M29 cannot. The analytical results from this testing will take 2 to 4 weeks for return. M30B does not meet the requirements for this test work due to its inability to measure particulate matter in the process gas stream and can only measure Hg in the gas stream. M30B will be used as a screening method to determine the appropriate PAC type for long-term testing.

The Hg-CEMS is not recommended at this time due to mercury particulate issues identified during Phase II testing and high costs to maintain and operate this technology.

6.0 Test Plan

Given the main objectives and the overall activities to be accomplished during this testing campaign, the following test protocol is set forth as a guide to the operations once all equipment has been set up and commissioned.

A. Nol-Tec Systems was selected as the vendor and test equipment provider for ACI
    1. Facilities Performance Group (FRP) (subcontractor to Nol-Tec)

B. Project team members
    1. Nate Holmes, Minorca site manager; Jaime Johnson, designated alternative
    2. Ryan Siats, Barr Engineering project manager; Boyd Eisenbraun, designated alternative
    3. ACI testing project managers
        a. Mitch Lund, Nol-Tec contract manager
        b. Grace Whiteford, Nol-Tec project manager

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c. Jason Johnson, Nol-Tec setup manager

d. Scott Spangenberg, Nol-Tec control engineer

e. Layne Wesley, FPG field testing manager

f. Jeremy Steele – FPG field testing

4. Ben Wiltse, Barr Engineering stack testing project manager; Tom Leier, designated alternative

5. Onsite testing team will also have a Minorca-supplied plant radio available for communication

C. To contact the project team members related to the ACI testing, the subsequent procedures should be followed. Contact information for each team member can be found in Attachment B. Always contact Minorca's project manager first unless directed otherwise.

1. Minorca plant operation and site testing management

    a. Minorca project site manager – testing and operating schedules, safety questions and concerns, accident or injury reports

        (1) Nate Holmes – primary contact

        (2) Jaime Johnson – secondary contact

    b. Minorca operations team – night shift, weekends, or not able to reach Minorca primary projects managers

        (1) onsite shift manager

        (2) control room operator

2. Carbon injection system and operation responsibility

    a. FPG – Responsible for operating the carbon injection system

        (1) Layne Wesley – FPG test manager

        (2) Jeremy Steele – FPG onsite project lead

    b. Nol-Tec Systems – responsible for carbon injection system, questions related to carbon injection operation, injection equipment, schedules, carbon storage and supply questions

        (1) Grace Whiteford – Nol-Tec project manager

        (2) Jason Johnson – Nol-Tec setup project manager

        (3) Scott Spangenberg – Nol-Tec control engineer

3. Barr Engineering

    a. Stack testing manager

        (1) Ben Wiltse – questions and stack testing schedules
        (2) Tom Leier – secondary contact
    b. Engineering assistance
        (1) Ryan Siats – primary contact
        (2) Boyd Eisenbraun – secondary contact

D. Safety

1. All staff working with the testing system:
    a. Shall be aware of the equipment and materials being used and the associated hazards of the materials and work areas. SDS's are required for any chemicals being used for testing.
    b. Shall be current on and have documentation available for their Mine Safety and Health Administration (MSHA) training, fall protection certified, and required site-specific training.
    c. Shall wear the appropriate personal protective equipment, including safety boots (metatarsals), hardhat, hearing protection, and safety glasses.
2. All accidents, injuries, or equipment damaged shall be reported immediately to the Minorca project manager or the onsite shift manager during nights and weekends.
3. In case of emergency, there is an emergency shutdown switch on the carbon injection system available if needed. Please refer to the procedure provided in Attachment C from Nate Holmes in the event the emergency shutdown switch is activated.

E. Planning

1. In addition to a safety briefing each morning, a daily planning discussion will also be held among the testing group and Minorca operation representatives. Communication is important to the success of this test. FPG personnel will complete daily a Hirac-Lite form as well as document a work place exam. Both of these will be updated if project conditions change throughout the day.
2. This daily plan will guide the work for that day.
3. The previous day's testing results will be reviewed to identify good and poor performance parameters and recommend adjustments or process changes if required.
4. Project team meetings will occur twice a week to update the team on testing

F. Data recording

1. In order to maximize the value of this test work, data must be recorded as clearly and completely as possible. Utilization of the data control system (DCS) historian database will

    be used to collect real time process and lab data, which will be critical in determining process operation and product quality during ACI testing.

    2. Barr will work with the Minorca operations staff to develop a list of key process and lab data points to monitor during the ACI testing. This list will collect data from reports and the data historians from the process. These data lists will be finalized two weeks prior to testing and approved by Minorca management. The initial list is included as Attachment D to this document.

G. Testing and project assistance from Barr

    1. Barr will assist Minorca as directed to manage the collection of process and test data collected from Minorca, analytical labs, and Nol-Tec. Minorca and Barr will confirm a list of key process variables required for analysis and data collection.
    2. Minorca will set up plant sample collection, and conduct the sample collection.
    3. Barr will provide containers for sample collection.
    4. Barr will manage the analytical data results and assist Minorca with the coordination and scheduling of analytical vendors.

H. Recommended ACI type based on discussion with Minorca staff

    1. The recommended activated carbon for testing is BPAC or HPAC based on preliminary screening.

I. ACI dose rate of 1 lb/mmacf for Minorca

    1. Change of dose rate will be determined by Minorca.

J. Baseline stack emission testing prior to ACI testing

    1. December 13-14, 2016
    2. M30B for mercury capture analysis on all 4 stacks (1 time)
        a. Minimum of 3 tests each time – 1-hour duration each test

K. Preliminary ACI selection and evaluation for long-term testing

    1. January 9-13, 2017
    2. M30B for mercury capture analysis (2 tests – 2 stacks)
        a. Minimum of 3 tests each time – 30-minute duration each test
    3. EPA Method 5 for particulate measure (2 tests – 2 stacks)
        a. Minimum of 3 tests each time – 30-minute duration each test

L. Hg stack emissions reduction evaluation – long-term testing

    1. Week of February 6 and week of March 28, 2017

    2. Ontario Hydro Method (ASTM D6784) for mercury analysis and Method 5 for particulate analysis (2 tests – 4 stacks)
        a. 3 tests each time – 2-hour duration each test
    3. Compare Hg emissions during ACI to baseline

M. Baseline testing post-ACI

    1. April 11-12, 2017
    2. M30B for mercury capture analysis on all 4 stacks (1 time)
        a. Minimum of 3 tests each time – 1-hour duration each test
    3. No ACI injection but continue wasting scrubber solids

N. Post-ACI testing analysis

Barr will assist Minorca in assessing the following aspects of ACI as a potential mercury reduction technology with the data and information collected during the extended ACI testing:

1. Determine final destination of Hg from scrubber blowdown
2. Determine effectiveness of discarding scrubber solids
    a. All scrubber water and associated solids sent directly to tailings thickener following the stack testing during the week of February 6.
3. Document abnormal erosion/corrosion issues with plant equipment and ductwork during post shutdown visual inspections
4. Determine impact on pellet quality
5. Quantify operating and maintenance cost to determine economic feasibility

7.0 Mercury Measurement Method (Stack Emissions)

7.1 ACI Screening Test Hg Emission Measurement and Baseline Measurement

Measurement of Hg emissions during the screening tests of BPAC and HPAC will be conducted to determine which type shows the greatest reduction in stack mercury emissions. Previous ACI testing has shown particle bound Hg (HgP) is the significant portion of total Hg (HgT) when employing ACI for Hg control. However, historical compliance testing of stack mercury emissions has shown gas phase mercury (HgG) is the significant portion of HgT under normal operations. Therefore, for the purpose of screening tests, M30B will be used for Hg testing during ACI screening tests to determine the type of PAC with the greatest HgG reduction. These screening tests will be completed within the first week of testing.

7.2 ACI Performance Test Hg Emission Measurement

Measurement of Hg emissions during the ACI performance testing will be conducted to determine the total stack mercury emissions while injecting activated carbon. Previous ACI testing has shown HgP is the significant portion of HgT when employing ACI for Hg control. The O-H method will be utilized to determine the total Hg capture during the long-term ACI testing. This will determine the total mercury and speciation of mercury in the stack emissions. The phase and speciation of mercury will allow for a complete assessment of ACI for technical feasibility if applied to Minorca's indurating furnace.

A. Stack testing will be completed at the selected times during the test. The testing will occur during steady state operation, determined by Minorca plant management and operations.

  1. Baseline testing (December 13-14, 2016)
    a. M30B on all 4 stacks (1 time)
      (1) Minimum of 3 tests each time – 1 hour duration each test
  2. ACI screening (January 10-11, 2017)
    b. M30B on 2 stacks (2 times)
      (1) Minimum of 3 tests each time – 30-minute duration each test
    c. EPA Method 5 on 2 stacks (2 times)
      (1) Minimum of 3 tests each time – 30-minute duration each test
  3. Long-term performance testing (February 7-8 and March 28-29, 2017)
    d. Ontario Hydro (ASTM D6784) and Method 5 on all 4 stacks (2 times)
      (1) 3 tests each time – 2-hour duration each test
  4. Base line testing post-ACI (April 11-12, 2017)
    e. M30B on all 4 stacks (1 time)
      (1) Minimum of 3 tests each time – 1-hour duration each test

8.0 Determine Hg Removal, Scrubber Performance, and Final Destination of Hg from the Scrubber Blowdown

The scrubber blowdown water stream will be recycled within the process as normal for the first half of the ACI testing to determine the impact on mercury recycle effects to the greenball and process water streams. Following the first long-term stack test in February, this scrubber water recycle including the solids will be diverted to the tailings thickener for the remainder of the ACI testing. Diversion of the scrubber water will help evaluate the mercury recycle in the process.

Similar to Phase II testing, selected process samples are to be collected and analyzed to determine Hg concentrations. Coordination of sampling will be completed by Barr with approval from the Minorca project manager. Minorca will be responsible for collection of the process samples identified at the locations below. Barr staff will be responsible for providing sample containers, coordination and scheduling of analytical mercury analysis for these samples. Process samples should be taken during steady state operation, which will be determined by Minorca staff. During the testing, it is recommended that Minorca staff conduct visual audits of the process for the spent ACI solids recycle back into the process.

The recommended sample points for Hg analysis during ACI testing are listed below and identified in the process flow diagram in Attachment E.

Weekly Process Sampling

In addition to the stack testing and mercury mass balance sampling described in Section 13, weekly sampling will be completed to track the changes in mercury loading during the ACI testing. Below is a list of weekly sample collection points:

1. Tails Thickener (underflow) (fine tails)
2. Tails Thickener (overflow)
3. Concentrate Thickener (underflow)
4. Concentrate Thickener (overflow)
5. Green Ball (balling disc discharge)
6. Scrubber Blowdown/Scrubber Sump
7. Final Pellet Sample

To complete an accurate mass balance, flow measurements will be required for each sample location. If real-time process flow rate measurements are not available, historical performance data will be utilized.

8.1 Placement of Discarded Scrubber Solids

The spent PACs and associated scrubber solids will be transferred/pumped with the scrubber blowdown stream to the tailings thickener in early February 2017. This effort will direct all mercury solids and liquids to the tailings basin, thus reducing the potential for mercury recycle back into in the process water. Minorca currently recycles the scrubber blowdown stream with solids back to the process. After the first stack test event in early February 2017, the scrubber blowdown stream will be diverted to the tailings thickener. Additionally, a daily visual inspection of the tailings thickener overflow is required for review of any spent carbon particulate returning to the process via the water recovery system.

9.0 Determine Economic Feasibility of ACI by Quantifying Operating and Maintenance Costs to

Operating costs associated with testing will be collected and documented for the estimation of operating and maintenance costs if a full-scale system were to be implemented. Operating costs will be determined by recording the total amount of PAC injected and operator labor required during the testing. Maintenance costs can vary depending on the condition of the equipment and the operating duration; however, any costs associated with maintaining the testing equipment will be documented and considered for a full-scale system. Barr will use the information gathered during the ACI testing and work with ACI vendors to extrapolate annual site-specific full-scale implementation costs associated with ACI.

10.0 Determine Technical Feasibility of ACI

Determining if ACI is technically feasible can be accomplished during the test by determining the Hg reduction at a rate of 1 lb/mmacf or lower without affecting normal operations or particulate emissions. Part of the technically feasible evaluation is to investigate the condition of the process equipment, ducting and equipment degradation. Barr and Minorca will develop an inspection plan to document possible effects to plant and process equipment from the extended testing of ACI. The inspection plan will be included in the final technical report for the overall ACI extended testing.

11.0 Determine Impact of ACI on Pellet Quality

Pellet physical and chemical quality parameters have been defined (see Table 1 below). Concentrate parameters will be evaluated if pellet quality parameters are out of specification. These parameters will be monitored during the testing to determine impacts associated with the ACI testing. The pellet quality parameters during ACI testing will be compared to historical pellet variability and quality parameter limits set at Minorca. If any pellet physical or chemical qualities exceed set parameters, the change will be identified and a root cause analysis will be performed to determine the potential cause. Minorca will continue to use the existing sampling procedure already in place for this task. Please refer to Section 8 for a list of sampling locations to be sampled weekly during the extended ACI testing, and Section 13 for a list of sampling locations to be sampled and collected during stack testing.

The quality parameters include:

- ☐ Concentrate – review and inspect when pellet properties become out of spec
- ☐ Greenball – not currently evaluated, moisture content
- ☐ Pellet – physical and chemical properties (normal)

Table 1 Minorca Pellet Specifications

Greenballs	Lower Spec	Target	Upper Spec	Frequency
Moisture	9.00%	9.20-9.30%	9.50%	2 hours
Pellets	**Lower Spec**	**Target**	**Upper Spec**	**Frequency**
CaO/SiO2 Ratio (C/S Ratio)	1.00%	1.10%	1.20%	4 hours
MgO/SiO2 Ratio (M/S Ratio)	0.28%	0.35%	0.42%	4 hours
Pellet Silica	3.78%	4.20%	4.62%	4 hours
Contraction	N/A	8.00	10.00	24 hours
Pellet Cold Compression Strength (CSS)	400	500	N/A	8 hours
(BT-1/4”) Pellet Size	N/A	1.00%	2.00%	4 hours
(AT+1/2”) Pellet % Oversize	8.00%	20.00%	32.00%	4 hours
(AT-3/8 X 1/2”) Pellet Size	46.00%	60.00%	N/A	4 hours
(AT-1/4”) Pellet Size	N/A	4.75%	6.00%	4 hours

12.0 Determine Potential Erosion/Corrosion Issues Associated with ACI

It was determined that for this ACI test period at Minorca, inspection of erosion/corrosion will be conducted. The outage in October 2016, prior to the ACI testing, did not allow cooling down of the furnace for entry into ductwork or furnace areas. Barr and Minorca will develop an inspection plan to document possible effects to plant and process equipment from the extended testing of ACI. The inspection plan will be included in the final technical report for the overall ACI extended testing.

13.0 Plant Process Sampling During Stack Testing

Four plant sampling events will take place during stack testing, corresponding to baseline testing before/after ACI testing, and the two stack tests during ACI. No plant sampling will be completed during ACI screening tests. These samples will strengthen the existing mercury mass balance data set already established.

The previous Minorca mercury baseline sampling efforts identified the following recommended process sampling locations during stack testing while conducting ACI. They are also identified in the process flow diagram in Attachment F:

1. Rod Mill Discharge
2. Sands of Spiral Classifier to Tails Bin (Cobber Tails)
3. Spiral Classifier (overflow)

4. Tails Thickener (underflow) (Fine Tails)
5. Tails Thickener (overflow)
6. Finishers Concentrate Discharge to Concentrate Thickener/FMS Sump
7. Flotation Reject Product to Tailings Thickener
8. Concentrate Thickener Feed
9. Concentrate Thickener (underflow)
10. Concentrate Thickener (overflow)
11. Fluxstone Feed (from Fluxstone Slurry Storage Tank)
12. Binder Supply (feed to bin)
13. If in use, Repulper Tank (Concentrate Reclaim Feed to Acid Concentrate – Slurry Tank/Fluxed Concentrate – Slurry Tank)
14. Green Ball (balling disc discharge)
15. Multiclones (windboxes recycle to concentrate thickener)
16. Scrubber Blowdown/Scrubber Sump
17. Final Pellet Sample
18. Make-up water sample from plant head tank/raw water feed to plant

To complete an accurate mass balance, flow measurements will be needed at each sample location. If real-time process flow rate measurements are not available, historical performance data will be utilized.

14.0 Report

Barr will produce a report detailing the results and conclusions of the testing that can be used to finalize a site-specific BAMRT analysis of ACI at Minorca.

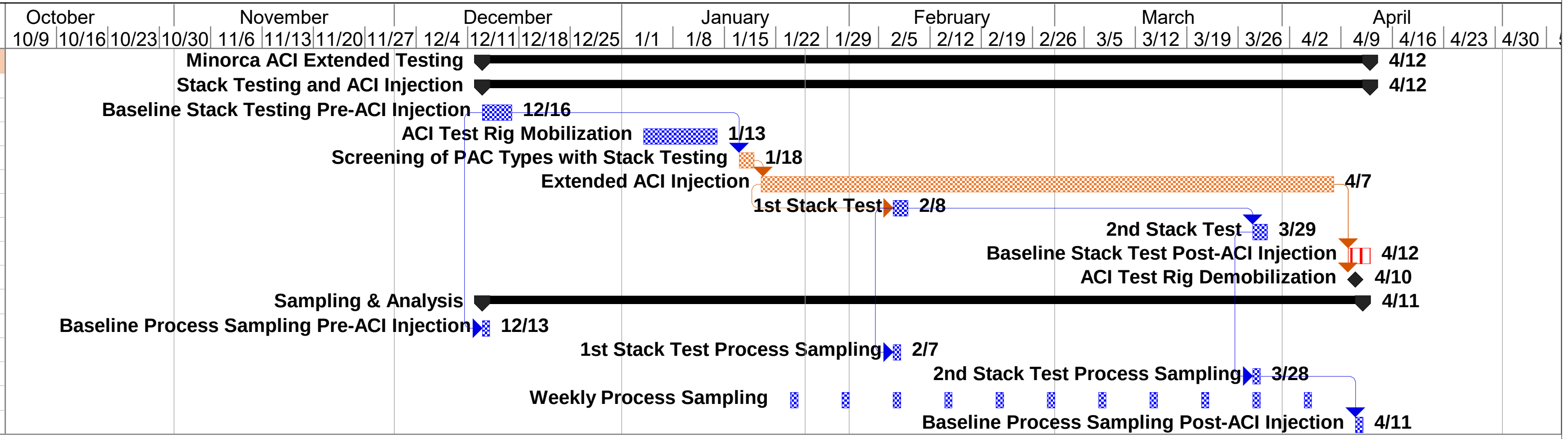
Attachment A

Detailed Schedule

Minorca ACI Testing

Coordination Schedule

ID	Task Name	Duration	Start	Finish	Predecessors
1	**Minorca ACI Extended Testing**	**17.2 wks**	**Tue 12/13/16**	**Wed 4/12/17**	
2	**Stack Testing and ACI Injection**	**17.2 wks**	**Tue 12/13/16**	**Wed 4/12/17**	
3	Baseline Stack Testing Pre-ACI Injection	4 days	Tue 12/13/16	Fri 12/16/16	
4	ACI Test Rig Mobilization	8 days	Wed 1/4/17	Fri 1/13/17	
5	Screening of PAC Types with Stack Testing	2 days	Tue 1/17/17	Wed 1/18/17	3FS+20 days
6	Extended ACI Injection	78 days	Fri 1/20/17	Fri 4/7/17	5FS+1 day
7	1st Stack Test	2 days	Tue 2/7/17	Wed 2/8/17	6SS
8	2nd Stack Test	2 days	Tue 3/28/17	Wed 3/29/17	7
9	Baseline Stack Test Post-ACI Injection	3 days	Mon 4/10/17	Wed 4/12/17	6
10	ACI Test Rig Demobilization	0 days	Mon 4/10/17	Mon 4/10/17	6FS+1 day
11	**Sampling & Analysis**	**17 wks**	**Tue 12/13/16**	**Tue 4/11/17**	
12	Baseline Process Sampling Pre-ACI Injection	1 day	Tue 12/13/16	Tue 12/13/16	3SS
13	1st Stack Test Process Sampling	1 day	Tue 2/7/17	Tue 2/7/17	7SS
14	2nd Stack Test Process Sampling	1 day	Tue 3/28/17	Tue 3/28/17	8SS
15	Weekly Process Sampling (Tuesdays)	10.2 wks	Tue 1/24/17	Tue 4/4/17	12
28	Baseline Process Sampling Post-ACI Injection	1 day	Tue 4/11/17	Tue 4/11/17	14FS+9 days,15



Task	▨	Critical Task	▥	Milestone	◆	Summary	▬	Rolled Up Task	▨	Rolled Up Critical Task	▨

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Page 1 of 1
Print Date: Thu 1/26/17

Attachment B

Contact Information

ACI Project Team Contacts - Minorca Mine

Company	Description	First Name	Last Name	Contact Number (cell)
Nol-Tec	Project Lead	Grace	Whiteford	651-440-0411
	Project Controls	Scott	Spangenberg	651-491-1744
	Service Manager	Jason	Johnson	651-295-4298
	Technical Sales	Mitch	Lund	612-418-7108
FPG	Onsite Project Lead	Jeremy	Steele	770-283-0638
	Offsite Project	Layne	Wesley	770-283-0298
Minorca Mine	Project Lead	Nate	Holmes	218-410-0506
	Secondary Contact	Jaime	Johnson	218-290-0160
	Safety	Karla	McKenzie	218-750-1077
	Secondary Safety	Joyce	Vesel	218-421-8145
Barr Engineering	Project Lead	Ryan	Siats	218-788-6364 (office)
	Stack Testing Lead	Ben	Wiltse	952-832-2885 (office)

EMERGENCY CONTACT at MINORCA MINE

Control Room - 218-305-3407

Control Room - Channel 1 on Radio

Attachment C

ACI Testing Emergency Shutdown Procedure

To: Shift Managers/SOT, Control Room Operators, Robb Peterson, and Dave Tomassini

From: Nate Holmes

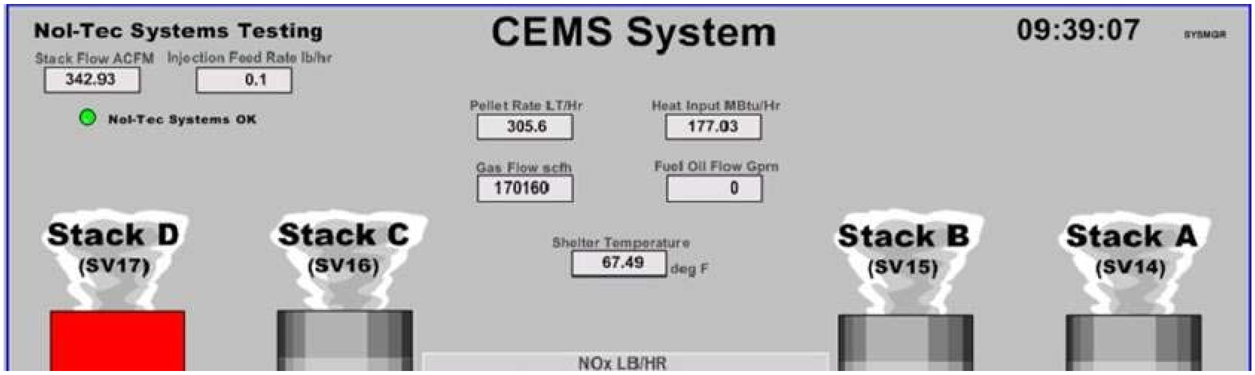
Date: January 23rd, 2017

Subject: Activated Carbon Testing

Nol-tec is currently injecting activated carbon at 20-25lb/hr. The carbon is being injected to remove mercury from the exhaust stacks. The test unit is set up west of the process fans.

There will be a Nol-tec representative on site during day shift, 7 days a week. The shift coordinator will need to check the system a couple times a night during night shifts. This check is a quick walk through the system to make sure everything is running correctly and that carbon is not being blown everywhere. If a problem is discovered, there is an "OFF" button located on the HMI screen in the front portion of the trailer. Enter the back of the trailer, walk thru the trailer, open the door at the back, to the right is the control panel with the "OFF" button. Just below the control panel is an emergency stop button, which should be used if the HMI screen is unavailable or if the issue is creating an immediate safety hazard.
If you shutdown the system, please call Nol-tec. Alarms have been programmed into the DCS system to make sure the system is feeding carbon in the correct operating range. If an alarm occurs, please take a quick walk thru of the system and call Nol-tec. **The Nol-tec representative is Layne Wesley (770) 283-0298.**

Alarms have been programmed into the DCS system to make sure the system is feeding carbon in the correct operating range (per email from Todd Sarazine on 1/20/2017 at 9:30am). If an alarm occurs, the Control Room Operator shall notify the Shift Manager/SOT to complete a site visit of the unit.



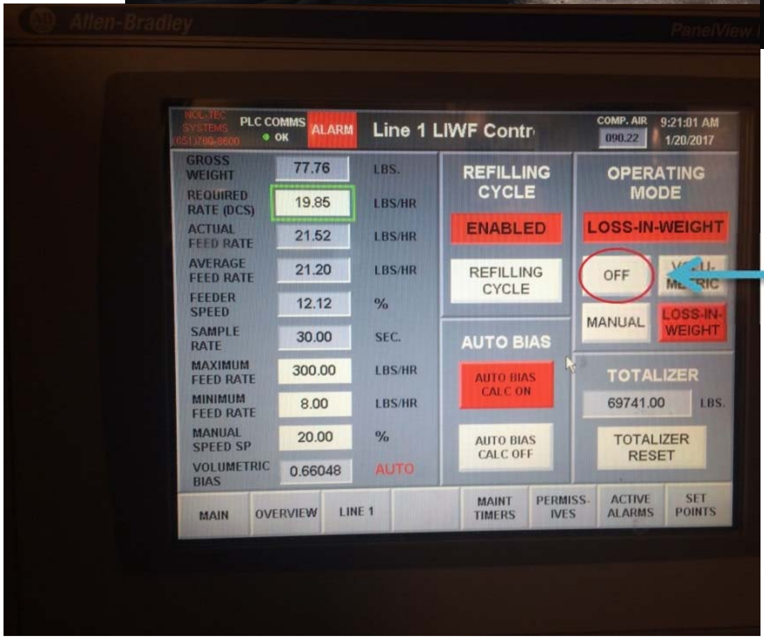
Nol-Tec Systems Testing

CEMS System

09:39:07

Stack Flow ACFM: 342.93
Injection Feed Rate lb/hr: 0.1
● Nol-Tec Systems OK
Pellet Rate LT/Hr: 305.6
Heat Input MBtu/Hr: 177.03
Gas Flow scfh: 170160
Fuel Oil Flow Gpm: 0
Shelter Temperature: 67.49 deg F

ACI TEST UNIT



Line 1 LIWF Contr

PLC COMMS ● OK

COMP. AIR 090.22

9:21:01 AM 1/20/2017

GROSS WEIGHT	77.76	LBS.
REQUIRED RATE (DCS)	19.85	LBS/HR
ACTUAL FEED RATE	21.52	LBS/HR
AVERAGE FEED RATE	21.20	LBS/HR
FEEDER SPEED	12.12	%
SAMPLE RATE	30.00	SEC.
MAXIMUM FEED RATE	300.00	LBS/HR
MINIMUM FEED RATE	8.00	LBS/HR
MANUAL SPEED SP	20.00	%
VOLUMETRIC BIAS	0.66048	AUTO

TOTALIZER 69741.00 LBS.

OFF Button

ACI Project Team Contacts - Minorca Mine

Company	Description	First Name	Last Name	Contact Number (cell)
Nol-Tec	Project Lead	Grace	Whiteford	651-440-0411
	Project Controls	Scott	Spangenberg	651-491-1744
	Service Manager	Jason	Johnson	651-295-4298
	Technical Sales	Mitch	Lund	612-418-7108
FPG	Onsite Project Lead	Jeremy	Steele	770-283-0638
	Offsite Project	Layne	Wesley	770-283-0298
Minorca Mine	Project Lead	Nate	Holmes	218-410-0506
	Secondary Contact	Jaime	Johnson	218-290-0160
	Safety	Karla	McKenzie	218-750-1077
	Secondary Safety	Joyce	Vesel	218-421-8145
Barr Engineering	Project Lead	Ryan	Siats	218-788-6364 (office)
	Stack Testing Lead	Ben	Wiltse	952-832-2885 (office)

EMERGENCY CONTACT at MINORCA MINE

Control Room - 218-305-3407

Control Room - Channel 1 on Radio

Attachment D

Process and Lab Data Points

ArcelorMittal Minorca Mine
Test Plan for Extended Testing of Activated Carbon Injection
Attachment D - Minorca Process Data Matrix Table

🟩 Will Monitor
🟥 Will Not Monitor
🟨 Will Not Monitor - Available on data base if problem occurs

Mine/Plant Location	Description
Mine Data	🟩 Mine Blend
	🟩 Silica Target
	🟩 projected wt recovery/project silica
Fines Crusher	🟥 FC Tonnage
	🟥 Reclaim tonnage from storage or piles- not to worry about this
	🟥 Dust Collector data
	🟥 Dust Supressant Data
Concentrator	🟩 Rod Mill Feed tons
	🟩 Rod Mill Feed Prodcut Size
	🟩 Plant Weight Recovery
	🟩 Iron Recovery
	🟩 Conc Iron
	🟩 Silica
	🟩 Grind Size- Final Concentrate
	🟥 Process Water Temperature
	🟩 Abiant Temperature
	🟩 Repulper Tank (Concentrate Reclaim Feed to Acid Conc - Slurry
	🟨 Head Tank Water flow
	🟨 Process Water Tank Flow
	🟥 Flotation data- Control Targets
	🟩 Tailing Coarse tonnage
	🟩 Tailings Fine tonnage
	🟩 Filter Cake Moisture
	🟩 Flux addition rate
	🟥 Dust Collection Emmission Data
	🟥 Flocculant Rates
	🟥 Flotation Chemical Rate

Pellet Plant	Feed tonnage to Grate
	Begin Preheat Temp
	Mid Preheat Temp
	End Preheat Temp
	Begin Firing Temp
	End Firing Temp
	Grate Temperature
	Exhaust Stack Temperatures
	Preheat Burner Tempertaure
	Recoup Temperature
	Pellet Temperature
	CEMS Data
	Fan Data - Motor amps (all)
	Pallet/Grate Speed
	Updraft Flows and Temperature
	DownDraft Flows and Temeperature
	Fuel Rate- Nat Gas Flow
	Air Flow - Inlet
	Windbox Information
	Windbox Fan Information
	Binder addition rate
	Scrubber Flow
	Scrubber Flow water
	All emmision data - pressures flows
	Cooling Zone Temperatures
	Recoup Fan Data
	Cooling Fan Data
	Updraft Drying Fan Data
	ExHaust Fan Data
	Greenball Quality Parameters?
	Greenball Moisture
	windbox exhaust fan vibration monitor

Pellet Quality Parameters	CaO/SiO2 Ratio (C/S Ratio)
	MgO/SiO2 Ratio (M/S Ratio)
	Pellet Silica
	Contraction
	Pellet Cold Compression Strength (CSS)
	(BT -1/4”) Pellet Size
	(AT +1/2”) Pellet % Oversize
	(AT 3/8 X 1/2”) Pellet Size
	(AT -1/4”) Pellet Size

Enviromental Monitor Parameters	Indurator scrubber (4 stacks) water flow
	Stack Temp (each stack)
	Stack Exhaust Gas Flow(each stack)
	Stack SO2 (each stack)
	Stack NOx (each stack)

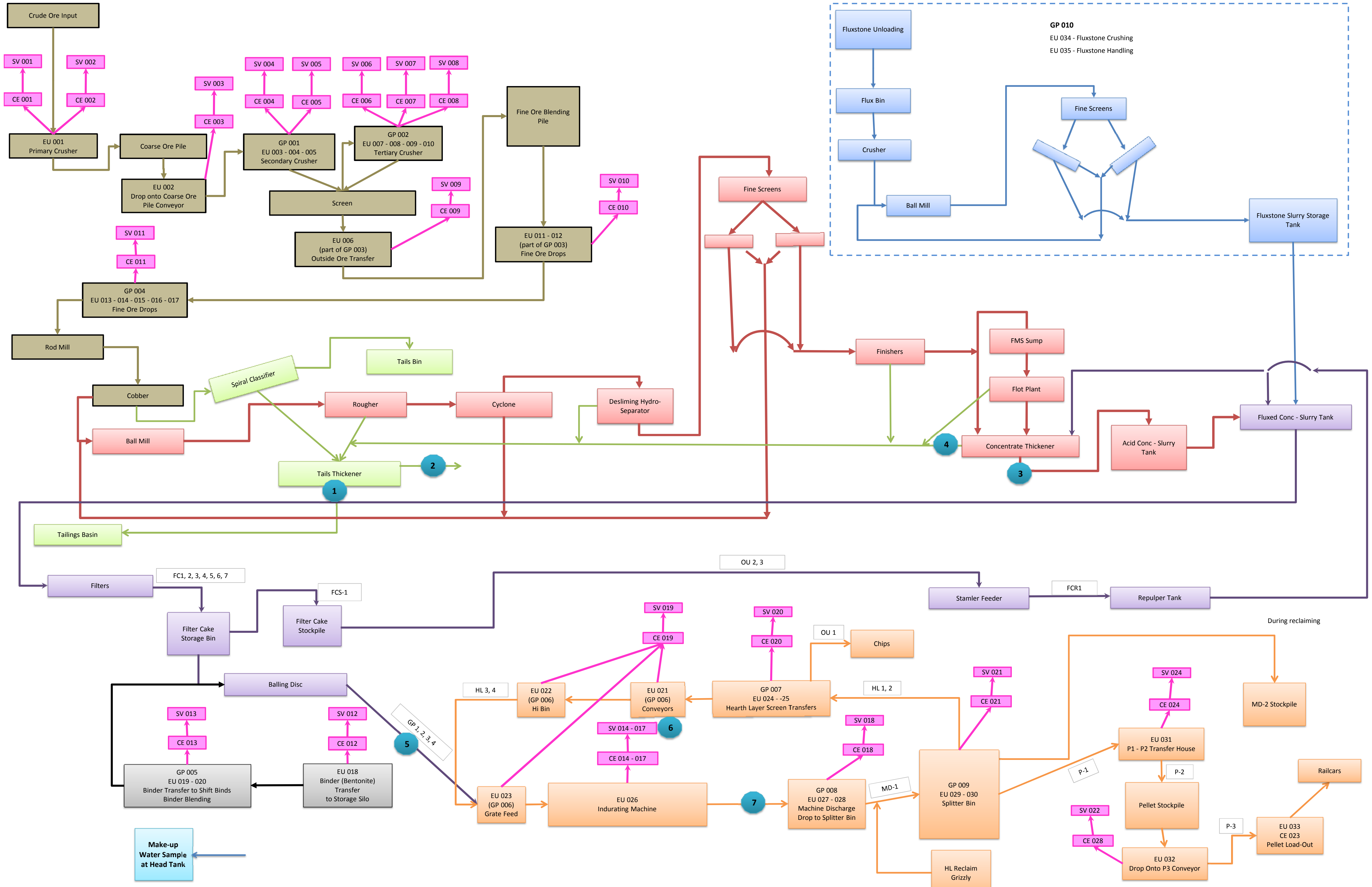
Attachment E

Weekly Process Sampling Locations

ArcelorMittal Minorca Mine
Process Flow Diagram

● Weekly Process Sampling Locations

Pink - CE + SV Numbers | Brown = Taconite ore | Red = Iron | Green = Tailings/Waste | Blue = Flux Stone | Purple = Pellet Mix/ Green Balls | Orange = Finished Pellets | Grey = Other Additions

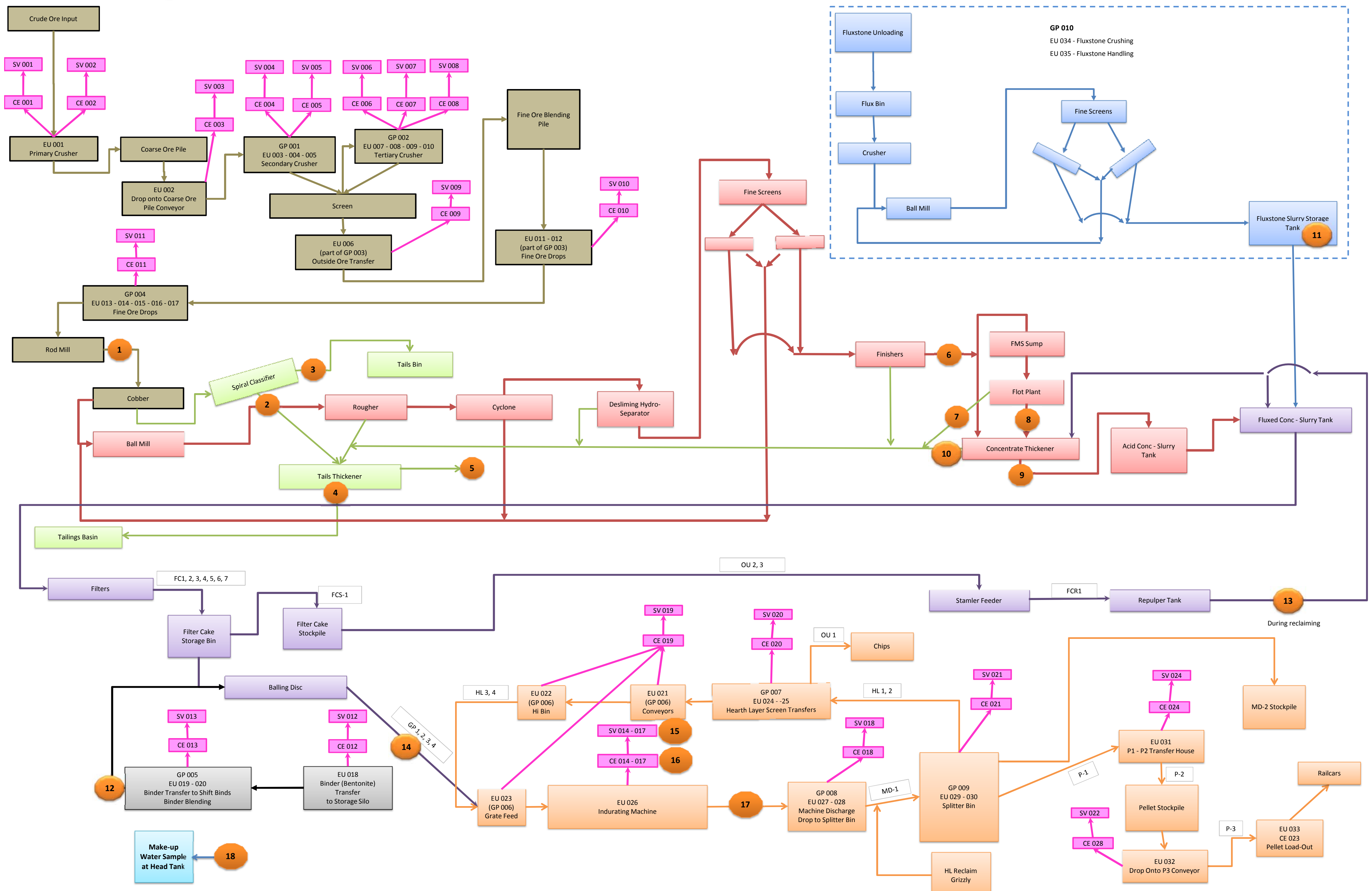


1. Tails Thickener (underflow) (fine tails)
2. Tails Thickener (overflow)
3. Concentrate Thickener (underflow)
4. Concentrate Thickener (overflow)
5. Green Ball (balling disc discharge)
6. Scrubber Blowdown/Scrubber Sump
7. Final Pellet Sample

Attachment F

Process Sampling Locations during Stack Testing

ArcelorMittal Minorca Mine
Process Flow Diagram



1. Rod Mill Discharge
2. Sands of Spiral Classifier to Tails Bin (Cobber Tails)
3. Spiral Classifier (overflow)
4. Tails Thickener (underflow) (Fine Tails)
5. Tails Thickener (overflow)
6. Finishers Concentrate Discharge to Concentrate Thickener/FMS Sump
7. Flotation Reject Product to Tailings Thickener
8. Concentrate Thickener Feed
9. Concentrate Thickener (underflow)
10. Concentrate Thickener (overflow)
11. Fluxstone Feed (from Fluxstone Slurry Storage Tank)
12. Binder Supply (feed to bin)
13. If in use, Repulper Tank (Concentrate Reclaim Feed to Acid Concentrate – Slurry Tank/Fluxed Concentrate – Slurry Tank)
14. Green Ball (balling disc discharge)
15. Multiclones (windboxes recycle to concentrate thickener)
16. Scrubber Blowdown/Scrubber Sump
17. Final Pellet Sample
18. Make-up water sample from plant head tank/raw water feed to plant

Attachment D

Coleraine Minerals Research Laboratory Report – Mercury Removal from Induration Off Gas by Wet Scrubbers

MAY 03 2002

MERCURY REMOVAL FROM INDURATION OFF GAS BY WET SCRUBBERS

COLERAINE MINERALS RESEARCH LABORATORY

November 15, 2001

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Mercury Removal from Induration Off Gas by Wet Scrubbers

SUMMARY

During the induration of taconite pellets, green balls are heated to greater than 2200°F. A previous study[1] indicated that greater than 90 percent of the mercury contained in the green balls is volatilized during induration. Some of the volatilized mercury is removed by the gas scrubbers. Studies[2-4] on coal burning power plants indicate that the mercury in flue gas is present as either elemental mercury or as divalent mercury. In power plant scrubbers, the majority of the divalent mercury is removed, but very little elemental mercury is removed by the scrubbers. The particulate matter in the off gas appears to remove a significant portion of the mercury that is removed. It is thought that the off gas chemistry and the scrubber water chemistry could affect the removal of mercury. To determine if the scrubber water chemistry could affect the removal of mercury from taconite pelletizing off gases, the Minnesota Department of Natural Resources' (MNDNR) environmental cooperative funded a study to sample around the scrubbers from the plants equipped with wet scrubbers to determine if water chemistry affects mercury removal. Another objective of the study was to determine the role of solids entrained in the off gases and removed by the scrubbers. These solids are returned to the process. If they were discarded, then some amount of mercury could be eliminated from the system, but at a cost of iron units.

Samples were obtained from Minntac, EVTAC, Minorca, Hibtac and Northshore. With the exception of the mercury analyses, all chemical analyses were conducted at Coleraine. Mercury analyses were run by Frontier Geosciences of Seattle, Washington.

While the various plants have different scrubber configurations and scrubber water chemistries, these differences appeared to have no significant affect on mercury removal. Accurate mercury balances were not possible because mercury content in the fired pellets from all of the plants was below the detection limit of about 0.6 parts per billion (ppb). Solids entrained in the off gases removed significantly more mercury than the scrubber water. Of the mercury removed in the scrubber systems, the amount contained in the solids ranged from 75 percent at Northshore to greater than 99 percent at EVTAC. The minus 10 micron fraction of the solids in the off gases appears to remove the most mercury. Analysis of the solids that are continually recycled to the Minorca wet scrubbers indicates a high capacity for mercury removal (the solids assayed over 3000 ppb mercury). This result indicates that the mercury should remain with the solids and should not leach if the solids were sent to the tailings basin.

INTRODUCTION

During the pelletizing process, the majority of mercury contained in the green balls is vaporized and leaves with the off gases. Wet scrubbers remove some of this mercury. Mercury that is removed is either dissolved in the water or is associated with the solids entrained in the off gas stream. It is generally assumed that mercury removed by the scrubber water and solids is present as divalent mercury and mercury that is not removed by the scrubbers is present as elemental mercury. Based on research on coal fired power plant emissions, most of the removed mercury is associated with the solids that are generally recovered in the electrostatic precipitators and that the amount of carbon, chlorine, and sulfur in the off gas can affect the amount of mercury removed. It is possible that other elements in the indurating off gas may also affect the amount of mercury removed by the wet scrubbers.

In most cases, the solids contained in the scrubber water are recovered and are recycled to green ball feed. This practice tends to increase the amount of mercury in the green balls. One of the objectives of this program is to determine how much mercury is being recycled and how much iron would be lost if the material was wasted instead of recycled.

The MNDNR's environmental cooperative funded a study by the Coleraine Minerals Research Laboratory (CMRL) to sample the various plants and conduct chemical analyses of the various streams. Sampling was conducted at the five operating taconite plants (Hibtac, Minntac, EVTAC, Minorca, and Northshore) that are equipped with some type of wet scrubbers on the indurating off gases. The main objective of the sampling program was to determine if scrubber water chemistry could be related to mercury removal by the wet scrubbers. The test program was **not** designed to provide a mercury balance around the indurating plant. Data contained in this report cannot be used to accurately calculate the amount of mercury being released to the atmosphere by any of the sampled plants.

SAMPLING PROGRAM

Grab samples were taken of the materials entering the system: green balls, solid fuel (if any), and scrubber inlet water; and exiting the system: fired pellets, scrubber water out, and multiclone solids (if any). Sampling devices were cleaned with dilute acid and distilled water prior to the sampling. Each of the sampling devices were purged with the material being sampled. All samples were brought to the Coleraine Minerals Research Laboratory (CMRL) for filtering and chemical analysis. (Samples from Hibtac were from a previous sampling program conducted by Hibtac in October of 1998.) All liquid samples were filtered through 0.45 micron paper, with the solids content being measured. All solids samples were dried, with the moisture content being recorded. All solids processing equipment was thoroughly cleaned and was purged with the material being processed (when possible). Splits of the solids and water samples were sent to Frontier Geosciences in Seattle for mercury analysis. All remaining analyses were run at CMRL by ICP.

OFF GAS TREATMENT SCHEMES

Each of the plants has slightly different wet scrubbers. Minntac has the simplest flowsheet, Figure 1, where the exhaust from the grate-kiln system is sent to one scrubber per line, fresh water is added to the scrubber, and the water with entrained solids is removed and sent to a thickener. Both the water and solids are eventually recycled to the process, but nothing is recycled to the scrubber.

EVTAC also employs the grate-kiln system, but has a more complicated scrubber flowsheet, as shown schematically in Figure 2. EVTAC's system consists of a scrubber and a de-misting tank. Fresh water is added through slats in the top of the de-misting tank. That water plus the water and solids from the scrubber are sent to a thickener. The thickener overflow is recycled to the scrubber. Thickener underflow is sent back to the process. In steady state, the water added at the slats (slat water) is equal to the amount of water removed with the thickener underflow.

Minorca has a traveling grate machine with two separate gas streams going to the scrubber as shown in Figure 3. The first (hood exhaust) goes directly to the scrubber, while the second and larger stream (window exhaust) goes to a series of "multi clones" to remove most of the entrained dust. Gas from the multi clones goes to the scrubber. Water to the scrubbers is continuously recycled, with fresh water being added to maintain sump level.

Hibtac is similar to Minorca in that it has a traveling grate and a dry dust removal step prior to the wet scrubbers, as shown schematically in Figure 4. It is not known if all of the off gas passes through the dry dust removal section, but all of the off gas is treated by the wet scrubbers. Scrubber water is not recycled directly to the scrubber.

Northshore also employs a traveling grate machine and has two off gas streams, as shown in Figure 5. Unlike Minorca and Hibtac, there is no dust removal prior to the scrubbers and there are separate scrubbers for each exhaust stream. Fresh water is added to the scrubbers with no direct recycle.

WATER CHEMISTRY

Chemical analyses for the water samples taken in the test program are given in Table I. All of the analyses are in parts per million (ppm) except for the mercury analyses, which are in nanograms per liter (ng/l) or parts per trillion (ppt).

For Minntac there were only two water samples; scrubber water in and scrubber water out. Looking at the Minntac analysis in Table I, the mercury results appear to be wrong in that the scrubber in water has more mercury than the water out. Previous work[1] showed a mercury content of 2.05 ng/l in the water in and 491.55 ng/l in the scrubber out water. The scrubber in water analysis was a quality control sample for Frontier, which means that it was run in duplicate and was run with a known addition. The duplicate analyses were 74.5 and 83.3 ng/l for an average of 78.9 ng/l report in Table I. Frontier's reports for all samples with the quality control results are given in Appendix I. Since the duplicate analyses were reasonably close, it appears that the mercury analysis of the scrubber in water is truly the mercury content on the sample sent to Frontier. It is possible that the scrubber out sample was accidentally poured into both the scrubber in and scrubber out bottles that were sent to Frontier. Based on the cation and anion analyses for the Minntac waters (Table I), samples were taken of the scrubber in and scrubber out waters.

For EVTAC there were five water samples as shown in Table I. EVTAC has two thickeners for the scrubbers; therefore, there is an overflow and underflow sample for each thickener as well as the makeup water (slat spray water). Again, there appears to be a problem with the mercury analyses. In this case, thickener overflow 2A appears to be too high in mercury. The other analyses look appropriate.

For Northshore there were also five water samples (Table I), since both lines 11 and 12 were sampled. With the exception of the Waste Gas Water from line 11, the analyses look consistent. The reason for the low cation and anion concentrations in line 11 waste gas water is unknown. Northshore has the most unique water chemistry due to the addition of soda ash to soften the water.

Only two water samples were obtained from Minorca - the recycled scrubber water and the make up water. As would be expected from recycling the water, the Minorca scrubber water had the highest mercury content of 112 ppt.

Hibtac supplied three water samples for analyses. It appears that only the make-up water and the scrubber water are germane to this study.

As mentioned above, some sampling of scrubber water was conducted as part of a previous study in 1997[1]. Mercury analyses of those waters were significantly different from the current study, as shown in Table II. For Minntac and Hibtac, there was a large decrease in the mercury content of the water coming out of the scrubber, while the mercury concentration in the water from the Northshore scrubbers increased, especially line 11. For Hibtac and Northshore, the mercury content in the scrubber input water had increased. The 1997 mercury analyses were also conducted by Frontier Geosciences.

SOLIDS CHEMISTRY

Solids from the sampling program were analyzed for mercury by Frontier. The samples were analyzed at Coleraine for total iron, ferrous iron, silica, CaO, MgO, alumina, sulfur and carbon (coal sample only). Results are given in Table III. Frontier Geosciences' reports of mercury analysis for the solid samples are included in Appendix I. Values in Table III are in dry weight percent except for the mercury, which are in ng/g (ppb).

For Minntac there were four solid samples: the greenballs, fired pellets, solids contained in the scrubber discharge, and coal. Fired pellet mercury content was below the detection limit of 0.6 ppb. For Minorca there were also four solid samples: the greenballs, fired pellets, multiclone dust, and the solids in the recycling scrubber water. As with the Minntac sample, the fired pellet mercury content was below detection limits. For EVTAC there were 7 solid samples: greenballs, fired pellets, coal, two thickener underflows (A & B), and two thickener overflows. Again, the fired pellets were below the mercury detection limits (0.69 ppb in this case). Hibtac provided 7 solid samples: filtercake, concentrate, greenballs, limestone, bentonite, fired pellets and multi-tube dust.

Unfortunately, Hibtac did not supply a sample of the solids in the scrubber discharge. Again, the fired pellets were below the mercury detection limits of 0.69 ppb. For Northshore there were eight samples (four per line): greenballs, fired pellets, solids from the hood exhaust scrubber and solids from the waste gas scrubber. Line 12 fired pellets were reported to contain 1.85 ppb mercury, which is most likely a mistake. Line 11 fired pellets were below the detection limit as were all the other fired pellet samples from the other plants.

Comparing the greenball mercury analysis with the 1997 study indicated essentially the same mercury concentration for both studies, as shown in Table IV.

Part of the work on the solids included screening selected samples on a 10 micron screen and having mercury analyses run on the size fractions. Samples screened were the two thickener underflow samples from EVTAC and the multitube dust from Hibtac. Results are given in Table V. As was expected, there was very little minus 10 micron material in the multitube dust. About 30 percent of the thickener underflow solids was minus 10 micron. Due to the relatively small amount of minus 10 micron material, no analysis was performed on that fraction. Mercury concentration in the minus 10 micron fraction was calculated from the head mercury, the mercury in the plus 10 micron fraction and the weight split. Mercury was concentrated in the minus 10 mesh fractions. All of the minus 10 mesh material had a calculated mercury concentration of greater than 1 ppm.

ESTIMATED MERCURY BALANCES

Estimated mercury balances for the various plant scrubbers are given in Table VI. Since all of the fired pellet mercury analyses were below detection limits, a value of 0.5 ng/g (ppb) was assumed for all fired pellets. Also included in Table VI is the mercury balance if the pellets contain 0 ng/g and 0.69 ng/g (detection limit).

Minntac - For the period tested, the greenball feed rate was 450 ltph at a moisture of 9.5 percent. Coal was added at the rate of 13,000 lb/hr and the flow rate to the scrubber was 2,960 gpm. As shown in Table VI, the greenballs added 3.355 grams per hour (g/hr) of mercury to the system; the coal added 0.149 g/hr and the scrubber water added 0.0067 g/hr. (a value of 10 ng/l was assumed for the scrubber in water). Coming out of the system the fired pellets (at the assumed mercury content) removed 0.194 g/hr mercury; the solids with the scrubber water removed 0.115 g/hr and the scrubber water removed 0.0447 g/hr. Based on the calculated tonnage of solids with the scrubber water and the iron analysis (Table III) of the scrubber, there are about 0.832 tph of iron in the scrubber solids. Assuming 100 percent operating time (8,760 hours per year), not recycling the scrubber solids would result in about 2.2 pounds of mercury being removed from the system with a loss of about 7,300 tons of iron units per year.

Northshore - Line 11 was being fed 196 ltph of greenballs at 10.1 percent moisture with an estimated scrubber feed rate of 1,000 gpm. As shown in Table VI, this results in 0.258 g/hr mercury being added to the system with the greenballs and 0.0016 g/hr being added with the scrubber water. Coming out of the system, the fired pellets removed 0.0847 g/hr (using the assumed mercury content in the fired pellets); the combined scrubber solids removed 0.021 g/hr; and the combined scrubber water removed

0.007 g/hr. Line 12 was very similar, as shown in Table VI. As was the case for Minntac, more mercury was removed with the scrubber solids than with the scrubber water.

EVTAC - The system was being fed 600 ltph of greenballs at 9.5 percent moisture. Coal was being added at a rate of 7.52 ltph and slat water at 980 gpm. At these rates, the greenballs added 6.627 g/hr mercury; the coal added 0.0788 g/hr; and the slat water added 0.0012 g/hr as shown in Table VI. Exiting the system, the fired pellets removed 0.2619 g/hr mercury, the combined solids in the thickener underflows removed 0.7761 g/hr mercury; and the thickener underflow water removed 0.0040 g/hr mercury. Assuming 100 percent operating time, discarding the thickener underflow solids would remove 14.99 pounds of mercury a year from the system with a loss of about 5,423 tons of iron units.

Minorca - Since there was no estimate of the amount of dust from the multiclone, there was no way to estimate a mercury balance. It is of interest to note the high mercury concentration (3.179 ppm) in the solids recycled with the scrubber. This indicates that magnetite dust has a high capacity for removing mercury and would suggest that any scrubber solids sent to the tailing basin would not be leached by the water.

Hibtac - As with Minorca, there was no estimate of the rate of multitube dust production. That, combined with a lack of the solids contained with the scrubber water, precluded the calculation of a mercury balance.

CONCLUSIONS

Sampling around the scrubbers at five taconite plants has indicated that the majority of the mercury that is removed by the various scrubbers is removed by the solids, either wet or dry. Mercury in the solids appears to be concentrated in the minus 10 micron fractions. There was no indication that the scrubber water chemistry had any affect on the amount of mercury removed by the water. Discarding the solids from the scrubber system could remove significant amounts of mercury from the system without a catastrophic loss of iron units. Results from Minorca's scrubber solids recycling indicates that the scrubber solids have a relatively high capacity for the deposition of mercury, which implies that the scrubber solids would retain the mercury in the tailings basin. Since the fired pellet mercury analyses were all below detection limits, no accurate mercury balances could be calculated. Using an assumed value of 0.5 ng/g mercury in the fired pellets, the fired pellets removed a significant amount of mercury compared to the scrubber solids and water.

REFERENCES

1. Engesser and Niles, Mercury Emissions for Taconite Pellet Production, Technical Report CMRL/TR-97-11, September 1997.
2. Meij, Vredenbregt, and Winkel, The Fate of Mercury in Coal-Fired Power Plants, The A&WMA Specialty Conference on Mercury Emissions: Fate, Effects, and Control, Chicago, IL, August, 2001.
3. Gibb, Clarke, and Mehta, The Fate of Coal Mercury During Combustion, Fuel Processing Technology, Vol. 65-66, pp 365-377, 2000.
4. Galbreath and Zygarlicke, Mercury Speciation in Coal Combustion and Gasification Flue Gases, Environmental Science and Technology, Vol. 30, No. 8, page 2421, 1996.

Table I - Chemical Analysis of Water Samples

						ppm					
Minntac	Hg, ng/g	pH	IC	Na	K	Ca	Mg	SO4	Cl	F	TOC
Scrub in	78.90	8.11	41.00	73.23	26.26	117.14	176.81	717.60	141.80	2.91	3.70
Scrub out	66.50	6.62	5.60	74.57	27.47	135.63	180.27	878.10	163.80	8.00	2.80
				2%	5%	15%	2%	22%	16%	175%	
Inland											
Process water	5.67	7.88	37.10	41.41	9.72	32.69	52.46	74.70	82.00	5.79	3.80
Scrub out	112.00	4.57	1.40	52.07	14.61	62.03	73.63	154.20	205.70	47.50	2.80
Northshore											
Feed Water	7.05	9.71	36.90	738.50	53.33	22.57	6.08	426.30	395.00	35.80	6.70
Hood Exhaust 11	32.80	7.65	30.30	780.60	56.01	24.32	7.12	531.60	436.30	130.90	6.80
Hood Exhaust 12	15.70	7.54	31.40	808.30	53.01	23.42	7.00	504.30	458.30	136.30	7.80
Waste Gas Wat 11	29.10	7.81	34.20	441.40	33.70	19.65	7.17	279.30	266.70	68.50	5.00
Waste Gas Wat 12	15.70	7.79	44.60	851.30	63.77	25.29	7.34	518.10	487.20	130.90	9.10
Evtac											
Thick unflo 2A	15.48	4.44	2.76	103.38	20.83	175.16	67.73	752.10	79.50	31.70	5.12
Thick oflo 2A	82.22	3.92	2.96	103.50	20.26	168.11	65.29	766.50	84.10	45.70	5.81
Thick unflo 2B	18.12	4.49	2.61	100.26	18.82	146.36	67.62	704.10	76.00	38.80	5.44
Thick oflo 2B	24.35	4.53	3.32	98.92	18.69	136.31	65.30	668.40	78.20	40.40	5.17
Slat Spray Water	5.25	7.25	29.24	74.30	10.89	44.57	55.74	246.60	55.00	12.00	6.41
Hibtac											
Conc water	8.61	7.99	90.89	58.75	10.80	74.79	128.89	265.20	64.20	8.30	7.92
Make-up water	5.37	8.00	40.79	58.31	16.26	40.32	74.58	204.90	57.20	9.80	3.62
Scrub water	11.95	7.63	22.79	58.95	16.94	41.23	74.77	267.60	62.30	18.00	2.84

Table II - Comparison of Mercury Content in Water Samples From 1997 and Current Study.

			Hg, ng/l	
Minntac		1997	Current	Current
	Scrubber in	2.05	78.9	
	Scrubber out	491.55	66.5	
Hibtac				
	Scrubber in	2.81	5.37	
	Scrubber out	63.35	11.95	
Northshore			Line 11	Line 12
	Scrubbers in	2.21	7.05	7.05
	Hood Exhaust out	6.61	32.8	15.7
	Waste Gas out	10.87	29.1	15.7

Table III - Chemical Analyses of Solid Samples

					Percent					
	Hg, ng/g	Fe	SiO2	CaO	MgO	Al2O3	Sat Mag	Fe+2	S	C
Evtac Greenball	12.00	66.60	6.14	0.80	0.48	0.10	66.53	22.92	0.016	
Evtac Fired Pellet	<0.69	64.90	6.18	0.72	0.48	0.10	0.58	0.79	0.003	
Evtac Coal	10.30	0.09	2.01			0.95			2.980	74.63
Evtac Thickner Unflow 2A	527.00	55.00	17.56	0.98	1.25	0.74	39.56	14.50	0.064	
Evtac Thickner Oflow 2A	233.00	49.60	23.64	0.85	1.68	1.08	28.53	11.89	0.083	
Evtac Thickner Unflow 2B	367.00	57.20	15.53	0.87	1.06	0.53	43.86	14.93	0.099	
Evtac Thickner Oflow 2B	826.00	48.30	24.21	1.31	1.81	0.90	28.47	11.83	0.074	
Hibtac Filter Cake	13.90	67.90	4.17	0.31	0.30	0.07	68.90	22.88	0.015	
Hibtac Concentrate	18.20	68.40	3.97	0.16	0.28	0.05	68.12	23.24	0.005	
Hibtac Limestone	3.72	0.02	0.46	55.05	0.69	0.11			0.285	
Hibtac Multi-tube Dust	154.00	66.90	4.56	0.28	0.32	0.13	38.01	12.58	0.028	
Hibtac Greenball	16.70	67.60	4.69	0.31	0.30	0.18	68.67	21.39	0.022	
Hibtac Bentonite	26.40	3.03	61.47	0.09	1.91	17.60			0.295	
Hibtac Fired Pellet	<0.69	66.20	4.62	0.31	0.33	0.17	1.99	1.09	0.000	
Northshore Waste Gas 11	211.00	61.20	5.94	3.80	1.25	0.35	52.76	16.49	0.030	
Northshore Waste Gas 12	110.00	62.20	4.34	3.96	1.12	0.32	52.74	16.40	0.022	
Northshore Hood Exhaust 11	26.00	63.20	3.92	3.68	1.02	0.33	56.68	18.53	0.030	
Northshore Hood Exhaust 12	26.40	62.70	4.56	3.72	1.04	0.35	54.26	17.01	0.031	
Northshore Greenball 11	1.44	63.20	3.86	3.85	1.03	0.28	63.33	20.73	0.013	
Northshore Greenball 12	1.10	63.10	4.06	3.85	1.04	0.32	62.81	20.29	0.018	
Northshore Fired Pellet 11	<0.69	63.30	4.42	3.91	1.05	0.34	2.01	0.21	0.011	
Northshore Fired Pellet 12	1.85	63.20	4.25	3.94	1.04	0.33	1.76	0.18	0.014	
Minntac greenball	8.10	62.90	4.48	3.27	1.12	0.18	62.88	21.00	0.016	
Minntac fired pellet	<0.6	63.60	4.64	5.58	1.13	0.20	1.45	0.20	0.014	
Minntac scrubber out	87.00	64.00	4.57	2.19	1.10	0.25	52.50	15.20	0.015	
Minntac coal	25.30	0.20	0.86			0.74			0.327	66.39
Minorca scrubber solids	3179.00	55.40	14.13	2.88	1.78	0.22	13.85	4.38	0.050	
Minorca multiclone dust	193.00	49.40	5.18	9.63	4.94	0.15	13.47	4.26	0.058	
Minorca green balls	7.80	61.10	4.29	4.35	1.39	0.15	61.00	20.99	0.014	
Minorca fired pellet	<0.6	62.60	4.38	4.52	1.45	0.15	6.44	1.47	0.004	

Table IV - Comparison of Mercury Content in Greenballs and Fired Pellets From 1997 and Current Study.

			Hg, ng/g	
Minntac		1997	Current	Current
	Greenballs	7.5	8.1	
	Fired Pellets	0.65	<0.60	
Hibtac				
	Greenballs	16.2	16.7	
	Fired Pellets	0.94	<0.69	
Northshore			Line 11	Line 12
	Greenballs	0.83	1.44	1.1
	Fired Pellets	0.29	<0.69	<0.69

Table V - Distribution of Mercury Between Plus and Minus 10 Micron Fractions

EVTAC	Sample	Wt, g	Wt %	Hg, ng/g	Hg Dist, %
Un'flow 2A	+10 microns	2.75	66.91	38.8	4.93
	-10 microns	1.36	33.09	1514.2	95.07
	head			527.0	
Un'flow 2B	+10 microns	4.70	73.90	48.6	9.79
	-10 microns	1.66	26.10	1268.5	90.21
	head			367.0	
Hibtac Multitube	+10 microns	5.40	93.43	86.8	52.66
Dust	-10 microns	0.38	6.57	1108.9	47.34
	head			154.0	

Table VI - Estimated Mercury Balances for the Various Plants

		Hg Analysis	Flow Rate	Total Hg g/hr	% solids
Minntac	IN				
	Greenball	8.1 ng/g	450 ltph	3.3547	90.50
	Coal	25.3 ng/g	13000 lb/hr	0.1493	
	Scrubber water	10 ng/l	2960 gpm	0.0067	
	Total in			3.5107	
	OUT				
	Pellets	0.5 ng/g	382.5 ltph	0.1945	
	Scrubber solids	87 ng/g	1.33 tph	0.1150	
	Scrubber water	66.5 ng/l	2960 gpm	0.0447	0.18
	Total out			0.3542	
Northshore					
Line 11	IN				
	Green Balls	1.44 ng/g	196 lpth	0.2583	89.90
	Scrubber water	7.05 ng/l	1000 gpm	0.0016	
	Total in			0.2599	
	OUT				
	Pellets	0.5 ng/g	166.6 ltph	0.0847	
	Waste Gas Solids	211 ng/g	0.08 tph	0.0171	0.08
	Waste Gas water	29.1 ng/l	400 gpm	0.0026	
	Exhaust Solids	26 ng/g	0.15 tph	0.0039	0.10
	Exhaust water	32.8 ng/l	600 gpm	0.0045	
	Total out			0.1129	
Line 12	IN				
	Green Balls	1.1 ng/g	184 ltph	0.1852	90.00
	Scrubber water	7.05 ng/l	1000 gpm	0.0016	
	Total in			0.1869	
	OUT				
	Pellets	0.5 ng/g	156.4 ltph	0.0795	
	Waste Gas Solids	110 ng/g	0.09 tph	0.0100	0.09
	Waste Gas water	15.7 ng/l	400 gpm	0.0014	
	Exhaust Solids	26.4 ng/g	0.09 tph	0.0024	0.06
	Exhaust water	15.7 ng/l	600 gpm	0.0021	
	Total out			0.0955	
EVTAC	IN				
	Green balls	12 ng/g	600 lpth	6.6265	90.50
	Slat water	5.25 ng/l	980 gpm	0.0012	
	Coal	10.3 ng/g	7.52 ltph	0.0788	
	Total in			6.7064	
	OUT				
	Fired pellets	0.5 ng/g	515 ltph	0.2619	
	Underflow water	18.12 ng/l	980 gpm	0.0040	
	Underflow solids a	527 ng/g	0.49 tph	0.2621	0.40
	Underflow solids b	826 ng/g	0.61 tph	0.5140	0.50
	Total out			1.0420	

Total Hg in Solids (University of Minnesota)

analyzed by:

Frontier Geosciences R&C 414 Pontius Avenue North, Suite B, Seattle WA 98109
phone: (206) 622-6960 fax: (206) 622-6870 email: nicolasb@frontier.wa.com

Sample Identification	**Dry Fraction**	**Total Hg, ng/g*** wet wt basis	**dry wt basis**
Evtac Green Ball	1.000	12.0	12.0
Evtac Final Pellet	0.999	ND(<0.69)	ND(<0.69)
Evtac Coal	0.998	10.3	10.3
Evtac Thickener Un'flow 2A	0.999	526	527
Evtac Thickener O'flow 2A	0.998	233	233
Evtac Thickener Un'flow 2B	0.997	366	367
Evtac Thickener O'flow 2B	0.996	823	826
Hibtac Filter Cake	0.998	13.9	13.9
Hibtac Concentrate	0.999	18.2	18.2
Hibtac Limestone	0.999	3.72	3.72
Hibtac Mult-tube Dust	1.000	154	154
Hibtac Green Ball	1.000	16.7	16.7
Hibtac Bentonite	0.980	25.9	26.4
Hibtac Fired Pellet	1.000	ND(<0.69)	ND(<0.69)
North Shore Waste Gas Line 11	0.999	211	211
North Shore Waste Gas Line 12	0.999	110	110
North Shore Hood Exhaust Line 11	0.998	25.9	26.0
North Shore Hood Exhaust Line 12	1.000	26.4	26.4
North Shore Green Ball Line 11	0.999	1.44	1.44
North Shore Green Ball Line 12	1.000	1.10	1.10
North Shore Fired Pellet Line 11	0.999	ND(<0.69)	ND(<0.69)
North Shore Fired Pellet Line 12	1.000	1.85	1.85

*Blank corrected

ND-less than estimated MDL

Total Hg in Solids (University of Minnesota)

analyzed by:

Frontier Geosciences R&C 414 Pontius Avenue North, Suite B, Seattle WA 98109
phone: (206) 622-6960 fax: (206) 622-6870 email: nicolasb@frontier.wa.com

Sample Identification	**Dry Fraction**	**Total Hg, ng/g wet wt basis**	**Total Hg, ng/g dry wt basis**

Method Blanks

Blank-1		0.89	
Blank-2		1.96[a]	
Blank-3		0.49	
Blank-4		0.49	
Mean method blank		**0.62**	
Estimated MDL		**0.69**	

[a]Excluded from calcuation of mean method blank

Standard Reference Materials

NIST-2709		1,529	
recovery		**109.2%**	
reference value		1,400	

Total Hg in Solids (University of Minnesota)

analyzed by:

Frontier Geosciences R&C 414 Pontius Avenue North, Suite B, Seattle WA 98109
phone: (206) 622-6960 fax: (206) 622-6870 email: nicolasb@frontier.wa.com

Sample Identification	Dry Fraction	Total Hg, ng/g* wet wt basis	dry wt basis
Matrix Duplicates			
North Shore Hood Exhaust Line 11		25.89	
North Shore Hood Exhaust Line 11 MD		25.85	
Mean		**25.87**	
RPD		**0.2%**	
North Shore Fired Pellet Line 11		-0.01	
North Shore Fired Pellet Line 11 MD		1.32	
Mean		**0.66**	
RPD		**203.1%**	
Evtac Green Ball		11.98	
Evtac Green Ball MD		11.95	
Mean		**11.97**	
RPD		**0.3%**	
Matrix Spikes			
North Shore Fired Pellet Line 11 MS		9,980	
spiking level		9,488	
net		9,979	
recovery		**105.2%**	
North Shore Fired Pellet Line 11 MSD		9,868	
spiking level		9,901	
net		9,867	
recovery		**99.7%**	
RPD		**5.4%**	

*Blank corrected

Total Mercury in Process Water (University of Minnesota)

analyzed by

Frontier Geosciences R&C 414 Pontius North, Suite B Seattle WA 98109
phone: 206-622-6960 fax: 206-622-6870 e-mail: nicolasb@frontier.wa.com

sample ID	description	[Hg], ng/L	comments
#8	evtac thickener u'flow water 2A	15.48	
#20	evtac concentrate water	8.61	
#12	evtac slat spray water	5.25	
#10	evtac thickener u'flow water 2B	18.12	
#22	hibtac scrubber water	11.95	
#21	hibtac makeup water	5.37	
#9	evtac thickener o'flow water 2A	82.22	
#11	evtac thickener o'flow water 2B	24.35	
B-1	blank-1	0.12	
B-2	blank-2	0.16	
B-3	blank-3	0.16	
	mean	0.15	
	estimated MDL	0.07	
#12	evtac slat spray water rep 1	4.97	
#12	evtac slat spray water rep 2	6.21	
	mean	5.25	10.5% RPD
	matrix spike level	40.40	
#8	evtac thickener u'flow water 2A + MS	53.71	94.6% recovery
#8	evtac thickener u'flow water 2A + MSD	54.77	97.3% recovery
	mean	52.24	2.1% RPD
NIST-1641d	NIST certified water CRM rep 1	7,751	diluted 200x
NIST-1641d	NIST certified water CRM rep 2	7,054	diluted 200x
	mean	7,403	9.4% RPD
	certified value	7,950	93.1% recovery
	analysis date	2-Jul-01	

Total Mercury in Process Water (University of Minnesota)

analyzed by

Frontier Geosciences R&C 414 Pontius Avenue North, Suite B Seattle WA 98109
phone: (206) 622-6960 fax: (206) 622-6870 email: ericv@frontier.wa.com

sample ID	description	[Hg], ng/L	comments
#9	N.S. Feed Water	7.05	
#10	N.S. Hood Exhaust Water Line 11	32.8	
#11	N.S. Hood Exhaust Water Line 12	15.7	
#12	N.S. Waste Gas Water Line 11	29.1	
#13	N.S. Waste Gas Water Line 12	15.7	
B-1	blank-1	0.05	
B-2	blank-2	0.10	
B-3	blank-3	0.05	
	mean	0.06	
	estimated MDL	0.09	
#11	N.S. Hood Exhaust Water Line 12	15.72	
#11	N.S. Hood Exhaust Water Line 12	17.67	
	mean	15.89	11.7% RPD
	matrix spike level	40.40	
#11	N.S. Hood Exhaust Water Line 12 + MS	57.94	97.2% recovery
#11	N.S. Hood Exhaust Water Line 12+ MSD	56.11	92.9% recovery
	mean	57.03	3.2% RPD
NIST-1641d	NIST certified CRM (diluted 200x)	8,042	101.2% recovery
	certified value	7,950	
	analysis date	July 9, 2001	

Total Mercury in Taconite Mill Substances (Coleraine Minerals Research Lab)

analyzed by

Frontier Geosciences Inc. 414 Pontius North, Seattle WA 98109
phone: 206-622-6960 fax: 206-622-6870 e-mail: nicolasb@frontier.wa.com

sample #	sample description	[Hg]	units	date analyzed	comment
#01	Mintac scrubber in water	78.9	ng/L	18-Jul-01	QC sample
#02	Mintac Scrubber out water	66.5	ng/L	18-Jul-01	
#03	Inland process water	5.67	ng/L	18-Jul-01	
#04	Inland scrubber water	112	ng/L	18-Jul-01	
#05	Mintac greenball	8.1	ng/g	31-Aug-01	QC sample
#06	Mintac fired pellet	< 0.6	ng/g	31-Aug-01	
#07	Mintac scrubber out solids	87.0	ng/g	31-Aug-01	
#08	Mintac coal	25.3	ng/g	31-Aug-01	
#09	Inland scrubber water solids	3,179	ng/g	31-Aug-01	
#10	Inland multi-clone dust	193	ng/g	31-Aug-01	
#11	Inland fired pellet	< 0.6	ng/g	31-Aug-01	
#12	Inland greenball	7.8	ng/g	31-Aug-01	
#13	Evtac thickener 2A + 10m	38.8	ng/g	31-Aug-01	
#14	Evtac thickener 2B + 10m	48.6	ng/g	31-Aug-01	
#15	Hibtac multi-tube dust + 10m	86.8	ng/g	31-Aug-01	
	solids blank #1	0.4	ng/g	31-Aug-01	
	solids blank #2	0.4	ng/g	31-Aug-01	
	solids blank #3	0.2	ng/g	31-Aug-01	
	solids blank #4	0.8	ng/g	31-Aug-01	
	solids blank #5	0.3	ng/g	31-Aug-01	
	solids blank #6	0.2	ng/g	31-Aug-01	
	mean	0.4	ng/g	31-Aug-01	estimated MDL = 0.6 ng/g
	water blank #1	0.05	ng/L	18-Jul-01	
	water blank #2	0.06	ng/L	18-Jul-01	
	water blank #3	0.09	ng/L	18-Jul-01	
	mean	0.07	ng/L	18-Jul-01	estimated MDL = 0.06 ng/L

Total Mercury in Taconite Mill Substances (Coleraine Minerals Research Lab)

analyzed by

Frontier Geosciences Inc. 414 Pontius North, Seattle WA 98109
phone: 206-622-6960 fax: 206-622-6870 e-mail: nicolasb@frontier.wa.com

sample #	sample description	[Hg]	units	date analyzed	comment
#05	Mintac greenball	8.3	ng/g	31-Aug-01	
#05	Mintac greenball dup	7.8	ng/g	31-Aug-01	
	mean	8.1	ng/g	31-Aug-01	6.2% RPD
#05	Mintac greenball + 93.5 ng/g MS	97.4	ng/g	31-Aug-01	
	% recovery	95.6			
#05	Mintac greenball + 99.7 ng/g MSD	107.2	ng/g	31-Aug-01	
	% recovery	99.4			3.9% RPD
	NIST-2709 (soil)	1,367	ng/g	31-Aug-01	certified = 1,400 ng/g
	% recovery	97.6			
#01	Mintac scrubber in water	74.5	ng/L	18-Jul-01	
#01	Mintac scrubber in water dup	83.3	ng/L	18-Jul-01	
	mean	78.9	ng/L	18-Jul-01	11.2% RPD
#01	Mintac scrubber in water + 202 ng/L MS	292.5	ng/L	18-Jul-01	
	% recovery	105.7			
#01	Mintac scrubber in water + 202 ng/L MSD	279.7	ng/L	18-Jul-01	
	% recovery	99.4			6.4% RPD
	NIST-1641d (water)	7,926	ng/L	18-Jul-01	certified 7,950 ng/L @ 200x dilution
	% recovery	99.7			

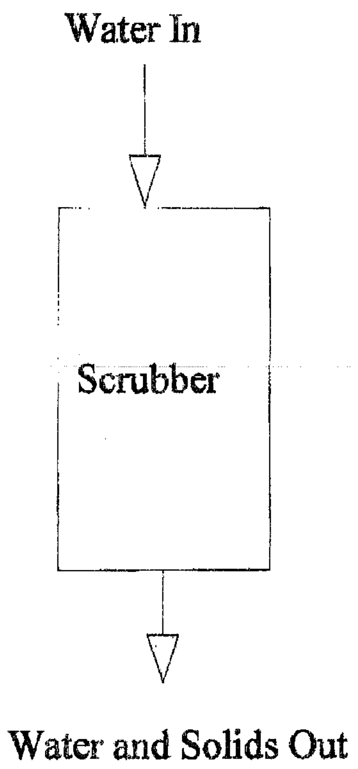

FIGURE 1 - SCHEMATIC OF MINNTAC SCRUBBER

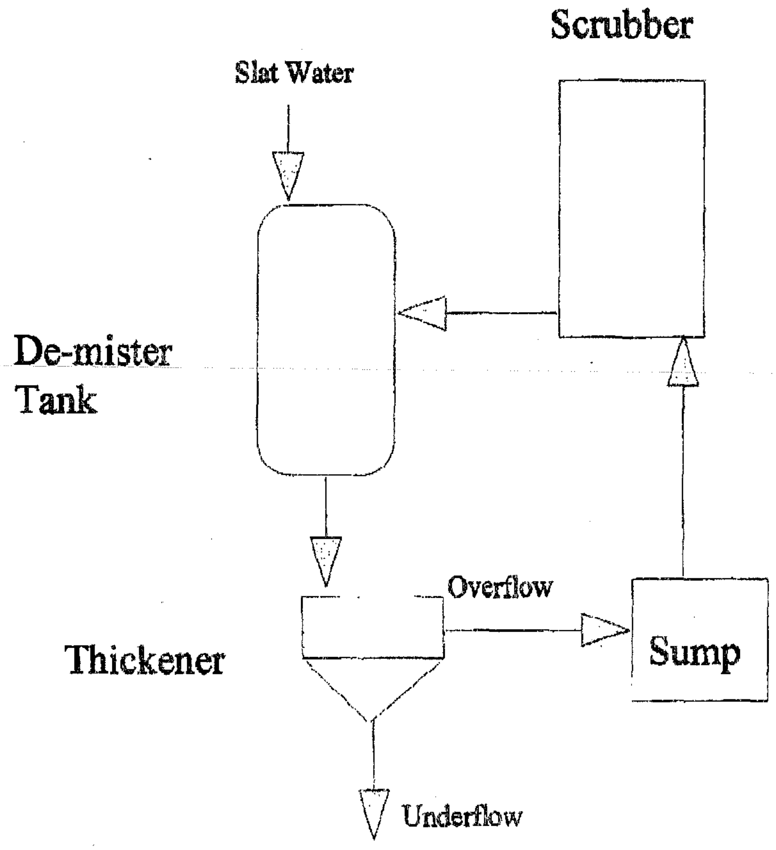

FIGURE 2 - SCHEMATIC OF EVTAC SCRUBBER

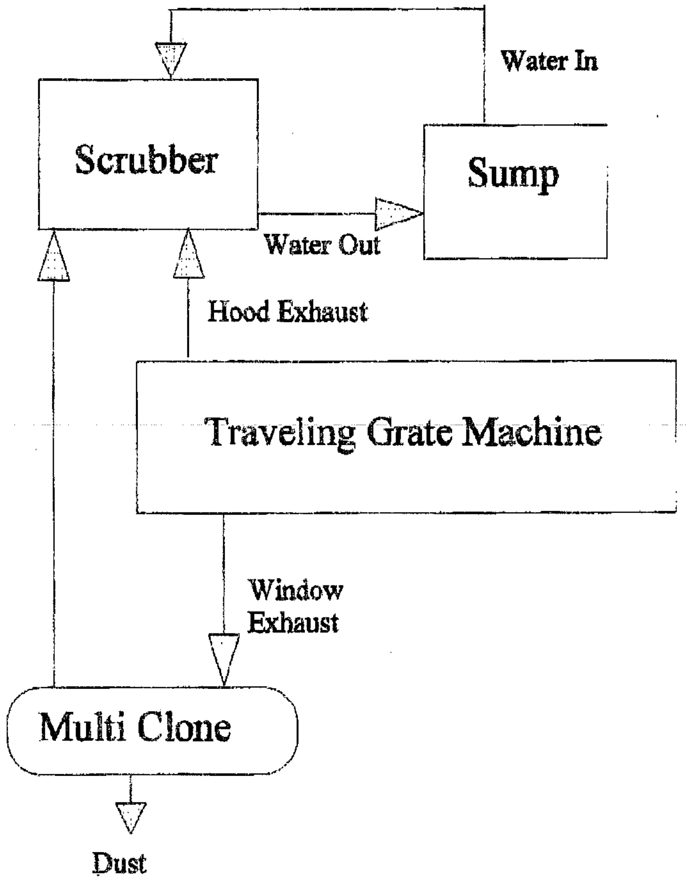

FIGURE 3 - SCHEMATIC OF MINORCA SCRUBBER

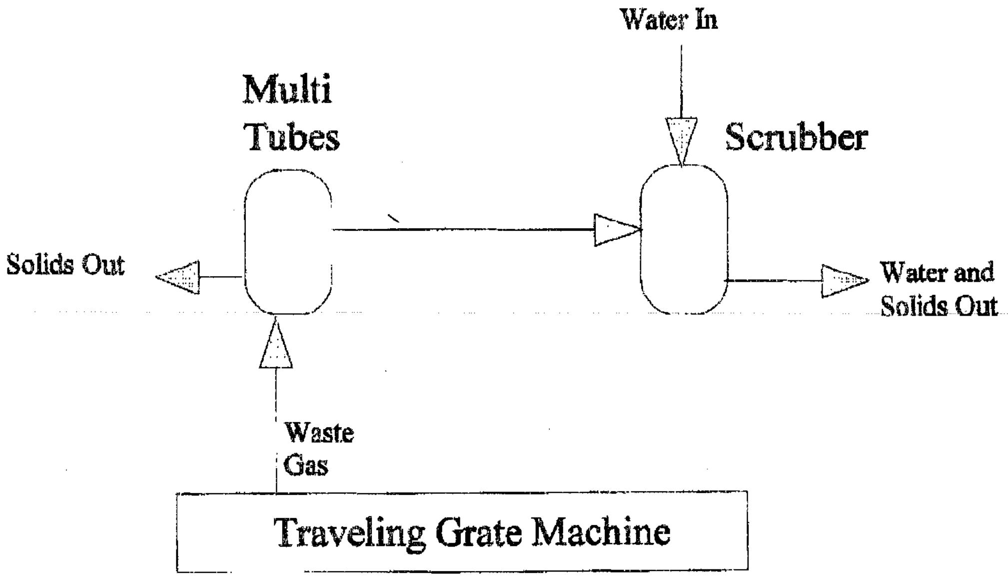

FIGURE 4 - SCHEMATIC OF HIBTAC SCRUBBER

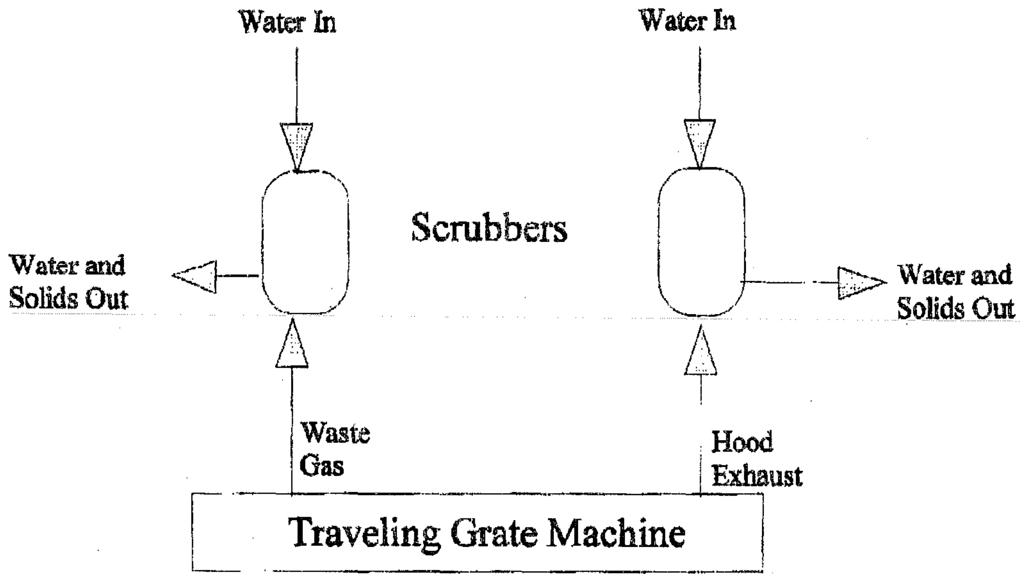

FIGURE 5 - SCHEMATIC OF NORTHSHORE SCRUBBERS

APPENDIX I - MERCURY ANALYSES REPORTS FROM FRONTIER GEOSCIENCE

Total Hg in Solids (University of Minnesota)

analyzed by:

Frontier Geosciences R&C 414 Pontius Avenue North, Suite B, Seattle WA 98109
phone: (206) 622-6960 fax: (206) 622-6870 email: nicolasb@frontier.wa.com

Sample Identification	Dry Fraction	Total Hg, ng/g* wet wt basis	Total Hg, ng/g* dry wt basis
Evtac Green Ball	1.000	12.0	12.0
Evtac Final Pellet	0.999	ND(<0.69)	ND(<0.69)
Evtac Coal	0.998	10.3	10.3
Evtac Thickener Un'flow 2A	0.999	526	527
Evtac Thickener O'flow 2A	0.998	233	233
Evtac Thickener Un'flow 2B	0.997	366	367
Evtac Thickener O'flow 2B	0.996	823	826
Hibtac Filter Cake	0.998	13.9	13.9
Hibtac Concentrate	0.999	18.2	18.2
Hibtac Limestone	0.999	3.72	3.72
Hibtac Mult-tube Dust	1.000	154	154
Hibtac Green Ball	1.000	16.7	16.7
Hibtac Bentonite	0.980	25.9	26.4
Hibtac Fired Pellet	1.000	ND(<0.69)	ND(<0.69)
North Shore Waste Gas Line 11	0.999	211	211
North Shore Waste Gas Line 12	0.999	110	110
North Shore Hood Exhaust Line 11	0.998	25.9	26.0
North Shore Hood Exhaust Line 12	1.000	26.4	26.4
North Shore Green Ball Line 11	0.999	1.44	1.44
North Shore Green Ball Line 12	1.000	1.10	1.10
North Shore Fired Pellet Line 11	0.999	ND(<0.69)	ND(<0.69)
North Shore Fired Pellet Line 12	1.000	1.85	1.85

*Blank corrected

ND-less than estimated MDL

Total Hg in Solids (University of Minnesota)

analyzed by:

Frontier Geosciences R&C 414 Pontius Avenue North, Suite B, Seattle WA 98109
phone: (206) 622-6960 fax: (206) 622-6870 email: nicolasb@frontier.wa.com

Sample Identification	**Dry Fraction**	**Total Hg, ng/g**	
		wet wt basis	**dry wt basis**

Method Blanks

Blank-1		0.89	
Blank-2		1.96[a]	
Blank-3		0.49	
Blank-4		0.49	
Mean method blank		**0.62**	
Estimated MDL		**0.69**	

[a] Excluded from calcuation of mean method blank

Standard Reference Materials

NIST-2709		1,529	
recovery		**109.2%**	
reference value		1,400	

Total Hg in Solids (University of Minnesota)

analyzed by:

Frontier Geosciences R&C 414 Pontius Avenue North, Suite B, Seattle WA 98109
phone: (206) 622-6960 fax: (206) 622-6870 email: nicolasb@frontier.wa.com

Sample Identification	**Dry Fraction**	**Total Hg, ng/g*** wet wt basis	dry wt basis
Matrix Duplicates			
North Shore Hood Exhaust Line 11		25.89	
North Shore Hood Exhaust Line 11 MD		25.85	
Mean		**25.87**	
RPD		**0.2%**	
North Shore Fired Pellet Line 11		-0.01	
North Shore Fired Pellet Line 11 MD		1.32	
Mean		**0.66**	
RPD		**203.1%**	
Evtac Green Ball		11.98	
Evtac Green Ball MD		11.95	
Mean		**11.97**	
RPD		**0.3%**	
Matrix Spikes			
North Shore Fired Pellet Line 11 MS		9,980	
spiking level		9,488	
net		9,979	
recovery		**105.2%**	
North Shore Fired Pellet Line 11 MSD		9,868	
spiking level		9,901	
net		9,867	
recovery		**99.7%**	
RPD		**5.4%**	

*Blank corrected

Total Mercury in Process Water (University of Minnesota)

analyzed by

Frontier Geosciences R&C 414 Pontius North, Suite B Seattle WA 98109
phone: 206-622-6960 fax: 206-622-6870 e-mail: nicolasb@frontier.wa.com

sample ID	description	[Hg], ng/L	comments
#8	evtac thickener u'flow water 2A	15.48	
#20	evtac concentrate water	8.61	
#12	evtac slat spray water	5.25	
#10	evtac thickener u'flow water 2B	18.12	
#22	hibtac scrubber water	11.95	
#21	hibtac makeup water	5.37	
#9	evtac thickener o'flow water 2A	82.22	
#11	evtac thickener o'flow water 2B	24.35	
B-1	blank-1	0.12	
B-2	blank-2	0.16	
B-3	blank-3	0.16	
	mean	0.15	
	estimated MDL	0.07	
#12	evtac slat spray water rep 1	4.97	
#12	evtac slat spray water rep 2	6.21	
	mean	5.25	10.5% RPD
	matrix spike level	40.40	
#8	evtac thickener u'flow water 2A + MS	53.71	94.6% recovery
#8	evtac thickener u'flow water 2A + MSD	54.77	97.3% recovery
	mean	52.24	2.1% RPD
NIST-1641d	NIST certified water CRM rep 1	7,751	diluted 200x
NIST-1641d	NIST certified water CRM rep 2	7,054	diluted 200x
	mean	7,403	9.4% RPD
	certified value	7,950	93.1% recovery
	analysis date	2-Jul-01	

Total Mercury in Process Water (University of Minnesota)

analyzed by

Frontier Geosciences R&C 414 Pontius Avenue North, Suite B Seattle WA 98109
phone: (206) 622-6960 fax: (206) 622-6870 email: ericv@frontier.wa.com

sample ID	description	[Hg], ng/L	comments
#9	N.S. Feed Water	7.05	
#10	N.S. Hood Exhaust Water Line 11	32.8	
#11	N.S. Hood Exhaust Water Line 12	15.7	
#12	N.S. Waste Gas Water Line 11	29.1	
#13	N.S. Waste Gas Water Line 12	15.7	
B-1	blank-1	0.05	
B-2	blank-2	0.10	
B-3	blank-3	0.05	
	mean	0.06	
	estimated MDL	0.09	
#11	N.S. Hood Exhaust Water Line 12	15.72	
#11	N.S. Hood Exhaust Water Line 12	17.67	
	mean	15.89	11.7% RPD
	matrix spike level	40.40	
#11	N.S. Hood Exhaust Water Line 12 + MS	57.94	97.2% recovery
#11	N.S. Hood Exhaust Water Line 12+ MSD	56.11	92.9% recovery
	mean	57.03	3.2% RPD
NIST-1641d	NIST certified CRM (diluted 200x)	8,042	101.2% recovery
	certified value	7,950	
	analysis date	July 9, 2001	

Total Mercury in Taconite Mill Substances (Coleraine Minerals Research Lab)

analyzed by

Frontier Geosciences Inc. 414 Pontius North, Seattle WA 98109
phone: 206-622-6960 fax: 206-622-6870 e-mail: nicolasb@frontier.wa.com

sample #	sample description	[Hg]	units	date analyzed	comment
#01	Mintac scrubber in water	78.9	ng/L	18-Jul-01	QC sample
#02	Mintac Scrubber out water	66.5	ng/L	18-Jul-01	
#03	Inland process water	5.67	ng/L	18-Jul-01	
#04	Inland scrubber water	112	ng/L	18-Jul-01	
#05	Mintac greenball	8.1	ng/g	31-Aug-01	QC sample
#06	Mintac fired pellet	< 0.6	ng/g	31-Aug-01	
#07	Mintac scrubber out solids	87.0	ng/g	31-Aug-01	
#08	Mintac coal	25.3	ng/g	31-Aug-01	
#09	Inland scrubber water solids	3,179	ng/g	31-Aug-01	
#10	Inland multi-clone dust	193	ng/g	31-Aug-01	
#11	Inland fired pellet	< 0.6	ng/g	31-Aug-01	
#12	Inland greenball	7.8	ng/g	31-Aug-01	
#13	Evtac thickener 2A + 10m	38.8	ng/g	31-Aug-01	
#14	Evtac thickener 2B + 10m	48.6	ng/g	31-Aug-01	
#15	Hibtac multi-tube dust + 10m	86.8	ng/g	31-Aug-01	
	solids blank #1	0.4	ng/g	31-Aug-01	
	solids blank #2	0.4	ng/g	31-Aug-01	
	solids blank #3	0.2	ng/g	31-Aug-01	
	solids blank #4	0.8	ng/g	31-Aug-01	
	solids blank #5	0.3	ng/g	31-Aug-01	
	solids blank #6	0.2	ng/g	31-Aug-01	
	mean	0.4	ng/g	31-Aug-01	estimated MDL = 0.6 ng/g
	water blank #1	0.05	ng/L	18-Jul-01	
	water blank #2	0.06	ng/L	18-Jul-01	
	water blank #3	0.09	ng/L	18-Jul-01	
	mean	0.07	ng/L	18-Jul-01	estimated MDL = 0.06 ng/L

Total Mercury in Taconite Mill Substances (Coleraine Minerals Research Lab)

analyzed by

Frontier Geosciences Inc. 414 Pontius North, Seattle WA 98109
phone: 206-622-6960 fax: 206-622-6870 e-mail: nicolasb@frontier.wa.com

sample #	sample description	[Hg]	units	date analyzed	comment
#05	Mintac greenball	8.3	ng/g	31-Aug-01	
#05	Mintac greenball dup	7.8	ng/g	31-Aug-01	
	mean	8.1	ng/g	31-Aug-01	6.2% RPD
#05	Mintac greenball + 93.5 ng/g MS	97.4	ng/g	31-Aug-01	
	% recovery	95.6			
#05	Mintac greenball + 99.7 ng/g MSD	107.2	ng/g	31-Aug-01	
	% recovery	99.4			3.9% RPD
	NIST-2709 (soil)	1,367	ng/g	31-Aug-01	certified = 1,400 ng/g
	% recovery	97.6			
#01	Mintac scrubber in water	74.5	ng/L	18-Jul-01	
#01	Mintac scrubber in water dup	83.3	ng/L	18-Jul-01	
	mean	78.9	ng/L	18-Jul-01	11.2% RPD
#01	Mintac scrubber in water + 202 ng/L MS	292.5	ng/L	18-Jul-01	
	% recovery	105.7			
#01	Mintac scrubber in water + 202 ng/L MSD	279.7	ng/L	18-Jul-01	
	% recovery	99.4			6.4% RPD
	NIST-1641d (water)	7,926	ng/L	18-Jul-01	certified 7,950 ng/L @ 200x dilution
	% recovery	99.7			

Frontier
Geosciences Inc.
Environmental Research & Specialty Analytical Laboratory
414 Pontius Ave N · Seattle WA 98109

Mr. Blair Benner
University of Minnesota Duluth
Coleraine Minerals Research Lab
P.O. Box 188
Coleraine, MN 55722

July 16, 2001

Dear Mr. Blair,

Enclosed please find our results for the determination of total Hg in 22 solids samples which were received on June 25 and July 2, 2001 and 8 water samples received on July 2. Following receipt, the water samples were preserved with 1% (v/v) 0.2N BrCl and allowed to oxidze at least overnight prior to analysis.

One gram aliquots of the samples were accurately weighed into HF cleaned Teflon bombs, and 25 mL of a mixture of 2:1:1 (v/v) HNO_3 + HF + HCl were added. The samples were digested for 12 hours at 100°C. We find that even though common soils and rocks will easily go into solution in less than 4 hours under these conditions, the "conc." and "pellet" samples did not fully solubilize even after the full 12 hours. Although certain ores, including taconite and bauxite, do not fully solubilize during digestion, we have performed intercomparison exercises with thermal volatilization and aqua regia digestion which suggest that grinding to a powder, followed by HF/HNO_3/HCl digestion is never-the-less the most effective way to liberate the Hg for analysis.

After digestion, the samples were cooled and diluted to 100 mL with reagent water, and stored in their respective digestion bombs until analysis. Aliquots (2.0 mL) of the digests were analyzed using $SnCl_2$ reduction, purge and trapping on gold coated sand, and cold vapor atomic fluorescence spectrometry (CVAFS) detection. Overall, the analysis went very well, with excellent spike and CRM recoveries, and low blanks. One of the four blanks prepared and analyzed with the set was noted to be higher than the other three, and was excluded from calculation of the mean blank employed to blank correct the data.

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Frontier
Geosciences Inc.
Environmental Research & Specialty Analytical Laboratory
414 Pontius Ave N · Seattle WA 98109

July 24, 2001

Mr. Blair Benner
University of Minnesota-Duluth
Coleraine Minerals Research Lab
P.O. Box 188
Coleraine, MN 55722

Dear Mr. Benner,

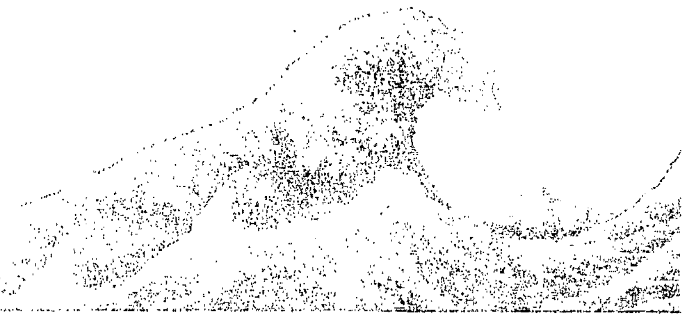
Enclosed please find our results for the determination of total mercury in process water samples received on July 2, 2001. The samples were received in good condition and immediately oxidized with 1% (v/v) 0.2N BrCl. All samples were allowed to oxidize at least overnight prior to analysis.

Aliquots of each sample were analyzed using $SnCl_2$ reduction, dual gold amalgamation, and cold vapor atomic fluorescence (CVAFS) detection. Analysis went very well, with no analytical problems encountered. Please feel free to contact me if you have any questions regarding these results.

Regards,

Eric J. von der Geest
Analytical Chemist

206 622 6960
fax 206 622 6870
email: info@Frontier.WA.com
www.FrontierGeosciences.com



FRONTIER GEOSCIENCES INC.
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414 Pontius North • Seattle, WA 98109

Mr. Blair Benner
University of Minnesota Duluth
Coleraine Minerals Research Lab
P.O. Box 188
Coleraine, MN 55722

September 9, 2001

Dear Mr. Blair,

Enclosed please find our results for the determination of total Hg in 11 taconite process solid samples and 4 waters, which were received on July 16, 2001. This is a hard copy report of the data table already forwarded to you by e-mail on September 8, 2001.

One gram aliquots of the solid samples were accurately weighed into HF cleaned Teflon bombs, and 25 mL of a mixture of 2:1:1 (v/v) HNO_3 + HF + HCl were added. The samples were digested for 12 hours at 100°C. We find that even though common soils and rocks will easily go into solution in less than 4 hours under these conditions, some ore samples do not fully solubilize even after the full 12 hours. Although certain ores, including taconite and bauxite, do not fully solubilize during digestion, we have performed intercomparison exercises with thermal volatilization and aqua regia digestion which suggest that grinding to a powder, followed by HF/HNO_3/HCl digestion is never-the-less the most effective way to liberate the Hg for analysis. After digestion, the samples were cooled and diluted to 100 mL with reagent water, and stored in their respective digestion bombs until analysis. Water samples were digested by the addition of 1% (v/v) of 0.2 N BrCl in 12N HCl to the original sample bottle, and allowing to sit over night at room temperature prior to analysis.

Aliquots (0.1-2.0 mL of the solids digests, or 5–50 mL of the waters) were analyzed using $SnCl_2$ reduction, purge and trapping on gold coated sand, and cold vapor atomic fluorescence spectrometry (CVAFS) detection. Overall, the analysis went very well, with excellent spike and CRM recoveries, and low blanks. One sample (Inland scrubber water solids) went off scale, but was re-analyzed on a different analyzer on the same day.

Please feel free to call or e-mail me if you have any questions, or are in need of additional analytical or contract research services.

Best Wishes,

Nicolas Bloom
Sr. Research Scientist

Attachment E

Nol-Tec Report

NOL-TEC SYSTEMS

SORB-N-JECT® Technology

www.nol-tec.com

August 7, 2017

PURPOSE

Nol-Tec Systems supplied injection Activated Carbon Injection (ACI) test at ArcelorMittal Minorca Mine from January to April, 2017. The purpose of the injection was mercury removal.

TESTING EQUIPMENT

PAC Injection System

The carbon was supplied in super sacks weighing 1000 lbs each. The supersacks are positioned using a fork lift and loaded into the system using an electric hoist to an unloading platform. Mechanical agitators are installed on this platform to assist in getting material out of the bags.

The material falls out of the bag into a confinement hopper. The bottom of the confinement hopper has aeration jets installed on it to influence material flow. Material flows out of the confinement hopper into a loss in weight feeder hopper through an air operated butterfly valve.

Once in the feeder hopper, a screw feeder controlling the injection rate feeds into a drop through rotary airlock. Both the feeder hopper and the airlock have dust filters mounted on top of them.

Please see Appendix A for list of components.
Please see Appendix B for photos of the injection system.

Carbon Convey/ Injection Set up

The discharged material fell into a 4 inch convey line. The material in the convey line was carried using a 40 HP blower package. The 4 inch convey line went from the bulk bag unloader to the splitter. From here, the line splits into three (3) 1-1/2” hoses connected to 36” length injection lances.

Running/ Injection Parameters Data

Through the course of the testing, the bulk bag unloader data collected includes:

- Required lbs (ReqLbs) – rate requested from the DCS based on stack air flow.
- Actual lbs (ActLbs) – The actual injection rate recorded.
- Blower Speed (BlowerSpd) – percentage associated with total speed (100% possible) of the variable frequency drive controlling the blower.
- Blower Pressure (BlowerPress) – The system backpressure seen at the blower.
- Feeder Speed Percent (FdrSpdPct) - percentage associated with total speed (100% possible) of the variable frequency drive controlling the screw feeder.

Please see Appendix C for rate data collected.

APPENDIX

Appendix A: Bulk Bag Unloader Equipment Components

1. One (1) Portable free standing bulk bag unloader, welded mild steel construction, having a maximum weight capacity of 4,000 lbs. for the storage of material at the unloader. The portable bulk bag unloader is complete with the following features:
   - Need for a crane to raise or lower the bulk bag unloader.
   - Bulk bag unloader upper section assembly consisting of one (1) hoist with a 2-ton certified capacity, mild steel construction. Includes frame and one (1) beam, bag spreader, electric hoist with power trolley, chain container, pendant controls and festooning.
   - One (1) Bulk bag pneumatic agitator systems, to assist in material flow during the discharge of the bulk bags. Agitator system is of mild steel construction and includes pneumatic operated massaging bars, with solenoid valves.
   - One (1) Surge Hopper, mild steel construction with 60° discharge cone and 8” air-operated “re-fill” butterfly valve.
   - One (1) Single cartridge dust filter, Model 279, 9" dia., mild steel fabricated for mounting direct to hopper top. Complete with 30 square feet of cartridge filter media, 36" long top removal mild steel cartridge, ½" dia. air hose. (Plumbing shipped loose for field assembly.) Includes solenoid valve, ½", 2-way, 24-volt.
   - Exterior painted finish is enamel. Interior is unpainted.

Please Note: *The bulk bag unloader is trailer delivered to the job-site via semi-tractor. The base will need to be set on level, compacted ground (no special foundation is required). Flexible connections at the surge hopper discharge system are connected to the inlet of weigh hopper after the bulk bag unloader is in position.*

1.a One (1) Loss-in-weight feeder assembly. Flexible polyurethane hopper has 10 cu. ft. of holding capacity, includes a 10" dia. inlet and a 7-⅞" dia. discharge. The feeder discharges to a 6" airlock.

1.b One (1) Airlock package, drop thru type, 8", with 0.065 CFR displacement. Cast iron housing construction with 8-vane welded steel rotor with fixed blades with beveled edges. Driven by a 0.5 HP, 230/460 volt, 3 phase, 60 hertz, 1750 RPM, TEFC inverter duty motor and chain drive which is side-mounted from the valve housing.

1.c One (1) Portable blower enclosure, coupled with the above bulk bag equipment will allow an injection capacity of 1 TPH of sorbent per hour maximum. Includes:
   - One (1) Control enclosure, capable of operating the injection system, requires 460/3/60 VAC @ 200 Amps, to power all of the following equipment.
   - One (1) Blower packages, positive displacement rotary blowers, each driven by a 40 HP, TEFC, 230/460/3/60 motor, mounted on a structural base with motor slide rails, each capable of providing 500 SCFM @11.5 PSIG.
   - One (1) Air Compressor, capable of generating 84 SCFM @ 125 PSIG, with 20 HP, TEFC, 230/460/3/60 motor.
   - One (1) Air Receiver, 120 gallon capacity.

- One (1) Heat Exchangers each with 2 HP, TEFC, 230/460/3/60 motor**.**
- One (1) Compressed air dryer, requires 120 VAC.
- Convey piping, hoses, couplings and miscellaneous components.
- Eight (8) Custom designed injection lances.

1.d One lot of Consumables. Includes: splitters (one 9 way, one 3 way), 9 injection lances and a lot of filters.

Appendix B: Bulk Bag Unloader Photographs and Sales Drawings

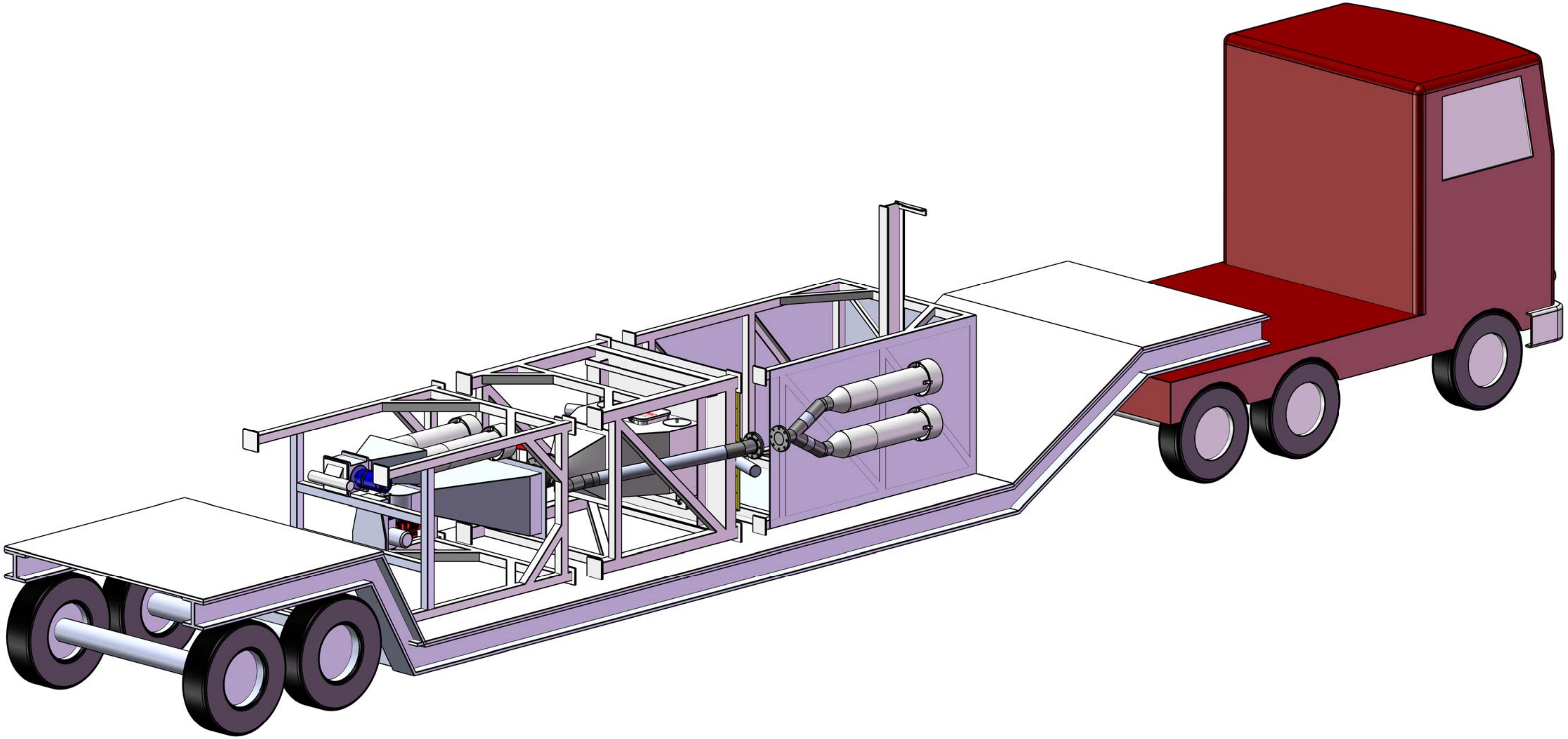
*Please note that the following site specific photographs will not be used outside of this report and will not be shared outside of Nol-Tec systems without prior authorization from ArcelorMittal Minorca Mine.


Providing Clean Air Solutions with
SORB-N-JECT® Technology
265
HOOD EX


WM
218-328-6212
218-262-3308
0004STL


Providing Clean Air Solutions with
SORB-N-JECT® Technology

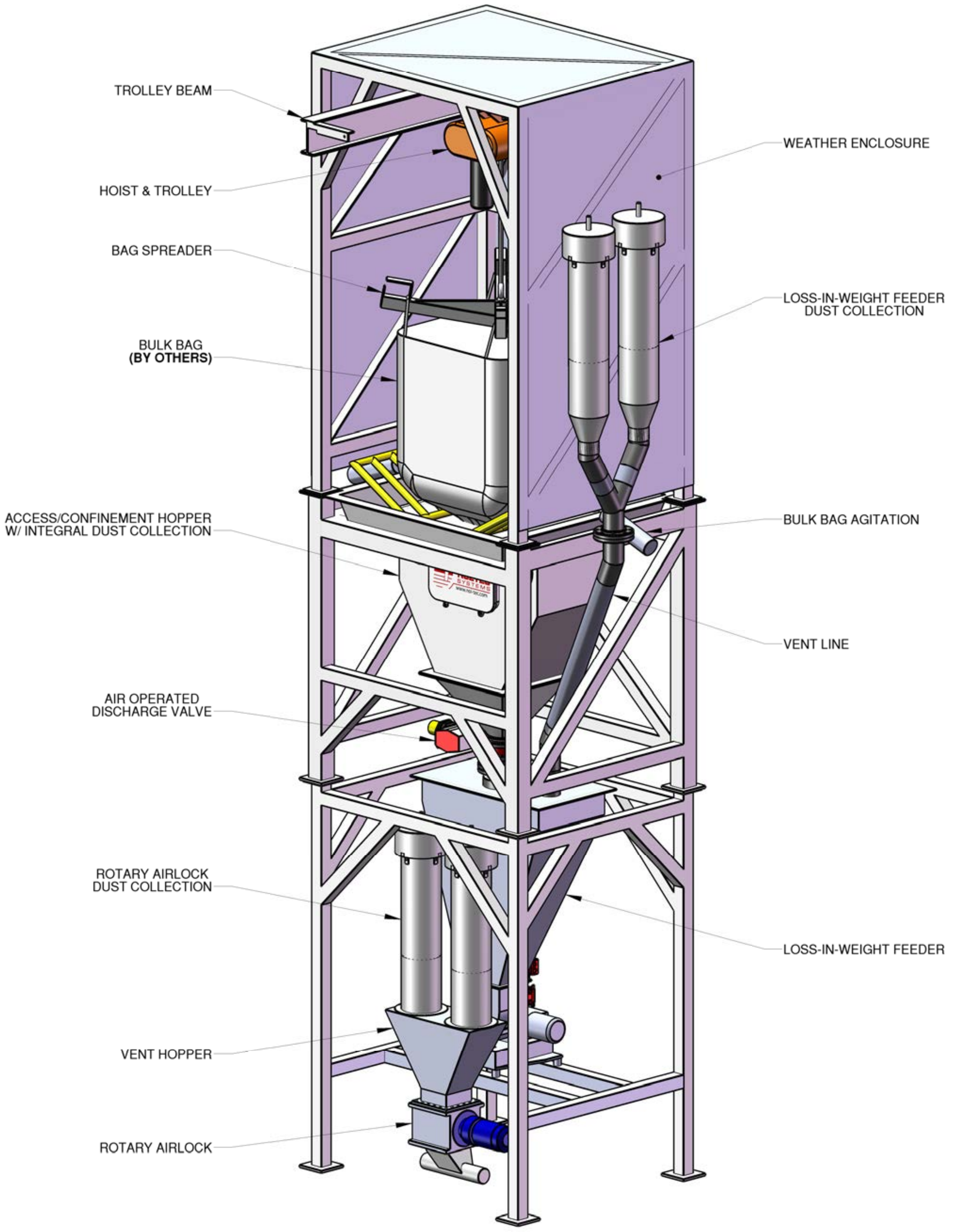

Providing Clean Air Solutions with
SORB-N-JECT® Technology



PORTABLE BULK BAG UNLOADING STATION
IN TRANSPORT CONFIGURATION

SORB-N-JECT™
Technology

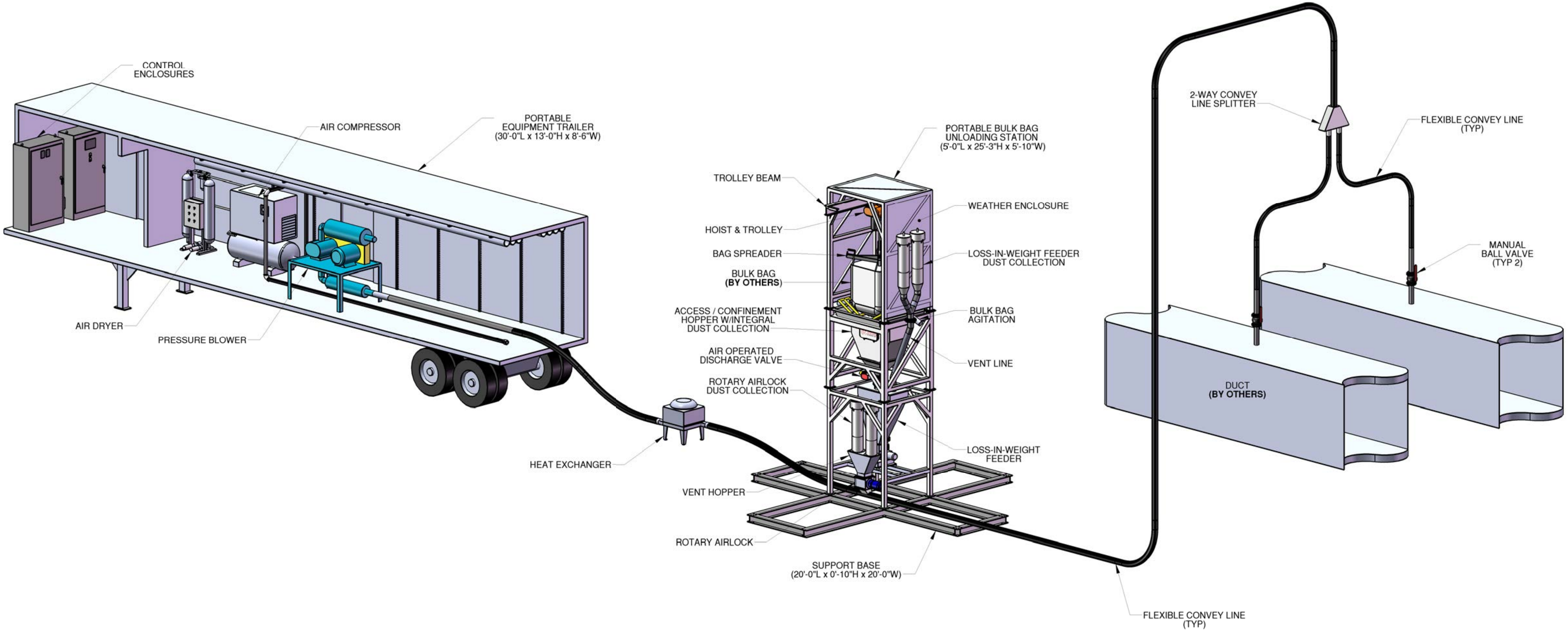
TITLE: PORTABLE BULK BAG UNLOADING STATION TRANSPORT CONFIGURATION	DATE: 04JAN13	NOL-TEC SYSTEMS www.nol-tec.com
	DRAWN BY: LTS	
	RSM: MGT	
CUSTOMER: UNIT 8	SAE: --	
	SCALE: 1:20	
	SHEET: 1 OF 3	DRAWING NUMBER: UNIT-8-0



NOTES:
-APPOXIMATE OVERALL DIMENSIONS: 5'-0"L x 25'-3"H x 5'-10"W

SORB-N-JECT™
Technology

TITLE: PORTABLE BULK BAG UNLOADING STATION OPERATING CONFIGURATION	DATE: 30APR13	NOL-TEC SYSTEMS www.nol-tec.com
	DRAWN BY: LTS	
	RSM: MGT	
CUSTOMER: UNIT 8	SAE: --	
	SCALE: 1:16	
	SHEET: 2 OF 3	DRAWING NUMBER: UNIT-8-0



NOTES:
-ALL DIMENSIONS ARE APPROXIMATE.

PORTABLE STAND ALONE BULK BAG UNLOADER IN OPERATION CONFIGURATION

SORB-N-JECT™
Technology

TITLE: PORTABLE BULK BAG UNLOADER OPERATING CONFIGURATION	DATE: 30APR13	NOL-TEC SYSTEMS www.nol-tec.com 651-780-8600 USA	
	DRAWN BY: LTS		
	RSM: MGT		
UNIT 8	SAE: ML		
	SCALE: 1:42		
	SHEET: 3 OF 3	DRAWING NUMBER:	UNIT-8-0

Attachment F

2015 Method 29 Stack Testing Summary

TABLE 5

EPA METHOD 29 TEST RESULTS SUMMARY

Indurating Furnace Stacks A-D (SV014-017), (EU026)

Parameter	Stack A SV014	Stack B SV015	Stack C SV016	Stack D SV017	EU026
Test Date	6/23/2015-6/24/2015	6/25/2015	6/23/2015-6/24/2015	6/25/2015	
Air Flow Rate					
acfm	210,500	222,000	211,200	217,500	
scfm	177,600	186,400	175,000	178,200	Total dscfm
dscfm	159,700	166,200	152,600	152,600	631,100
Mercury Concentration, µg/dscf					
Front Half (Filterable) Mercury	0.013	0.012	0.011	< 0.0013	
Back Half Mercury	0.053	0.067	0.114	0.148	Flow Weighted Average
Total Mercury	0.066	0.079	0.126	0.150	0.10
Total Mercury Concentration, µg/dscm	2.3	2.8	4.4	5.3	3.7
Mercury Emission Rate, lb/hr					
Front Half (Filterable) Mercury	0.0003	0.0003	0.0002	< 0.000027	
Back Half Mercury	0.0011	0.0015	0.0023	0.0030	Total lb/hr
Total Mercury	0.0014	0.0017	0.0025	0.0030	0.0087
Process Rate					
Fired Pellet Production Rate, LTPH	361	352	361	352	357
Emission Factor					
Total Mercury lb/LT Fired Pellet	4.0E-06	4.9E-06	7.0E-06	8.6E-06	2.5E-05

MERCURY TEST RESULTS SUMMARY
EPA Method 30B
Stack D (SV017)

Parameter	Run 1	Run 2	Run 3	Average
Test Date	6/25/2015	6/25/2015	6/25/2015	---
Test Period	756-1013	1110-1310	1433-1633	---
Test Duration, min.	120	120	120	---
Air Flow Rate				
acfm	219,600	220,100	212,800	217,500
scfm	180,200	180,500	174,000	178,233
dscfm	153,700	154,800	149,300	152,600
Mercury Sorbent Trap Loading, ng				
Trap A	327.60	289.00	307.00	307.87
Mercury Concentration, µg/dscm				
Trap A	5.9	5.2	5.5	5.5
Mercury Emissions Rate, lb/hr				
Trap A	0.0034	0.0030	0.0031	0.0032

Attachment G

Water Sampling Protocol

STANDARD OPERATING PROCEDURE

Collection of Low Level Mercury Water Samples

Revision 5

September 4, 2014

Approved By:	Dana Pasi	Dana Pasi	9-4-14
	Print	QA Manager(s) Signature	Date
	KEVIN McGILP		9-4-14
	Print	Field Technician(s) Signature	Date

Barr Engineering Company
4700 West 77th Street • Minneapolis, MN 55435-4803
Phone: 952-832-2600 • Fax: 952-832-2601 • www.barr.com

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Annual Review of the SOP has been performed
and the SOP still reflects current practice.

Initials: ______________ Date: ______________

Initials: ______________ Date: ______________

Initials: ______________ Date: ______________

Initials: ______________ Date: ______________

Initials: ______________ Date: ______________

Standard Operating Procedures for the Collection of Low Level Mercury Water Samples

Purpose

To describe the standard procedures for collection of low level mercury (EPA methods 1631 and 1669) samples.

Applicability

These procedures apply to the collection of groundwater and/or surface water for laboratory analysis of mercury by EPA methods 1631 and 1669.

Definitions

BrCl Bromine Chloride
HCl Hydrochloric acid
Aliquot A part that is a definite fraction of a whole, as in aliquot samples for testing or analysis.
Clean Hands Person wearing polyethylene shoulder length non talc gloves
Dirty Hands Person wearing normal (wrist) non talc surgical gloves

Equipment

Pre-cleaned wind suits or Tyvek
Ziploc Baggies
Cooler
Bagged Ice
Chain of Custody Form
Sample Label
Talc-free nitrile and polyethylene gloves
0.45 micron pore size filter – required when filtering in the field
Peristaltic Pump– required when filtering in the field
Bubble Wrap
Fluoropolymer or glass bottles and preserved with high purity 0.5% BrCl or .05% HCl solution
Fluoropolymer tubing
Dual Inlet Sampler

References

Federal Register: October 29, 2002 (Volume 67, Number 209) Guidelines Establishing Test Procedures for the Analysis of Pollutants; Measurement of Mercury in Water; Revisions to EPA Method 1631EPA

Method 1669: Sampling Ambient Water for Trace Metals at EPA Water Quality Criteria Levels EPA Document EPA821-R-01-023

Responsibilities

The Field Operations/QA Officer or the field technician(s) will order the sample containers prior to the sampling event. The field technician(s) is responsible for the proper collection of groundwater and surface water samples, sample identification, quality control procedures, and documentation.

Discussion

Guidance for the collection of the low level mercury samples indicates that two person sampling teams be utilized. The following SOP is the procedure for a two person team collecting the samples.

Procedure

Samples collected for the determination of trace level mercury (0.5 - 100 ng/L) using EPA Method 1631 must be collected in tightly-capped fluoropolymer or borosilicate glass bottles with fluoropolymer-lined caps and preserved with high purity 0.5% BrCl or 0.05% HCl solution to a pH of less then 2, within 48 hours of sample collection. The time to preservation may be extended to 28 days if a sample is oxidized in the sample bottle.

Samples that have been collected for determination of total or dissolved trace level mercury must be analyzed within 90 days of sample collection.

The low level mercury samples will be collected first at each sampling location.

Collection of low level mercury samples to be filtered in the lab

Note: Due to the low analytical reporting limits required for low level mercury and the possibility of contamination in the field environment, laboratory filtration is preferred over field filtration methods. Lab filtration should be completed within 48 hours after collection and when the samples have been cooled consistently to 4 degrees C. If the samples are to be filtered in the laboratory, no preservative will be present in the containers upon receipt from the laboratory. The samples are then preserved as required at the laboratory upon receipt.

1. Complete the label with pertinent sample information, date, time, location. Samples can be labeled directly on outside baggie, minimizing potential for contaminating sample.
2. Both personnel don Wind or Tyvek suits.
3. Sampling staff should position themselves downwind to minimize cross contamination.
4. With dirty hands, open outside transit plastic Ziploc® baggies with container inside.
5. Clean hands open inside baggie and container.
6. Place appropriate sample container at the tubing flow outlet, or submerge the container into the water body for a surface water sample.
7. Clean hands fill container to the top, caps and places the container into baggie and seals.
8. Dirty hands close outside baggie.
9. Attach the sample label to the outside baggie.
10. Put sample container into cooler with bagged ice.
    Note: The samples should be double wrapped individually (as received from the laboratory) and stored in a separate cooler from other samples.
11. Dispose of in-line filter. A new filter is used for each sampling location. Depending on groundwater conditions, additional filters may be required.

12. Decontaminate sampling equipment.
13. Replace gloves.

Collection of low level mercury samples to be filtered in the field

Samples collected for dissolved trace level mercury should be filtered in the laboratory. However, If circumstances prevent overnight shipment, samples should be filtered in a designated clean area in the field, using the standard 0.45 micron filter as specified in Method 1669.

1. Complete the label with pertinent sample information, date, time, location. Samples can be labeled directly on outside baggie, minimizing potential for contaminating sample.
2. Both personnel don Wind or Tyvek suits.
3. Sampling staff should position themselves downwind to minimize cross contamination.
4. With dirty hands, open outside transit plastic Ziploc® baggies with container inside.
5. Clean hands open inside baggie and container and pours out “travel” solution.
6. Dirty hands connects 0.45 micron pore size filter to end of purge tubing, ensuring direction of flow is correct.
7. Place appropriate sample container at the filter outlet.
8. Turn on peristaltic pump and adjust speed until desired flow is obtained.
9. Purge a minimum of one filter volume before collecting sample.
10. Clean hands fills container to the top, caps and places the container into inside baggie.
11. Dirty hands close outside baggie.
12. Attach the sample label to the outside baggie.
13. Put sample container into cooler with bagged ice.
    Note: The samples should be double wrapped individually (as received from the laboratory) and stored in a separate cooler from other samples.
14. Dispose of in-line filter. A new filter is used for each sampling location. Depending on groundwater conditions, additional filters may be required.
15. Decontaminate sampling equipment.
16. Replace gloves.

Quality Control Samples

Field Blank samples are prepared on-site and are a sample of analyte-free water exposed to environmental conditions at the sampling site by transfer from one vessel to another. The field blank samples will be handled in the same manner as the sample group for which they are intended (i.e. blanks will be stored and transported with the sample group). It measures field and laboratory sources of contamination.

Equipment Blank *(or Rinsate Blanks)* samples are a type of field blank. The field technician pours analyte-free water through decontaminated sample collection equipment (bailer or pump, hand-trowl, etc.) and collects the “rinsate” in the appropriate sample container(s). In addition to the field sources of contamination that may be introduced in the transferring of samples to one vessel to another, it also tests the potential cross contamination from incomplete decontamination.

Field (or Masked) duplicate samples are collected to measure relative sampling precision. Five percent of all samples collected are collected in duplicate or as prescribed by the project data quality objectives. These samples are collected at the same time using the same procedures, equipment, and types of containers as the required samples. They are also preserved in the same manner and are either co-located or split and submitted for the same analyses as the required samples.

Sample Storage

The samples will be double bagged immediately after collection, stored in a sample cooler, packed on double bagged wet ice and accompanied with the proper chain of custody documentation. Samples must be kept cold (4 ±2°C) at all times until delivery to the laboratory. Custody seals may be present, but at minimum, the coolers must be taped shut with three straps of fiberglass tape. Samples must be secure to prevent tampering with or loss of samples. If sample coolers are left in a vehicle or field office for temporary storage, the area will be locked and secured. The coolers must be delivered to the laboratory via hand or over night delivery courier in accordance with all Federal, State and Local shipping regulations.

Note: Samples may have to be stored indoors in winter to prevent freezing.

Interferences

Collect samples facing upstream or upwind, at least 100 feet away from metal supports, bridges, wires, poles, busy roadways and from areas of lowest concentration to highest concentration whenever possible to minimize the introduction of contamination.

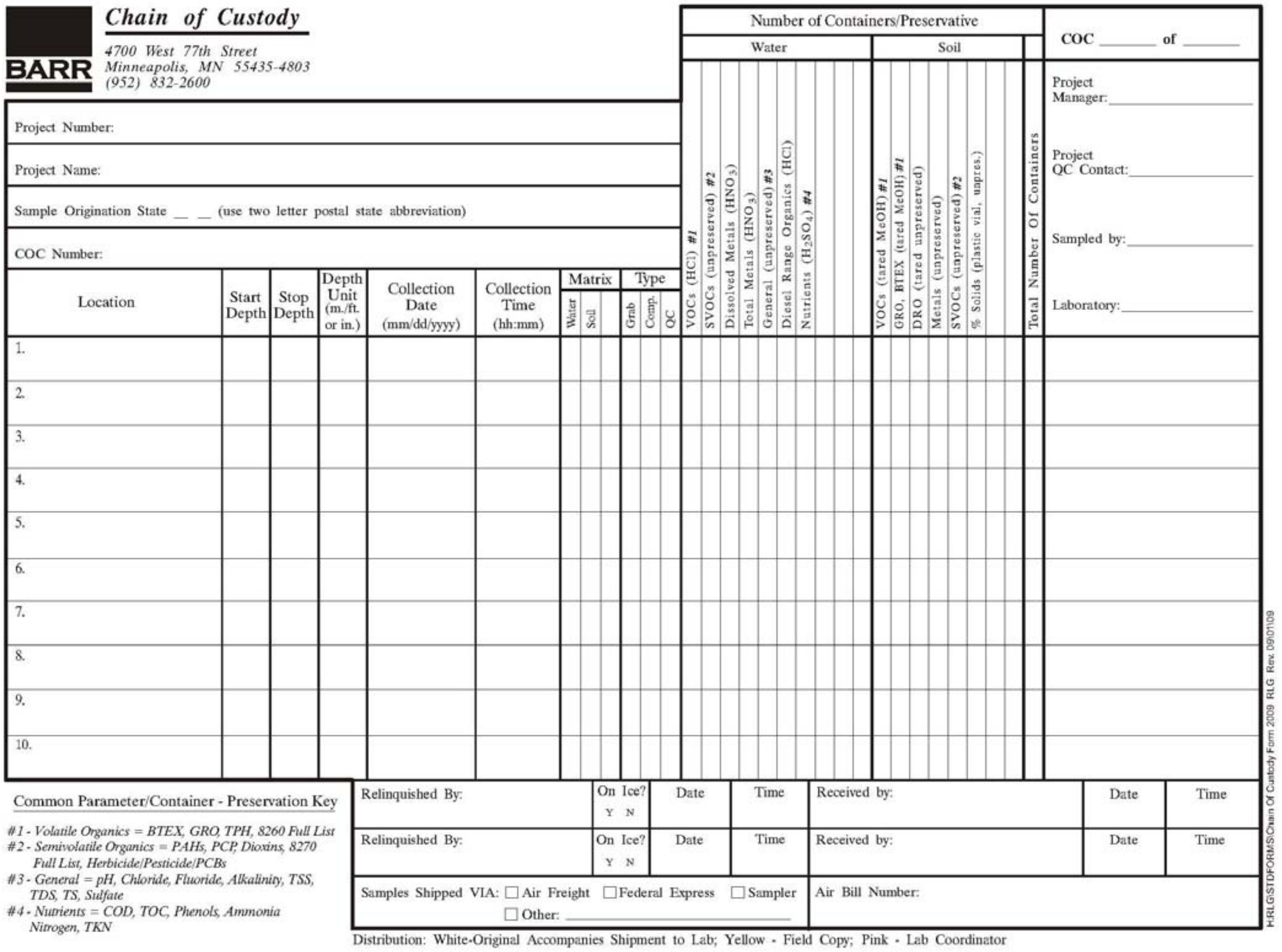
Documentation

The technician(s) will document the water sampling events on field log data sheets, field log cover sheets, and field log data reports. The technicians will document the number of filters and pre-filters used for each sample filtered on the field log data sheet. They will also document the type and number of bottles on both the field log data sheet and chain-of-custody record. The analysis for each bottle and the laboratory used will be documented on the chain-of-custody record. The sampling request form will document which sampling containers are used for which water samples.

Attachments

Attachment 1: Chain of Custody Form
Attachment 2: Sample Label
Attachment 3: Custody Seal – if applicable
Attachment 4: Field Sampling Report
Attachment 5: Field Log Cover Sheet
Attachment 6: Field Log Data Sheet

Attachment 1
Chain of Custody Form



Chain of Custody

4700 West 77th Street
Minneapolis, MN 55435-4803
(952) 832-2600

Project Number:

Project Name:

Sample Origination State __ __ (use two letter postal state abbreviation)

COC Number:

COC _______ of _______

Project Manager:__________________

Project QC Contact:________________

Sampled by:______________________

Laboratory:______________________

											Number of Containers/Preservative																			
						Matrix		Type			Water										Soil									
Location	Start Depth	Stop Depth	Depth Unit (m./ft. or in.)	Collection Date (mm/dd/yyyy)	Collection Time (hh:mm)	Water	Soil	Grab	Comp.	QC	VOCs (HCl) #1	SVOCs (unpreserved) #2	Dissolved Metals (HNO_3)	Total Metals (HNO_3)	General (unpreserved) #3	Diesel Range Organics (HCl)	Nutrients (H_2SO_4) #4				VOCs (tared MeOH) #1	GRO, BTEX (tared MeOH) #1	DRO (tared unpreserved)	Metals (unpreserved)	SVOCs (unpreserved) #2	% Solids (plastic vial, unpres.)			Total Number Of Containers	
1.																														
2.																														
3.																														
4.																														
5.																														
6.																														
7.																														
8.																														
9.																														
10.																														

Common Parameter/Container - Preservation Key

#1 - Volatile Organics = BTEX, GRO, TPH, 8260 Full List
#2 - Semivolatile Organics = PAHs, PCP, Dioxins, 8270 Full List, Herbicide/Pesticide/PCBs
#3 - General = pH, Chloride, Fluoride, Alkalinity, TSS, TDS, TS, Sulfate
#4 - Nutrients = COD, TOC, Phenols, Ammonia Nitrogen, TKN

Relinquished By:	On Ice? Y N	Date	Time	Received by:	Date	Time
Relinquished By:	On Ice? Y N	Date	Time	Received by:	Date	Time

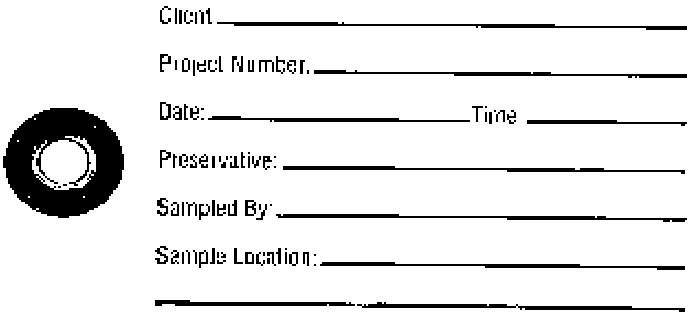
Samples Shipped VIA: ☐ Air Freight ☐ Federal Express ☐ Sampler ☐ Other: ____________

Air Bill Number:

Distribution: White-Original Accompanies Shipment to Lab; Yellow - Field Copy; Pink - Lab Coordinator

H:RLG\STDFORMS\Chain Of Custody Form 2009 RLG Rev. 090109

Attachment 2
Example - Sample label



Client ____________________

Project Number ____________________

Date: ______________ Time __________

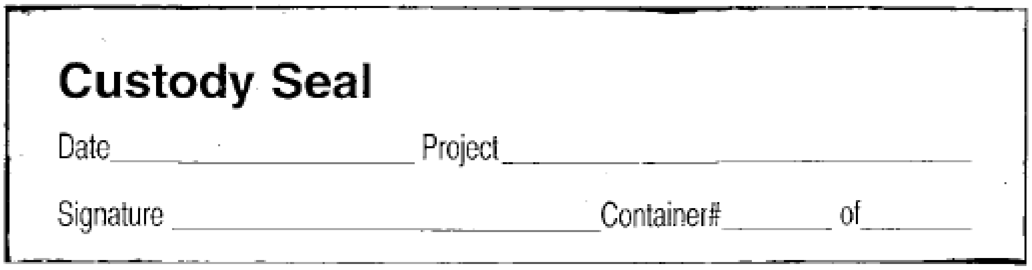
Preservative: ____________________

Sampled By: ____________________

Sample Location: ____________________

____

Attachment 3
Custody Seal – if applicable

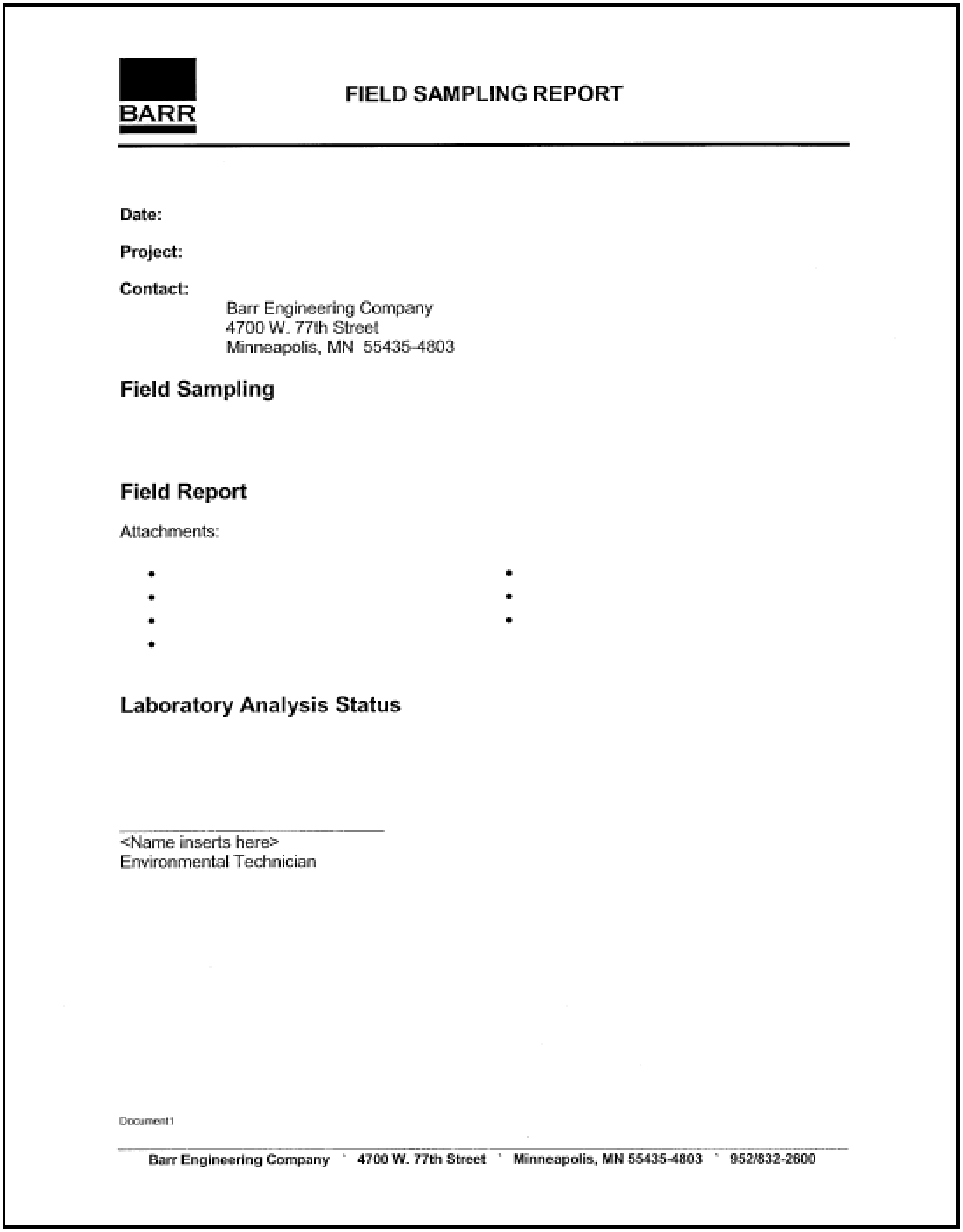


Custody Seal

Date____________________ Project______________________________________

Signature ____________________________________ Container#_________ of_________

Attachment 4
Field Sampling Report



BARR

FIELD SAMPLING REPORT

Date:

Project:

Contact:

Barr Engineering Company
4700 W. 77th Street
Minneapolis, MN 55435-4803

Field Sampling

Field Report

Attachments:

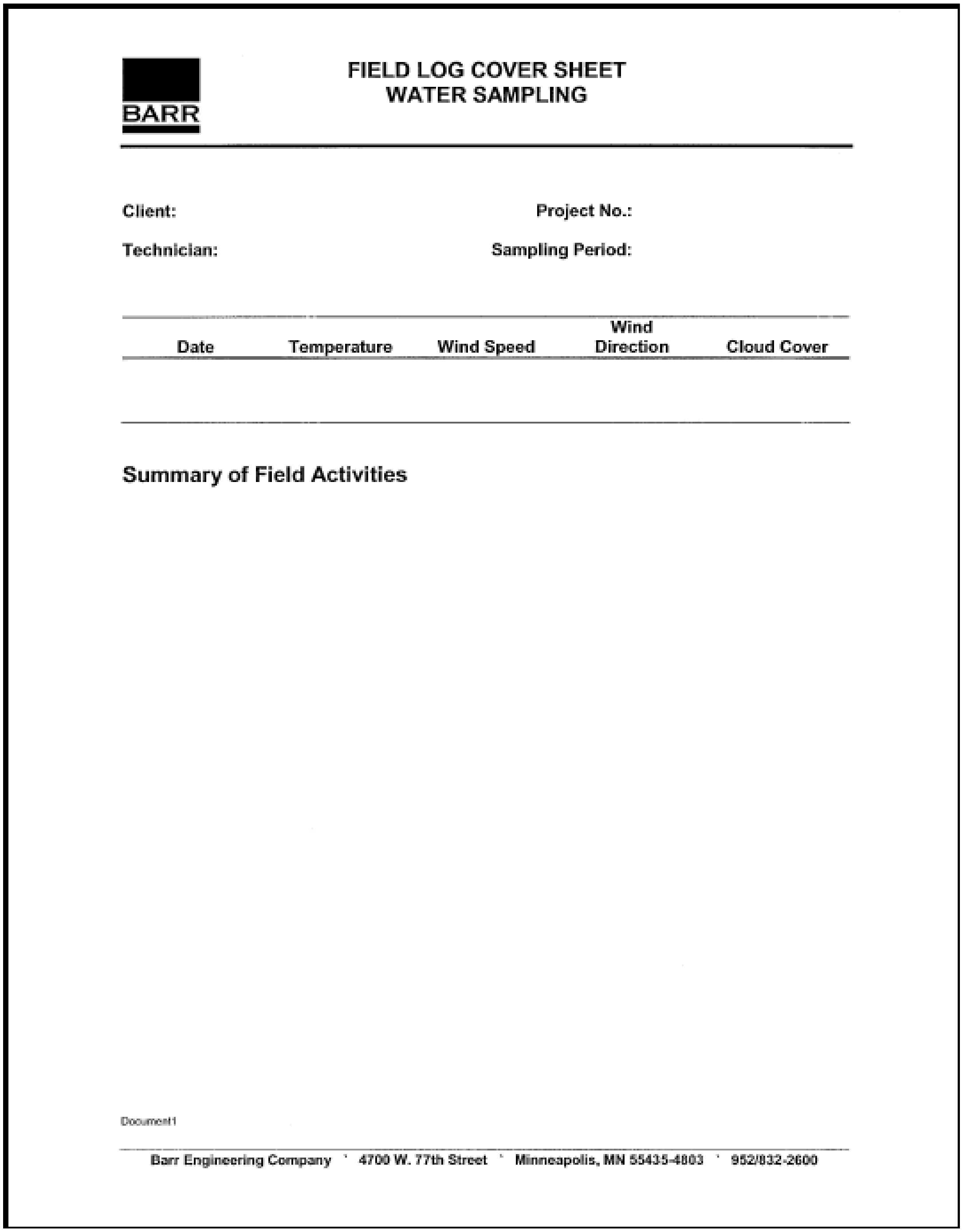
Laboratory Analysis Status

____
<Name inserts here>
Environmental Technician

Document1

Barr Engineering Company ' 4700 W. 77th Street ' Minneapolis, MN 55435-4803 ' 952/832-2600

Attachment 5
Field Log Cover Sheet



BARR

FIELD LOG COVER SHEET
WATER SAMPLING

Client: **Project No.:**

Technician: **Sampling Period:**

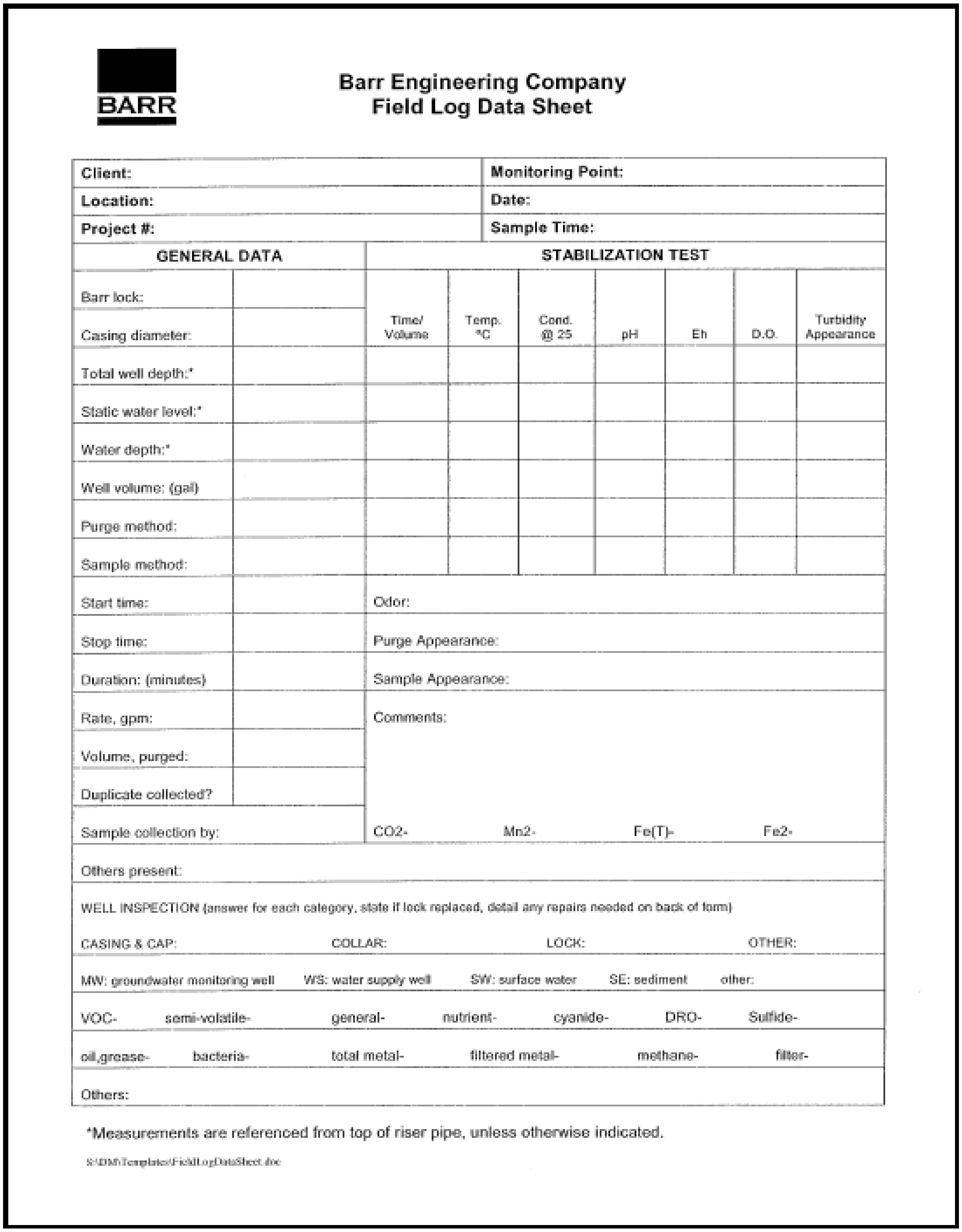
Date	Temperature	Wind Speed	Wind Direction	Cloud Cover

Summary of Field Activities

Document1

Barr Engineering Company · 4700 W. 77th Street · Minneapolis, MN 55435-4803 · 952/832-2600

Attachment 6
Field Log Data Sheet



BARR

Barr Engineering Company
Field Log Data Sheet

Client:

Monitoring Point:

Location:

Date:

Project #:

Sample Time:

GENERAL DATA

Barr lock:

Casing diameter:

Total well depth:*

Static water level:*

Water depth:*

Well volume: (gal)

Purge method:

Sample method:

STABILIZATION TEST

Time/ Volume	Temp. °C	Cond. @ 25	pH	Eh	D.O.	Turbidity Appearance

Start time:

Stop time:

Duration: (minutes)

Rate, gpm:

Volume, purged:

Duplicate collected?

Sample collection by:

Odor:

Purge Appearance:

Sample Appearance:

Comments:

CO2- Mn2- Fe(T)- Fe2-

Others present:

WELL INSPECTION (answer for each category, state if lock replaced, detail any repairs needed on back of form)

CASING & CAP: COLLAR: LOCK: OTHER:

MW: groundwater monitoring well WS: water supply well SW: surface water SE: sediment other:

VOC- semi-volatile- general- nutrient- cyanide- DRO- Sulfide-

oil,grease- bacteria- total metal- filtered metal- methane- filter-

Others:

*Measurements are referenced from top of riser pipe, unless otherwise indicated.

S:\DM\Templates\FieldLogDataSheet.doc

Attachment H

Minorca Process Data Matrix

ArcelorMittal Minorca Mine
Activated Carbon Injection Testing To Control Mercury Air Emissions
Attachment H Minorca Process Data Matrix

🟩 Did Monitor
🟥 Did Not Monitor
🟨 Did Not Monitor - Available on data base if problem occurs

Mine/Plant Location	**Description**
Mine Data	🟩 Mine Blend
	🟩 Silica Target
	🟩 projected wt recovery/project silica
Fines Crusher	🟥 FC Tonnage
	🟥 Reclaim tonnage from storage or piles- not to worry about this
	🟥 Dust Collector data
	🟥 Dust Suppressant Data
Concentrator	🟩 Rod Mill Feed tons
	🟩 Rod Mill Feed Product Size
	🟩 Plant Weight Recovery
	🟩 Iron Recovery
	🟩 Conc Iron
	🟩 Silica
	🟩 Grind Size- Final Concentrate
	🟥 Process Water Temperature
	🟩 Ambient Temperature
	🟩 Repulper Tank (Concentrate Reclaim Feed to Acid Conc - Slurry
	🟨 Head Tank Water flow
	🟨 Process Water Tank Flow
	🟥 Flotation data- Control Targets
	🟩 Tailing Coarse tonnage
	🟩 Tailings Fine tonnage
	🟩 Filter Cake Moisture
	🟩 Flux addition rate
	🟥 Dust Collection Emission Data
	🟥 Flocculant Rates
	🟥 Flotation Chemical Rate

Pellet Plant	Feed tonnage to Grate
	Begin Preheat Temp
	Mid Preheat Temp
	End Preheat Temp
	Begin Firing Temp
	End Firing Temp
	Grate Temperature
	Exhaust Stack Temperatures
	Preheat Burner Temperature
	Recoup Temperature
	Pellet Temperature
	CEMS Data
	Fan Data - Motor amps (all)
	Pallet/Grate Speed
	Updraft Flows and Temperature
	DownDraft Flows and Temperature
	Fuel Rate- Nat Gas Flow
	Air Flow - Inlet
	Windbox Information
	Windbox Fan Information
	Binder addition rate
	Scrubber Flow
	Scrubber Flow water
	All emission data - pressures flows
	Cooling Zone Temperatures
	Recoup Fan Data
	Cooling Fan Data
	Updraft Drying Fan Data
	Exhaust Fan Data
	Greenball Quality Parameters?
	Greenball Moisture
	windbox exhaust fan vibration monitor

Pellet Quality Parameters	CaO/SiO2 Ratio (C/S Ratio)
	MgO/SiO2 Ratio (M/S Ratio)
	Pellet Silica
	Contraction
	Pellet Cold Compression Strength (CSS)
	(BT -1/4”) Pellet Size
	(AT +1/2”) Pellet % Oversize
	(AT 3/8 X 1/2”) Pellet Size
	(AT -1/4”) Pellet Size

Environmental Monitor Parameters	Indurator scrubber (4 stacks) water flow
	Stack Temp (each stack)
	Stack Exhaust Gas Flow(each stack)
	Stack SO2 (each stack)
	Stack NOx (each stack)

Attachment I

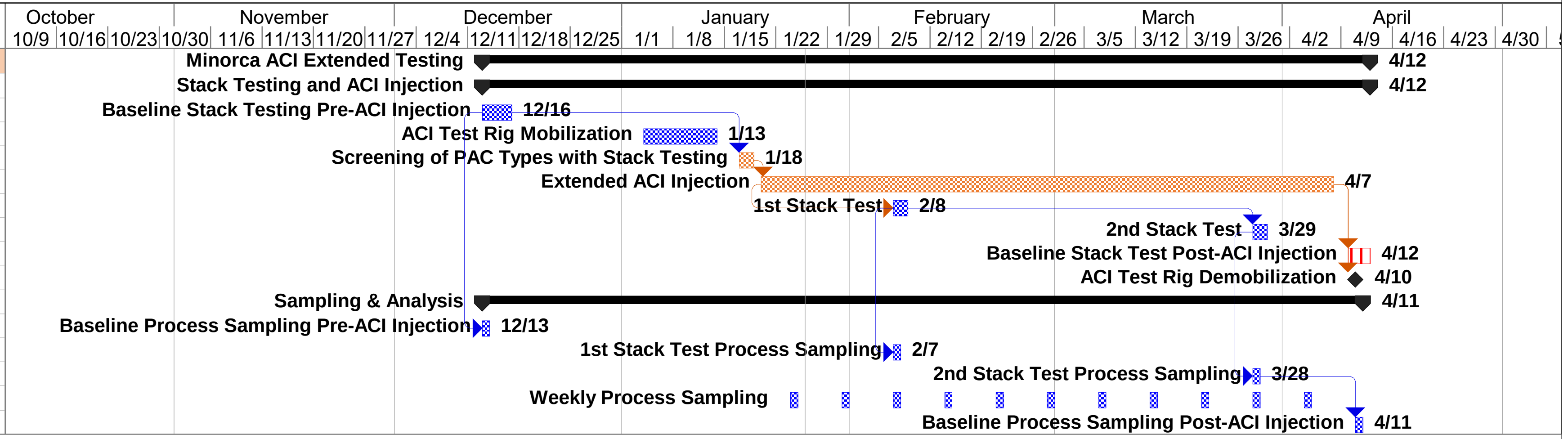
Process Sampling and Stack Testing Schedule

BARR

Minorca ACI Testing

Coordination Schedule

ID	Task Name	Duration	Start	Finish	Predecessors
1	**Minorca ACI Extended Testing**	**17.2 wks**	**Tue 12/13/16**	**Wed 4/12/17**	
2	**Stack Testing and ACI Injection**	**17.2 wks**	**Tue 12/13/16**	**Wed 4/12/17**	
3	Baseline Stack Testing Pre-ACI Injection	4 days	Tue 12/13/16	Fri 12/16/16	
4	ACI Test Rig Mobilization	8 days	Wed 1/4/17	Fri 1/13/17	
5	Screening of PAC Types with Stack Testing	2 days	Tue 1/17/17	Wed 1/18/17	3FS+20 days
6	Extended ACI Injection	78 days	Fri 1/20/17	Fri 4/7/17	5FS+1 day
7	1st Stack Test	2 days	Tue 2/7/17	Wed 2/8/17	6SS
8	2nd Stack Test	2 days	Tue 3/28/17	Wed 3/29/17	7
9	Baseline Stack Test Post-ACI Injection	3 days	Mon 4/10/17	Wed 4/12/17	6
10	ACI Test Rig Demobilization	0 days	Mon 4/10/17	Mon 4/10/17	6FS+1 day
11	**Sampling & Analysis**	**17 wks**	**Tue 12/13/16**	**Tue 4/11/17**	
12	Baseline Process Sampling Pre-ACI Injection	1 day	Tue 12/13/16	Tue 12/13/16	3SS
13	1st Stack Test Process Sampling	1 day	Tue 2/7/17	Tue 2/7/17	7SS
14	2nd Stack Test Process Sampling	1 day	Tue 3/28/17	Tue 3/28/17	8SS
15	Weekly Process Sampling (Tuesdays)	10.2 wks	Tue 1/24/17	Tue 4/4/17	12
28	Baseline Process Sampling Post-ACI Injection	1 day	Tue 4/11/17	Tue 4/11/17	14FS+9 days,15



Task ▨ Critical Task ▥ Milestone ◆ Summary ▬ Rolled Up Task ▨ Rolled Up Critical Task 🟥

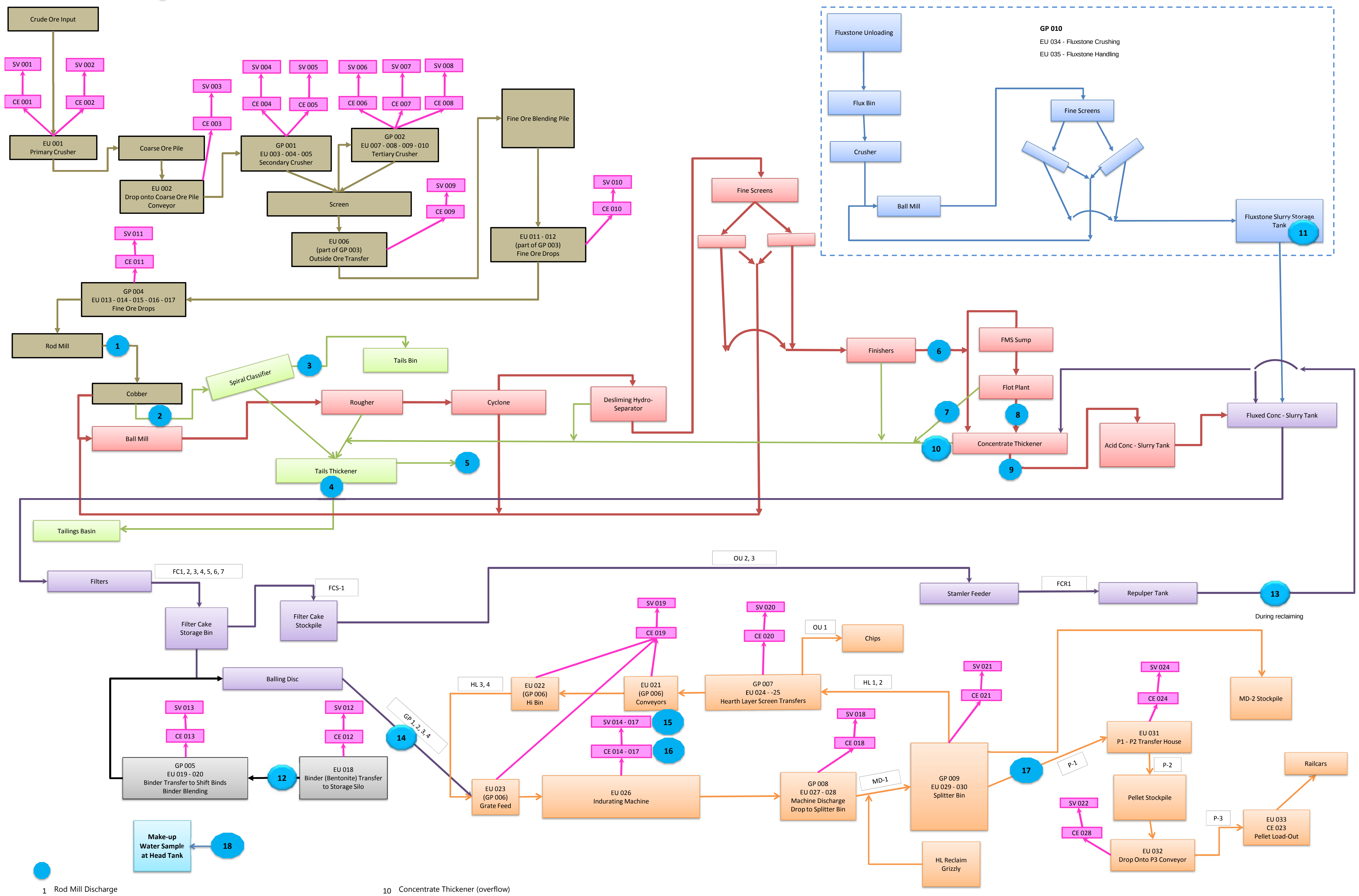
\\barr.com\projects\Duluth\23 MN\69\23691731 HibTac Arcelor Hg Test Plan\WorkFiles\Schedule\Minorca ACI Extended Testing Schedule 26Jan17.mpp

Print Date: Thu 1/26/17

Attachment J

Process Sampling Locations during Stack Testing

ArcelorMittal Minorca Mine
Process Flow Diagram

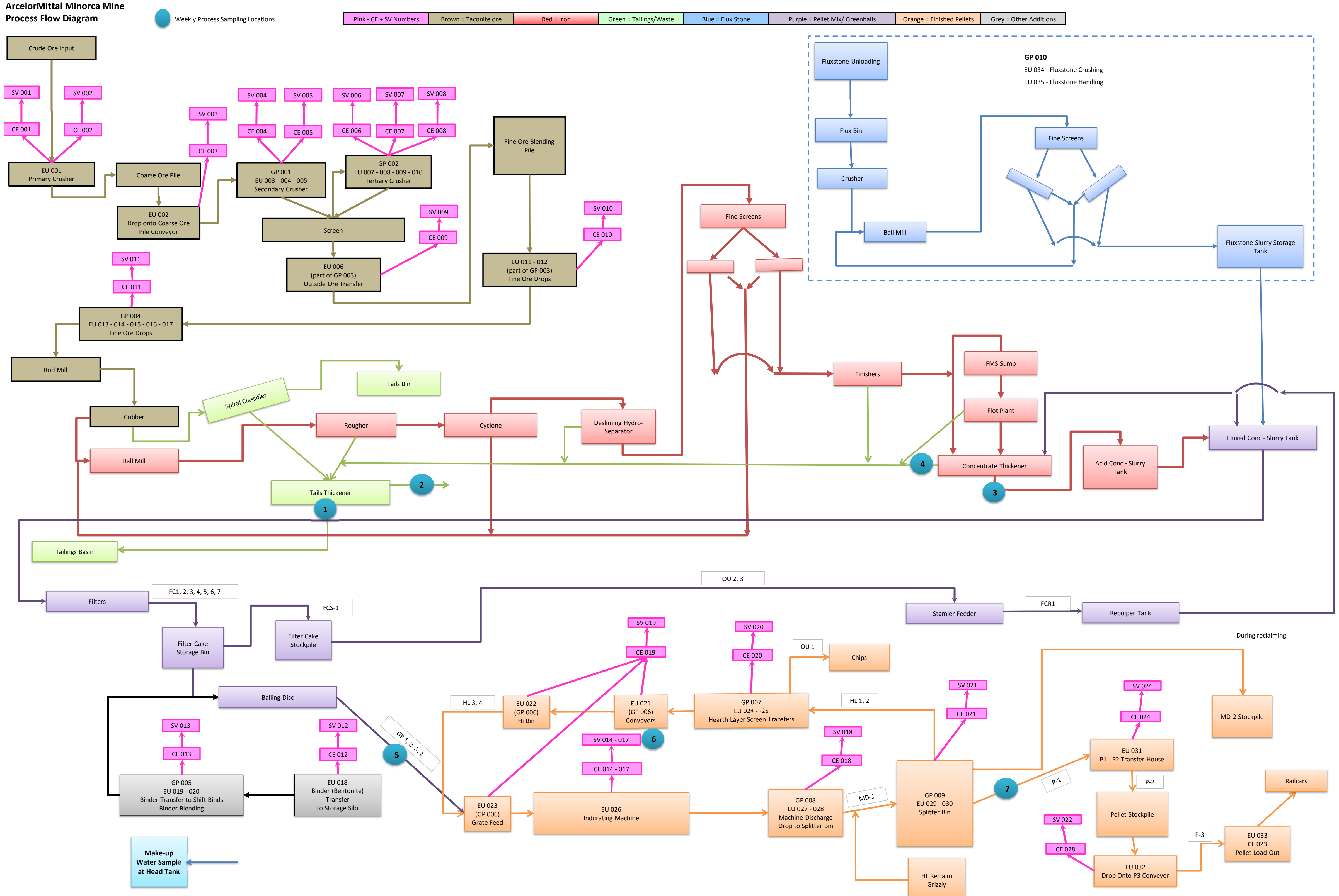


1 Rod Mill Discharge
2 Sands of Spiral Classifier to Tails Bin (Cobber Tails)
3 Spiral Classifier (overflow)
4 Tails Thickener (underflow) (Fine Tails)
5 Tails Thickener (overflow)
6 Finishers Concentrate Discharge to Concentrate Thickener/FMS Sump
7 Flotation Reject Product to Tailings Thickener
8 Concentrate Thickener Feed
9 Concentrate Thickener (underflow)
10 Concentrate Thickener (overflow)
11 Fluxstone Feed (from Fluxstone Slurry Storage Tank)
12 Binder Supply (feed to bin)
13 If in use, Repulper Tank (Concentrate Reclaim Feed to Acid Concentrate – Slurry Tank/Fluxed Concentrate – Slurry Tank)
14 Green Ball (balling disc discharge)
15 Multiclones (windboxes recycle to concentrate thickener)
16 Scrubber Blowdown/Scrubber Sump
17 Final Pellet Sample
18 Make-up water sample from plant head tank/raw water feed to plant

Attachment K

Weekly Process Sampling Locations

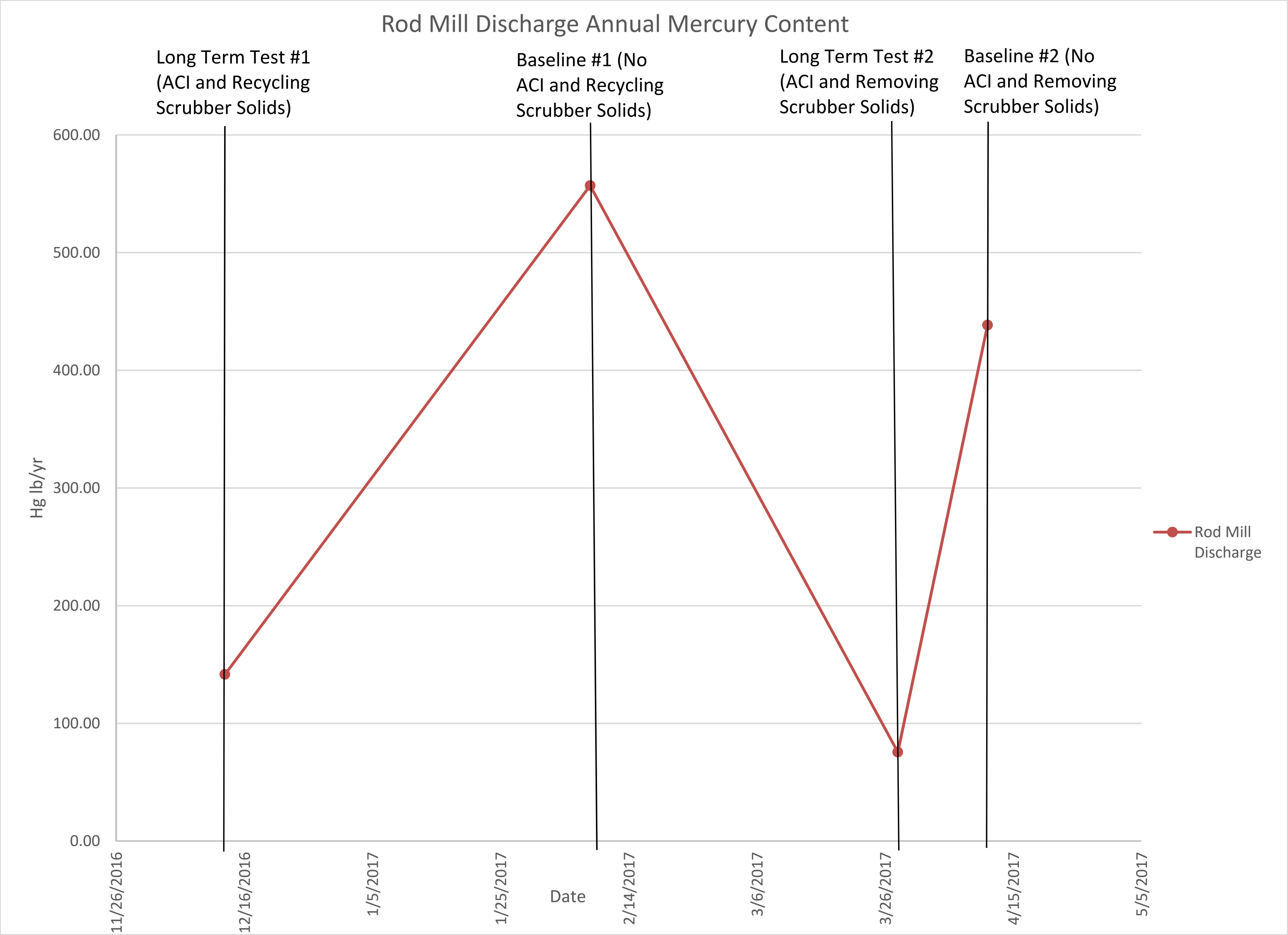
ArcelorMittal Minorca Mine
Process Flow Diagram

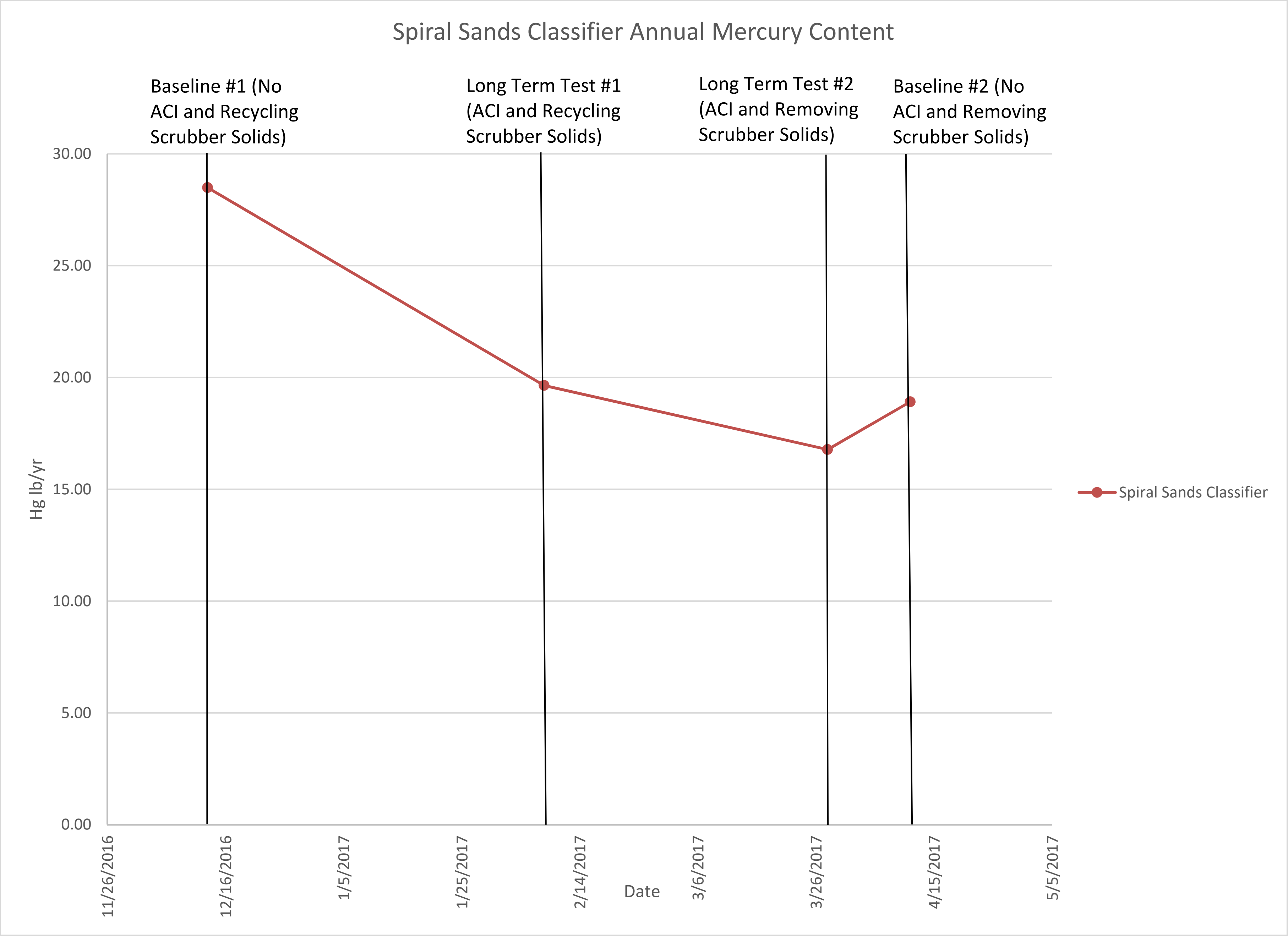


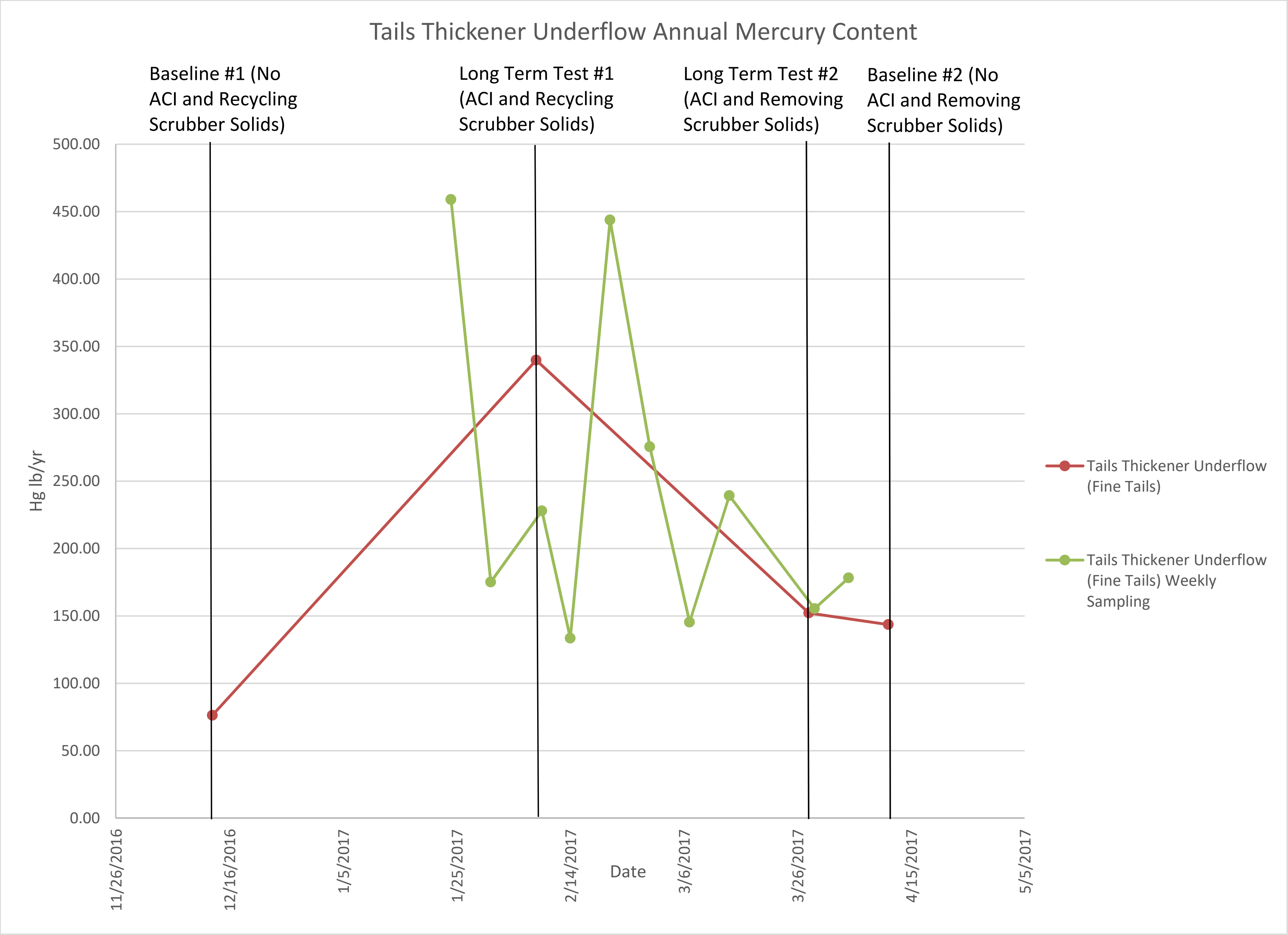
1. Tails Thickener (underflow) (fine tails)
2. Tails Thickener (overflow)
3. Concentrate Thickener (underflow)
4. Concentrate Thickener (overflow)
5. Greenball (balling disc discharge)
6. Scrubber Blowdown/Scrubber Sump
7. Final Pellet Sample

Attachment L

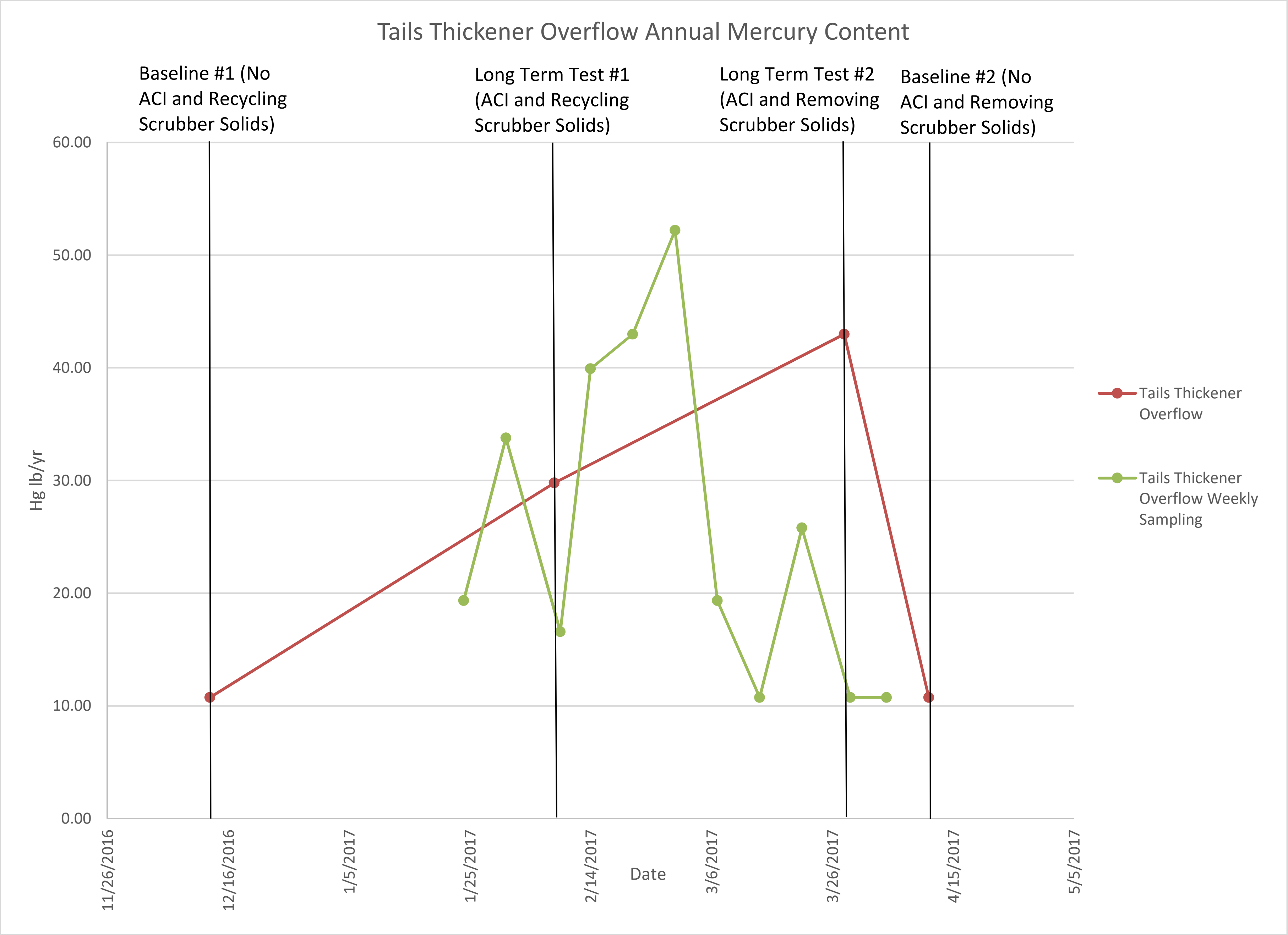
ACI Testing Results

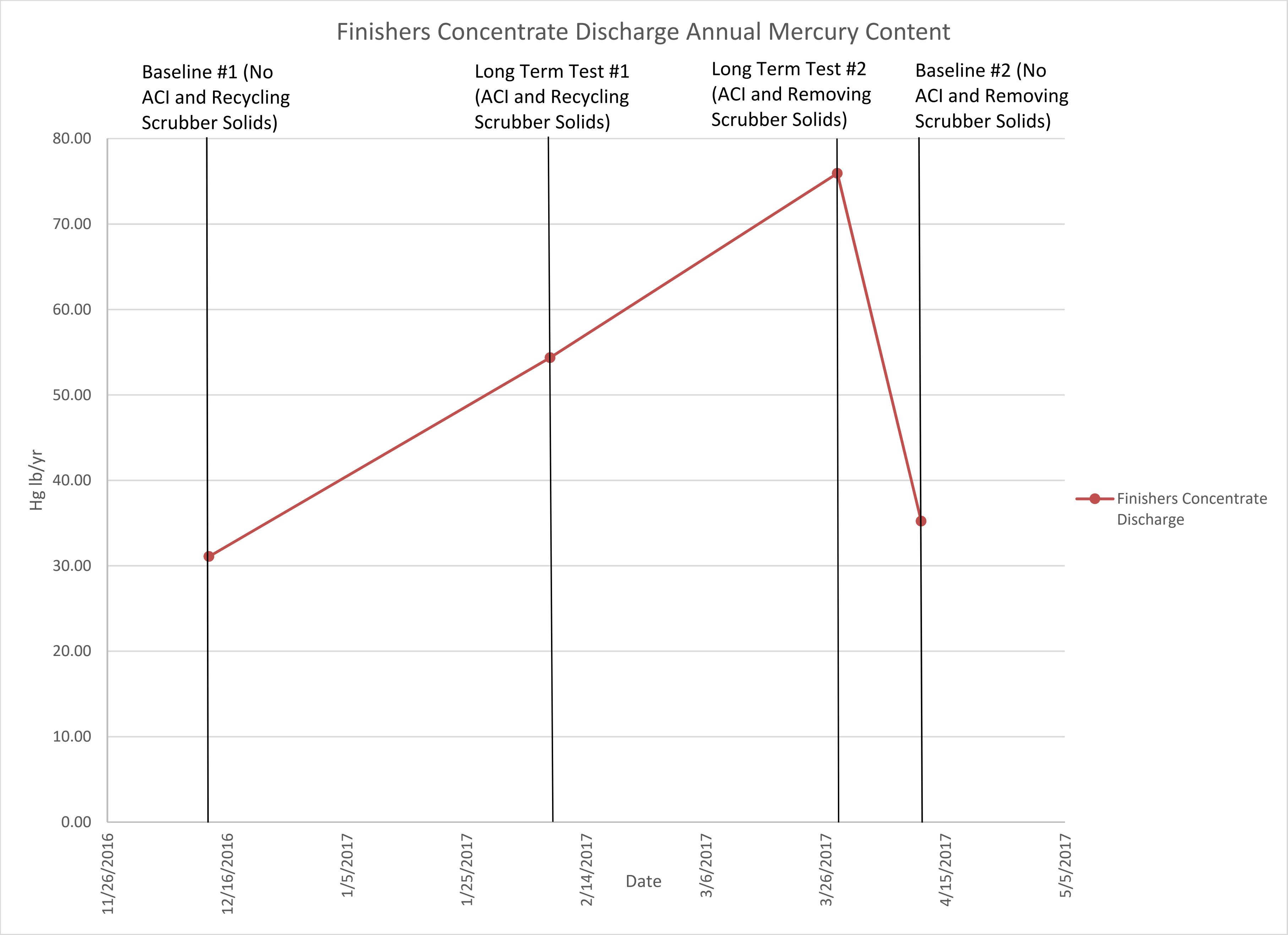

Rod Mill Discharge Annual Mercury Content
Long Term Test #1 (ACI and Recycling Scrubber Solids)
Baseline #1 (No ACI and Recycling Scrubber Solids)
Long Term Test #2 (ACI and Removing Scrubber Solids)
Baseline #2 (No ACI and Removing Scrubber Solids)
Hg lb/yr
600.00
500.00
400.00
300.00
200.00
100.00
0.00
11/26/2016
12/16/2016
1/5/2017
1/25/2017
2/14/2017
3/6/2017
3/26/2017
4/15/2017
5/5/2017
Date
Rod Mill Discharge

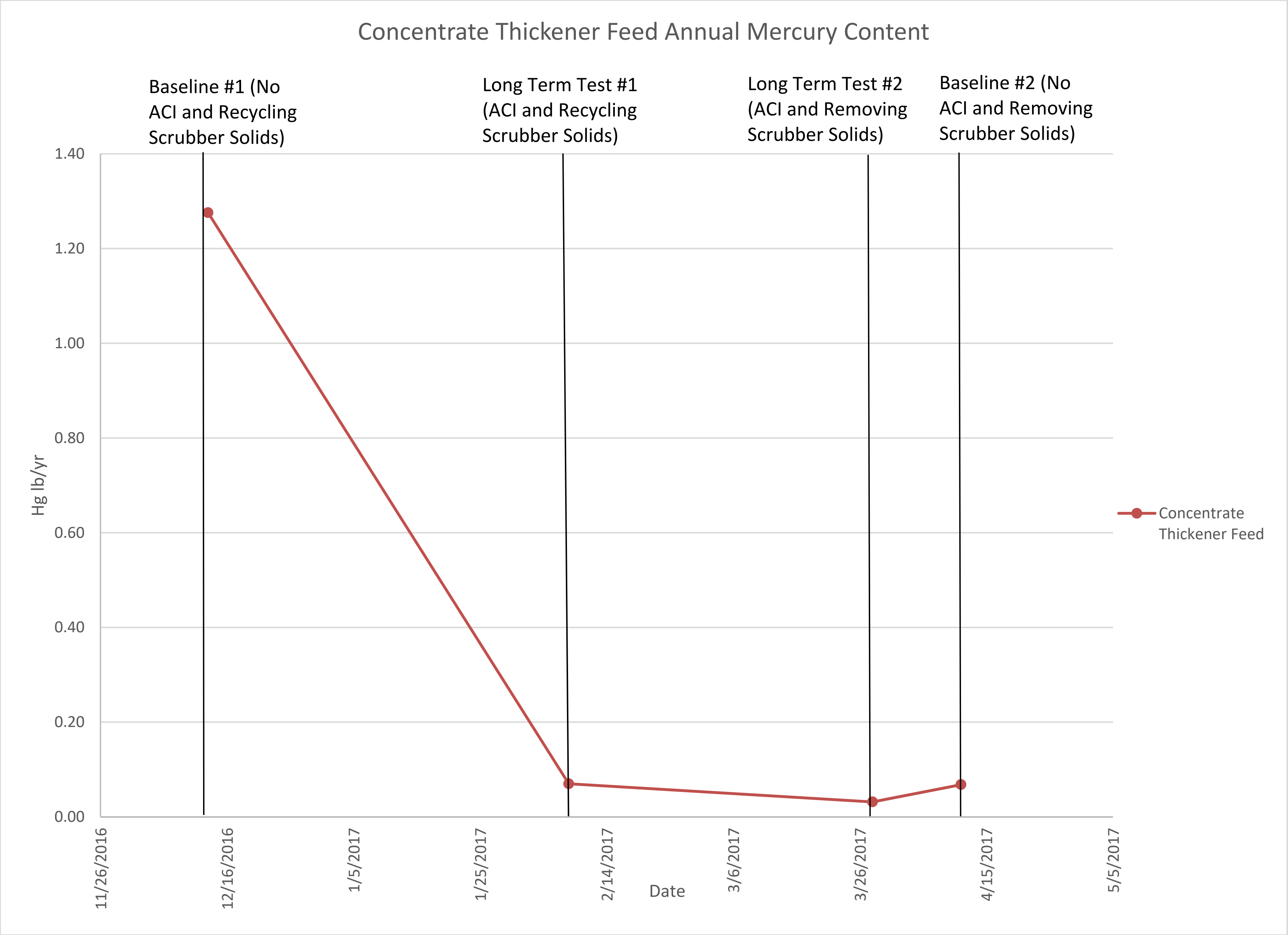

Spiral Sands Classifier Annual Mercury Content
Baseline #1 (No ACI and Recycling Scrubber Solids)
Long Term Test #1 (ACI and Recycling Scrubber Solids)
Long Term Test #2 (ACI and Removing Scrubber Solids)
Baseline #2 (No ACI and Removing Scrubber Solids)
30.00
25.00
20.00
15.00
10.00
5.00
0.00
Hg lb/yr
11/26/2016
12/16/2016
1/5/2017
1/25/2017
2/14/2017
3/6/2017
3/26/2017
4/15/2017
5/5/2017
Date
Spiral Sands Classifier

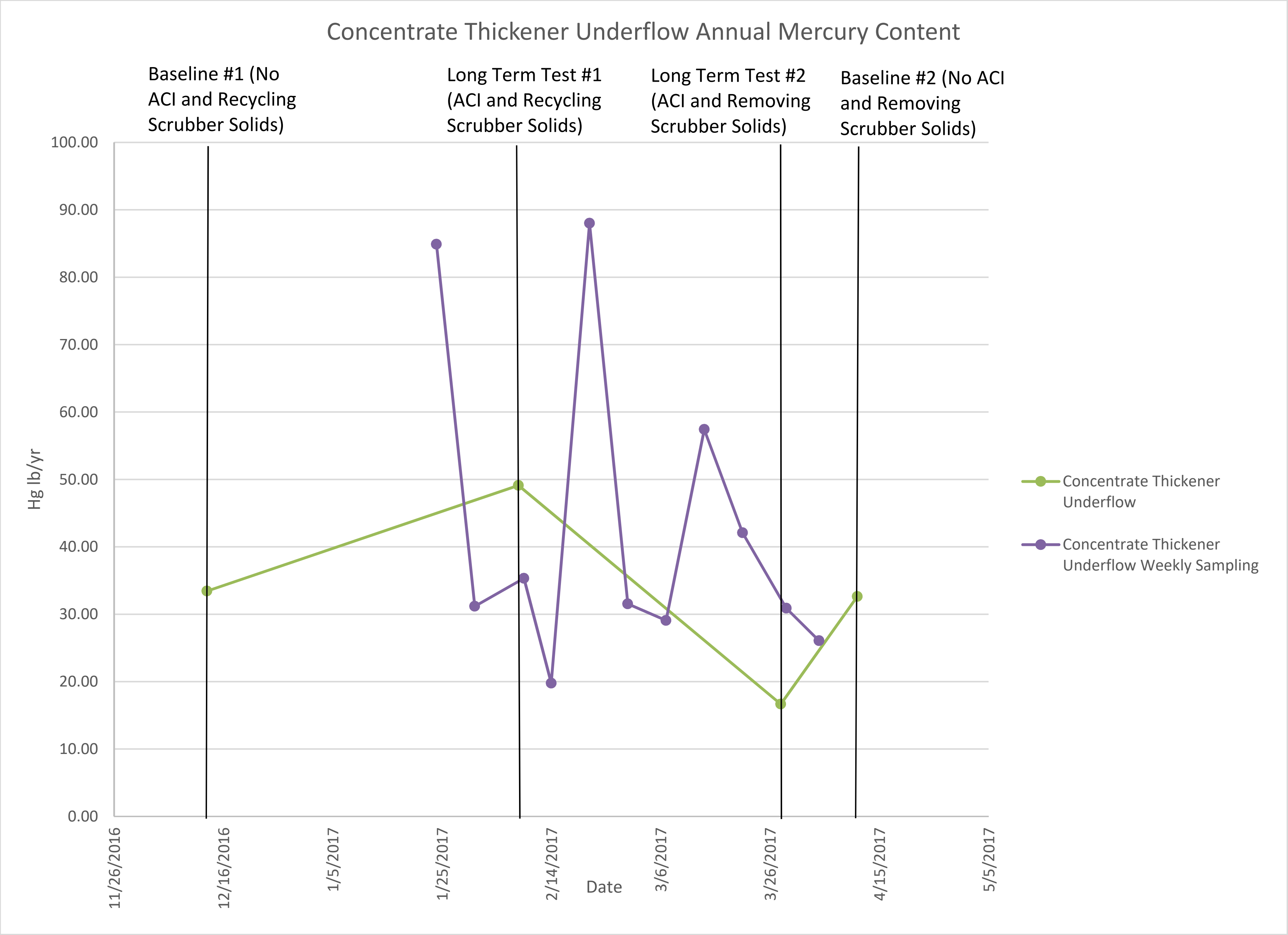


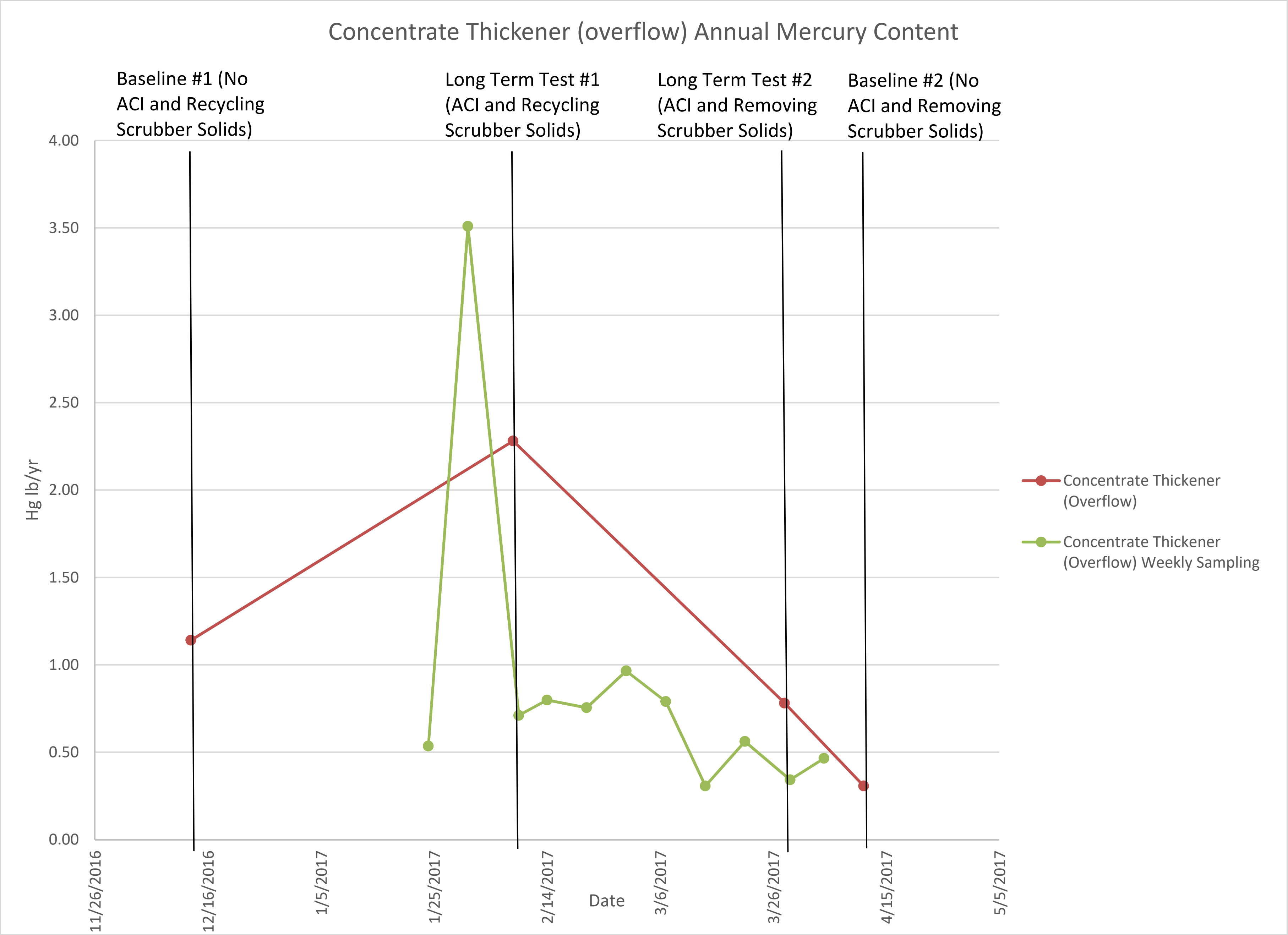
Tails Thickener Underflow Annual Mercury Content
Baseline #1 (No ACI and Recycling Scrubber Solids)
Long Term Test #1 (ACI and Recycling Scrubber Solids)
Long Term Test #2 (ACI and Removing Scrubber Solids)
Baseline #2 (No ACI and Removing Scrubber Solids)
Hg lb/yr
500.00
450.00
400.00
350.00
300.00
250.00
200.00
150.00
100.00
50.00
0.00
11/26/2016
12/16/2016
1/5/2017
1/25/2017
2/14/2017
3/6/2017
3/26/2017
4/15/2017
5/5/2017
Date
Tails Thickener Underflow (Fine Tails)
Tails Thickener Underflow (Fine Tails) Weekly Sampling

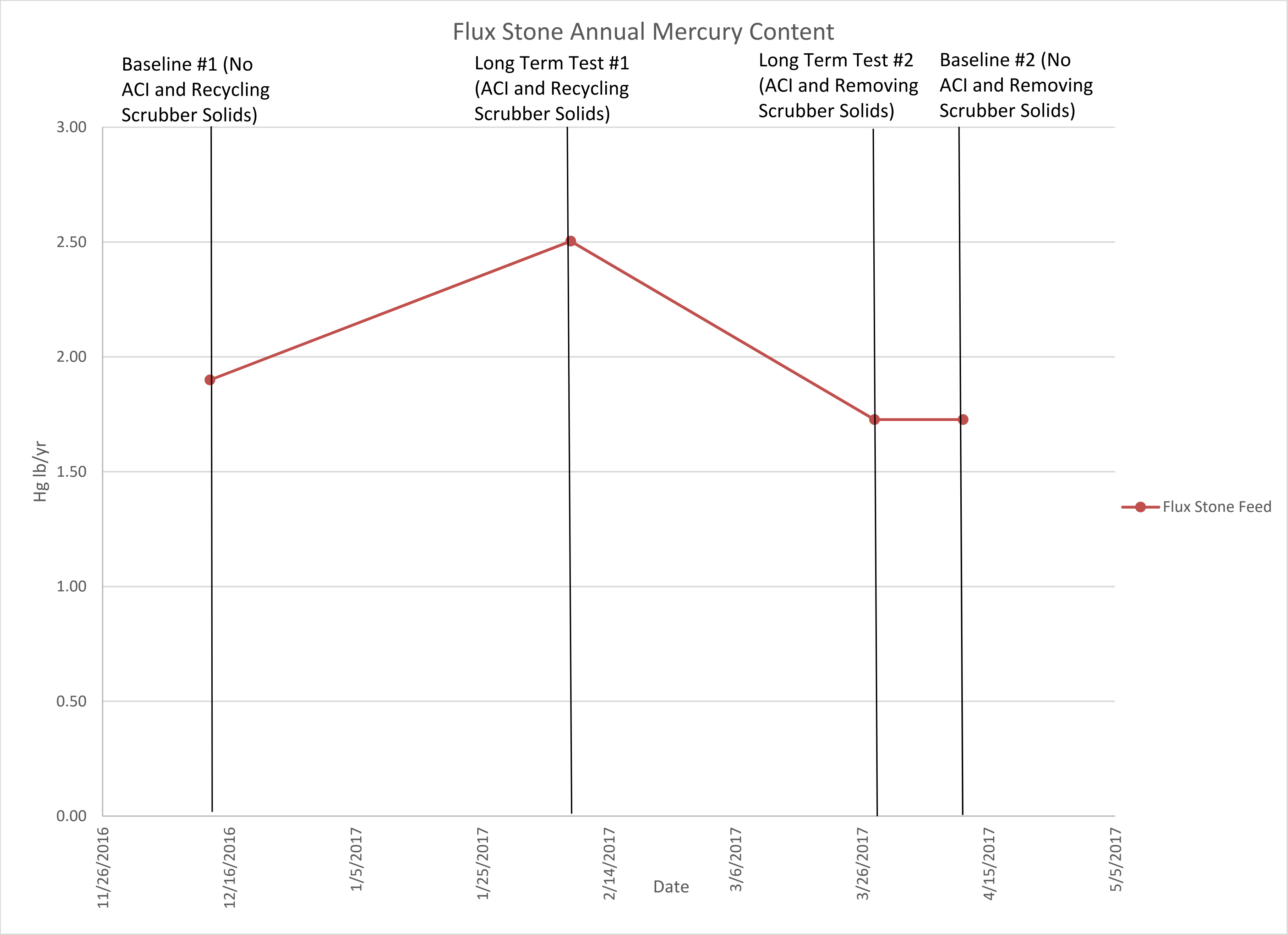

Tails Thickener Overflow Annual Mercury Content
Baseline #1 (No ACI and Recycling Scrubber Solids)
Long Term Test #1 (ACI and Recycling Scrubber Solids)
Long Term Test #2 (ACI and Removing Scrubber Solids)
Baseline #2 (No ACI and Removing Scrubber Solids)
Hg lb/yr
60.00
50.00
40.00
30.00
20.00
10.00
0.00
11/26/2016
12/16/2016
1/5/2017
1/25/2017
2/14/2017
3/6/2017
3/26/2017
4/15/2017
5/5/2017
Date
Tails Thickener Overflow
Tails Thickener Overflow Weekly Sampling

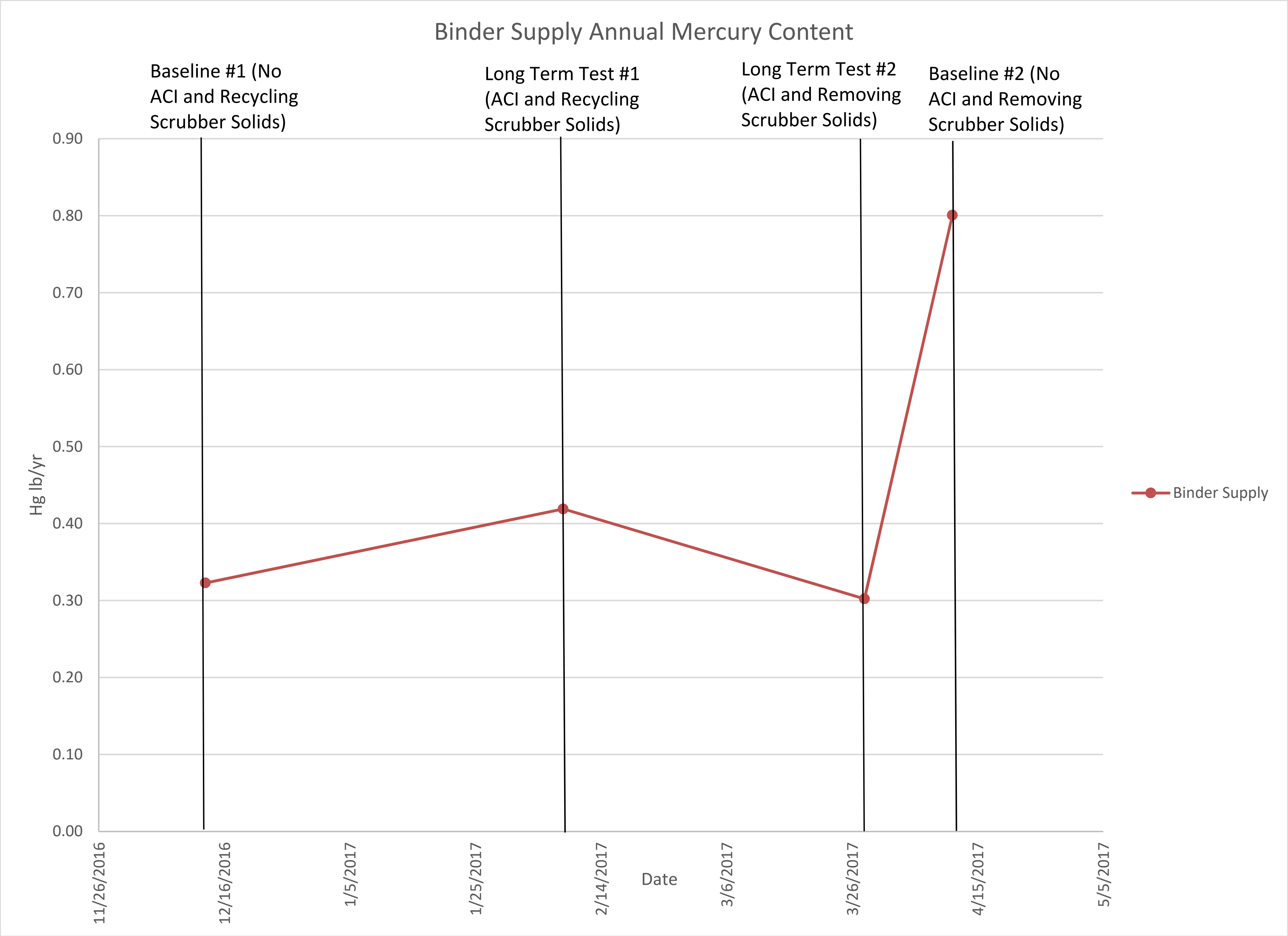

Finishers Concentrate Discharge Annual Mercury Content
Baseline #1 (No ACI and Recycling Scrubber Solids)
Long Term Test #1 (ACI and Recycling Scrubber Solids)
Long Term Test #2 (ACI and Removing Scrubber Solids)
Baseline #2 (No ACI and Removing Scrubber Solids)
Hg lb/yr
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
11/26/2016
12/16/2016
1/5/2017
1/25/2017
2/14/2017
3/6/2017
3/26/2017
4/15/2017
5/5/2017
Date
Finishers Concentrate Discharge


Concentrate Thickener Feed Annual Mercury Content
Baseline #1 (No ACI and Recycling Scrubber Solids)
Long Term Test #1 (ACI and Recycling Scrubber Solids)
Long Term Test #2 (ACI and Removing Scrubber Solids)
Baseline #2 (No ACI and Removing Scrubber Solids)
Hg lb/yr
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
11/26/2016
12/16/2016
1/5/2017
1/25/2017
2/14/2017
3/6/2017
3/26/2017
4/15/2017
5/5/2017
Date
Concentrate Thickener Feed

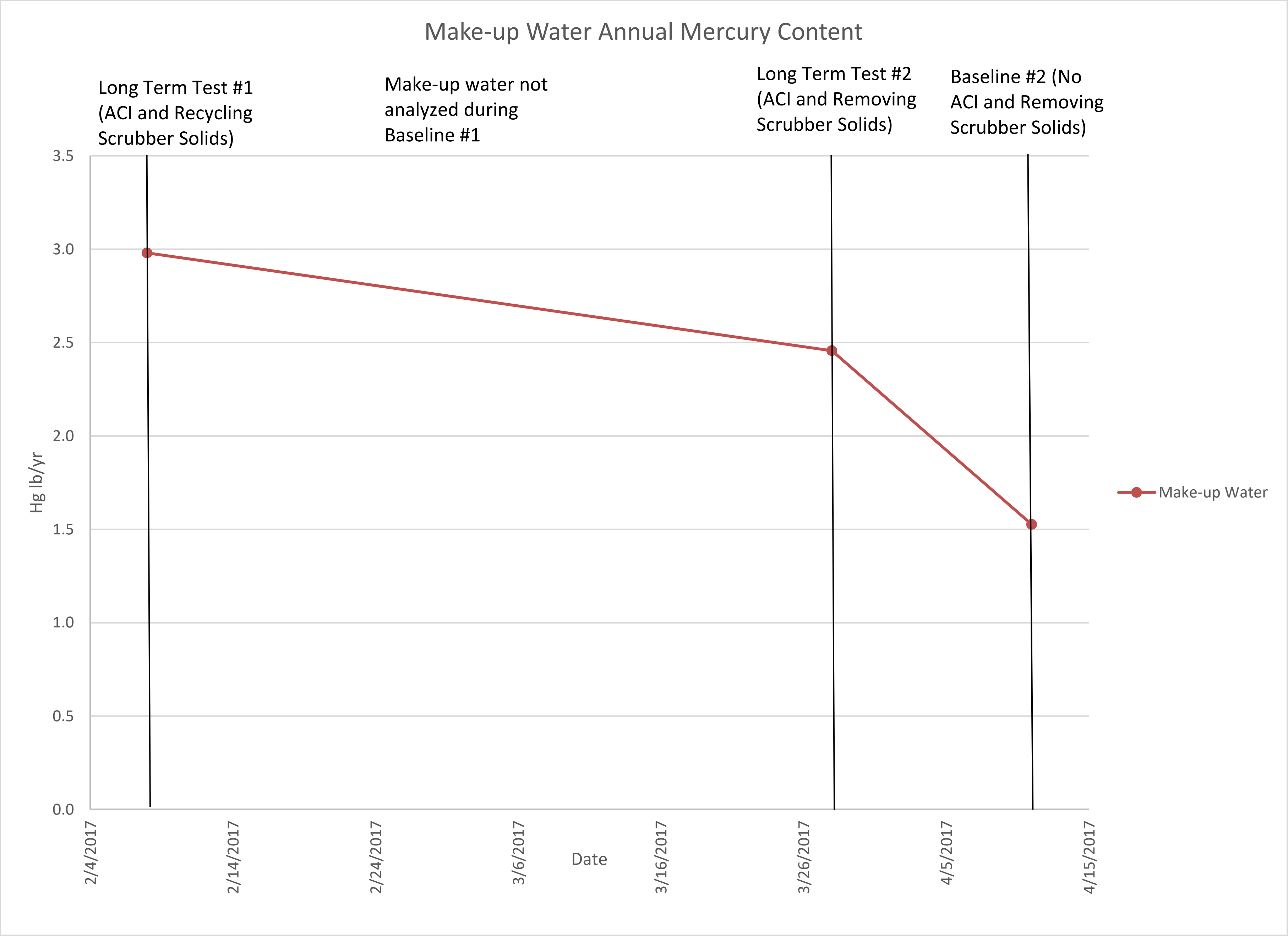

Concentrate Thickener Underflow Annual Mercury Content
Baseline #1 (No ACI and Recycling Scrubber Solids)
Long Term Test #1 (ACI and Recycling Scrubber Solids)
Long Term Test #2 (ACI and Removing Scrubber Solids)
Baseline #2 (No ACI and Removing Scrubber Solids)
Hg lb/yr
100.00
90.00
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
11/26/2016
12/16/2016
1/5/2017
1/25/2017
2/14/2017
3/6/2017
3/26/2017
4/15/2017
5/5/2017
Date
Concentrate Thickener Underflow
Concentrate Thickener Underflow Weekly Sampling

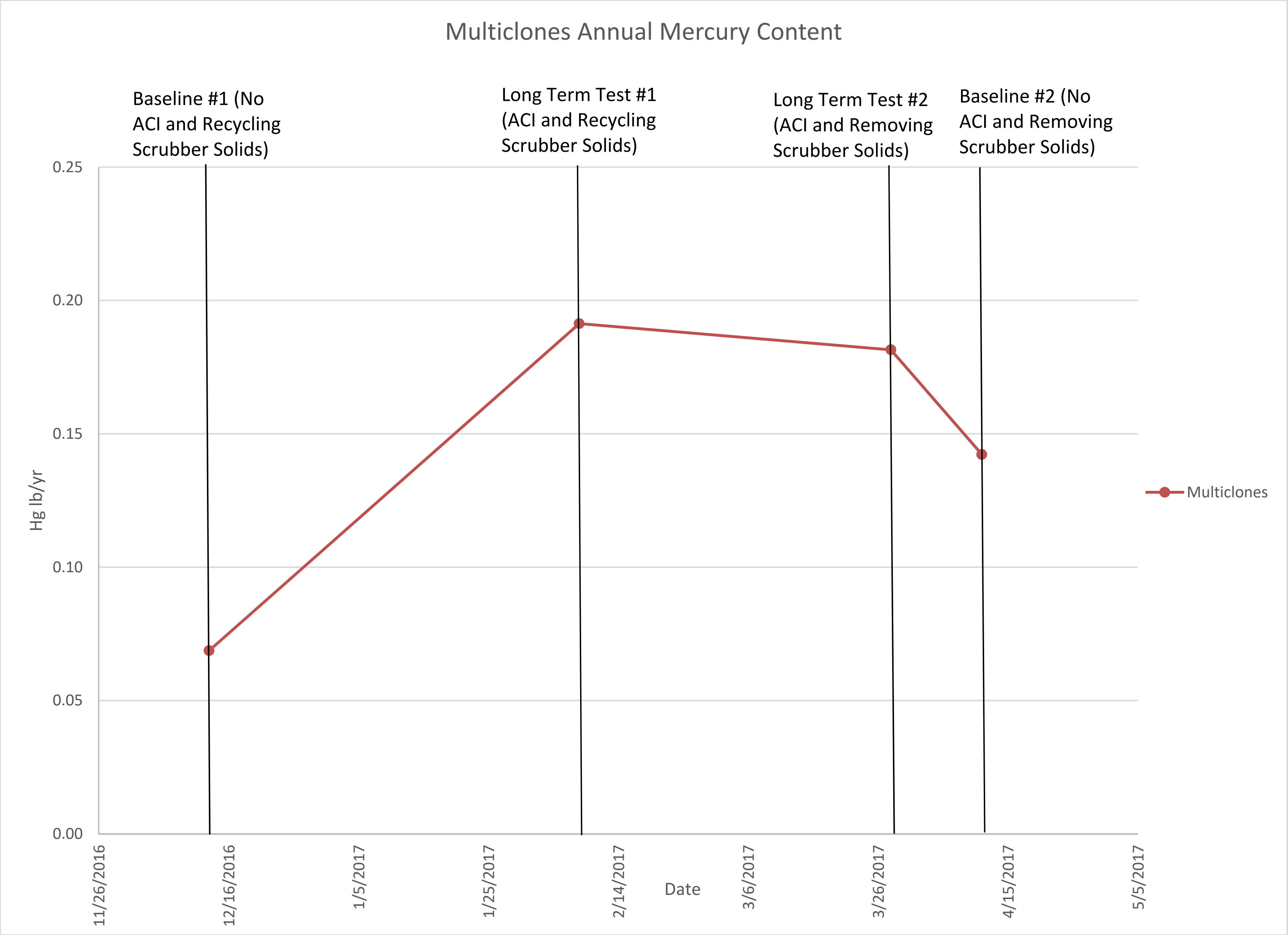

Concentrate Thickener (overflow) Annual Mercury Content
Baseline #1 (No ACI and Recycling Scrubber Solids)
Long Term Test #1 (ACI and Recycling Scrubber Solids)
Long Term Test #2 (ACI and Removing Scrubber Solids)
Baseline #2 (No ACI and Removing Scrubber Solids)
Hg lb/yr
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
11/26/2016
12/16/2016
1/5/2017
1/25/2017
2/14/2017
3/6/2017
3/26/2017
4/15/2017
5/5/2017
Date
Concentrate Thickener (Overflow)
Concentrate Thickener (Overflow) Weekly Sampling

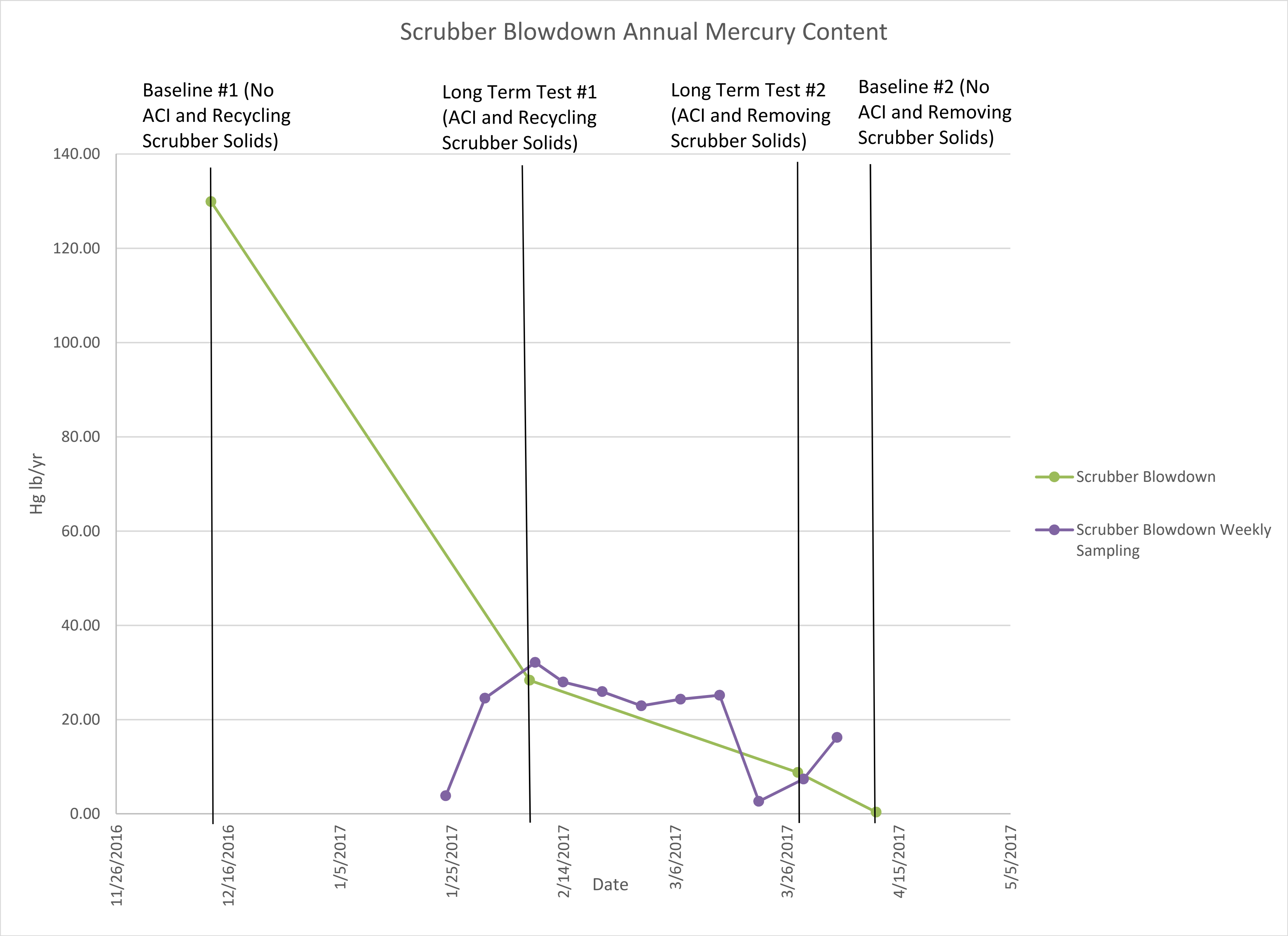

Flux Stone Annual Mercury Content
Baseline #1 (No ACI and Recycling Scrubber Solids)
Long Term Test #1 (ACI and Recycling Scrubber Solids)
Long Term Test #2 (ACI and Removing Scrubber Solids)
Baseline #2 (No ACI and Removing Scrubber Solids)
Hg lb/yr
3.00
2.50
2.00
1.50
1.00
0.50
0.00
11/26/2016
12/16/2016
1/5/2017
1/25/2017
2/14/2017
3/6/2017
3/26/2017
4/15/2017
5/5/2017
Date
Flux Stone Feed


Binder Supply Annual Mercury Content
Baseline #1 (No ACI and Recycling Scrubber Solids)
Long Term Test #1 (ACI and Recycling Scrubber Solids)
Long Term Test #2 (ACI and Removing Scrubber Solids)
Baseline #2 (No ACI and Removing Scrubber Solids)
Hg lb/yr
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
11/26/2016
12/16/2016
1/5/2017
1/25/2017
2/14/2017
3/6/2017
3/26/2017
4/15/2017
5/5/2017
Date
Binder Supply


Greenball Annual Mercury Content
Baseline #1 (No ACI and Recycling Scrubber Solids)
Long Term Test #1 (ACI and Recycling Scrubber Solids)
Long Term Test #2 (ACI and Removing Scrubber Solids)
Baseline #2 (No ACI and Removing Scrubber Solids)
Hg lb/yr
90.00
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
11/26/2016
12/16/2016
1/5/2017
1/25/2017
2/14/2017
3/6/2017
3/26/2017
4/15/2017
5/5/2017
Date
Greenball
Greenball Weekly Sampling


Make-up Water Annual Mercury Content
Long Term Test #1 (ACI and Recycling Scrubber Solids)
Make-up water not analyzed during Baseline #1
Long Term Test #2 (ACI and Removing Scrubber Solids)
Baseline #2 (No ACI and Removing Scrubber Solids)
Hg lb/yr
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
2/4/2017
2/14/2017
2/24/2017
3/6/2017
3/16/2017
3/26/2017
4/5/2017
4/15/2017
Date
Make-up Water


Multiclones Annual Mercury Content
Baseline #1 (No ACI and Recycling Scrubber Solids)
Long Term Test #1 (ACI and Recycling Scrubber Solids)
Long Term Test #2 (ACI and Removing Scrubber Solids)
Baseline #2 (No ACI and Removing Scrubber Solids)
Hg lb/yr
0.25
0.20
0.15
0.10
0.05
0.00
11/26/2016
12/16/2016
1/5/2017
1/25/2017
2/14/2017
3/6/2017
3/26/2017
4/15/2017
5/5/2017
Date
Multiclones


Scrubber Blowdown Annual Mercury Content
Baseline #1 (No ACI and Recycling Scrubber Solids)
Long Term Test #1 (ACI and Recycling Scrubber Solids)
Long Term Test #2 (ACI and Removing Scrubber Solids)
Baseline #2 (No ACI and Removing Scrubber Solids)
Hg lb/yr
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
11/26/2016
12/16/2016
1/5/2017
1/25/2017
2/14/2017
3/6/2017
3/26/2017
4/15/2017
5/5/2017
Date
Scrubber Blowdown
Scrubber Blowdown Weekly Sampling

Attachment M

Stack Test Report

Results of the December 2016 through April 2017 Mercury Emissions Tests Performed during Activated Carbon Injection Testing at ArcelorMittal Minorca Mine Inc. Located in Virginia, Minnesota

Indurating Furnace Stack A	SV014
Indurating Furnace Stack B	SV015
Indurating Furnace Stack C	SV016
Indurating Furnace Stack D	SV017

Agency Interest ID 699

Air Emissions Permit No. 13700062-003

Barr Project No. 23691863.00

Prepared for
ArcelorMittal Minorca Mine Inc.
Virginia, Minnesota

November 2017

Results of the December 2016 through April 2017 Mercury Emissions Tests Performed during Activated Carbon Injection Testing at ArcelorMittal Minorca Mine Located Inc. in Virginia, Minnesota

Indurating Furnace Stack A	SV014
Indurating Furnace Stack B	SV015
Indurating Furnace Stack C	SV016
Indurating Furnace Stack D	SV017

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Prepared for
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Virginia, Minnesota

November 2017

4300 MarketPointe Drive, Suite 200
Minneapolis, MN 55435-4803
952.832.2600
www.barr.com

Results of the December 2016 through April 2017 Mercury Emissions Tests Performed during Activated Carbon Injection Testing at ArcelorMittal Minorca Mine Inc. Located in Virginia, Minnesota

November 2017

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Report Certification

Certification of Sampling Procedures:

I certify under penalty of law that the sampling procedures were performed in accordance with the approved test plan and that the data presented in this test report are, to the best of my knowledge and belief, true, accurate, and complete. All exceptions are listed and explained below.

1/9/18

Ben Wiltse
Senior Air Quality Technician
Barr Engineering Co.

Date

Certification of Analytical Procedures:

I certify under penalty of law that the analytical procedures were performed in accordance with the requirements of the test methods and that the data presented for use in the test report were, to the best of my knowledge and belief, true, accurate, and complete. All exceptions are listed and explained below.

Richard Berg

1/9/18

Richard Berg
Senior Air Quality Technician
Barr Engineering Co.

Date

Certification of Test Report by Testing Company:

I certify under penalty of law that this test report and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gathered and evaluated the test information submitted. Based on my inquiry of the person or persons who performed sampling and analysis relating to the performance test, the information submitted in this test report is, to the best of my knowledge and belief, true, accurate, and complete. All exceptions are listed and explained below.

1/9/18

Tom Kuchinski
Stack Testing Services Coordinator
Barr Engineering Co.

Date

Certification of Test Report by Owner or Operator of Emission Facility:

I certify under penalty of law that the information submitted in this test report accurately reflects the operating conditions at the emission facility during this performance test and describes the date and nature of all operational and maintenance activities that were performed on the process and control equipment during the month prior to the performance test. Based on my inquiry of the person or persons who performed the operational and maintenance activities, the information submitted in this test report is, to the best of my knowledge and belief, true, accurate, and complete. All exceptions are listed and explained below.

Jaime Johnson
Manager - Environmental
ArcelorMittal Minorca Mine Inc.

5 January 2018
Date

Executive Summary

Barr Engineering Company performed five mercury emissions stack tests on the Indurating Furnace Line (EU026, SV014-017) at ArcelorMittal Minorca Mine Inc. (Minorca) located in Virginia, Minnesota. The stack tests were completed during extended testing of activated carbon injection (ACI) to determine its feasibility to reduce mercury emissions from Minorca's indurating furnace. Previous ACI testing at Minorca suggested that the technology has the potential to significantly reduce mercury emissions. However, the initial results left several data gaps that this round of testing sought to address while determining if the technology is technically and economically feasible for a full-scale installation.

Two baseline tests were performed with no carbon injection on December 13-14, 2017 and April 11-12, 2017, here on referred to as Baseline 1 and Baseline 2, respectively. A screening test was performed on January 17-18, 2017 to determine which type of carbon to inject long term, here on referred to as Screening. Two long-term tests were performed, one on February 8-9, 2017 and another on March 28-29, 2017 to obtain mercury data during injection, here on referred to as Long-term 1 and Long-term 2 respectively. Determinations were made for filterable particulate matter during the Screening, Long-term 1, and Long-term 2 tests.

A project summary of results for all five tests is presented in Tables ES-1.

Table ES-1 Executive Summary Table 1

Mercury Project Results Summary					
Parameter	**EPA Method**	**Stack A**	**Stack B**	**Stack C**	**Stack D**
Baseline 1 Results – December 13-14, 2016					
Hg, lb/yr	30B	12.4	14.8	19.0	20.6
Total Hg, lb/yr		**66.8**			
Screening Results – January 17-18, 2017					
BPAC					
PM – Filterable, lb/hr	5	---	---	8.9	9.3
PM – Filterable, gr/dscf	5	---	---	0.0064	0.0074
Hg, lb/yr	30B	---	---	11.4	12.9
HPAC					
PM – Filterable, lb/hr	5	---	---	9.2	9.5
PM – Filterable, gr/dscf	5	---	---	0.0067	0.0078
Hg, lb/yr	30B	---	---	9.7	10.6
Long-term 1 Results – February 8-9, 2017					
PM – Filterable, lb/hr	5	6.3	6.7	8.1	8.2
PM – Filterable, gr/dscf	5	0.0046	0.0047	0.0059	0.0068
Hg, lb/yr	Ont-Hydro	10.6	11.5	14.4	17.2
Total Hg, lb/yr		**53.6**			
Long-term 2 Results – March 28-29, 2017					
PM – Filterable, lb/hr	5	6.0	6.4	7.4	7.4
PM – Filterable, gr/dscf	5	0.0045	0.0047	0.0056	0.0064
Hg, lb/yr	Ont-Hydro	7.3	7.5	10.2	9.3
Total Hg, lb/yr		**34.3**			
Baseline 2 Results – April 11-12, 2017					
Hg, lb/yr	30B	6.4	8.1	12.1	12.8
Total Hg, lb/yr		**39.4**			

Annual emissions calculated assuming 8760 operating hours per year.

1.0 Introduction

Barr Engineering Company performed five mercury emissions stack tests on the Indurating Furnace Line (EU026, SV014-017) at ArcelorMittal Minorca Mine (Minorca) located in Virginia, Minnesota. The stack tests were completed during extended testing of activated carbon injection (ACI) to determine its feasibility to reduce mercury emissions from Minorca's indurating furnace. Previous ACI testing at Minorca suggested that the technology has the potential to significantly reduce mercury emissions. However, the initial results left several data gaps that this round of testing sought to address while determining if the technology is technically and economically feasible for a full-scale installation.

Two baseline tests were performed with no carbon injection on December 13-14, 2017 and April 11-12, 2017, here on referred to as Baseline 1 and Baseline 2, respectively. A screening test was performed on January 17-18, 2017 to determine which type of carbon to inject long term, here on referred to as Screening. Two long-term tests were performed, one on February 8-9, 2017 and another on March 28-29, 2017 to obtain mercury data during injection, here on referred to as Long-term 1 and Long-term 2 respectively. Emissions tests were performed on the Indurating Furnace Line (EU026) Stacks A-D (SV014-SV017). Determinations were made for filterable particulate matter during the Screening, Long-term 1, and Long-term 2 tests.

Ben Wiltse led the Barr test teams. Jaime Johnson of Minorca provided the coordination of the test team with facility operations. A list of project participants is provided in Appendix F.

Baseline 1 testing results are shown in Table 1 in the appendices and consisted of three (3) one-hour test runs of Method 30B on Stacks A-D (SV014-SV017). This test was performed to establish a baseline mercury concentration and emission rate for determination of mercury reduction during activated carbon injection (ACI). Baseline 1 testing was conducted under normal operating conditions with scrubber solids recycled to the concentrator process.

Two different powered activated carbons were screened for mercury removal and filterable particulate matter emissions performance. Screening test results are shown in Table 1 in the appendices and consisted of three (3) thirty-minute test runs of Method 5 and Method 30B on Stacks C and D (SV016 and SV017). Two different carbons were injected during the screening test, B-PAC, a brominated powered activated carbon the first day, and H-PAC, a high temperature brominated powered activated carbon, the second day. The screening test of H-PAC showed a greater mercury reduction than B-PAC, therefore H-PAC was chosen as the powered activated carbon for long-term testing.

Long-term 1 was performed to collect mercury and filterable particulate matter data during extended ACI. Three (3) two-hour test runs on Stacks A-D (SV014-SV017) by Ontario-hydro with Method 5 were performed for mercury and particulate matter emissions. During Long-term 1 testing was conducted under normal operating conditions with scrubber solids recycled to the concentrator process. Results from this test can be found in Table 1 in the appendices.

Long-term 2 was performed to collect mercury and filterable particulate matter data during extended ACI. Three (3) two-hour test runs on Stacks A-D (SV014-SV017) by Ontario-hydro with Method 5 were performed for mercury and particulate matter emissions. During Long-term 2 testing, scrubber solids were re-routed to the tailings thickener. Results from this test can be found in Table 1 in the appendices.

Baseline 2 testing consisted of three (3) one-hour test runs of Method 30B on Stacks A-D (SV014-SV017). This test was performed to check baseline mercury results after ACI had stopped. Baseline 2 testing was conducted under normal operating conditions, however scrubber solids were re-routed to the tailings thickener during this test. Results from this test can be found in Table 1 in the appendices.

Table 1-1 Emission Source Information

Source	Emission Unit	Control Equipment	Plant ID	Stack Vent
Indurating Furnace	EU026	CE014	Stack A 108DC01	SV014
		CE015	Stack B 108DC02	SV015
		CE016	Stack C 108DC03	SV016
		CE017	Stack D 108DC04	SV017

2.0 Results Summary

Mercury results are presented in pounds per year (lb/yr) based on 8760 hours and particulate results are presented in grains per dry standard cubic foot (gr/dscf) and lb/hr. Results displayed in the executive summary and on Table 1 are the average of three test runs.

Baseline 1

Baseline 1 testing was conducted under normal operating conditions with scrubber solids recycled to the concentrator process. Results of the Baseline 1 sample event performed at SV014-SV017 on December 13-14, 2016 are provided in Table 1 in the appendices. Total Hg emissions were 66.8 lb/yr. Detailed results for report calculations and nomenclature can be found in Appendix A. Baseline 1 established the base mercury concentration and emissions to be used for future mercury reduction calculations. Cold weather conditions caused testing equipment to freeze. Due to the freezing of equipment, five traps experienced reduced flow rates and therefore lower sample volumes. Although the sample volumes were lower on these traps, there was enough mercury on each trap for accurate analysis of all of the traps. The test results showed similar mercury emissions to those obtained in during the 2015 mercury stack test, which was analyzed using EPA Method 29.

Screening

Results of the Screening sample event performed at Stack C (SV016) and Stack D (SV017) on January 17-18, 2017 for mercury and particulate matter are provided in Table 1 in the appendices. Detailed results for report calculations and nomenclature can be found in Appendix A. H-PAC performance during the screening determined its use as the powered activated carbon for long-term testing.

Long-term 1

Long-term 1 testing was conducted under normal operating conditions while injecting H-PAC at approximately 1 lb/mmacf. Results of the Long-term 1 sample event performed at SV014-SV017 on February 8-9, 2017 for mercury and particulate matter are provided in Table 1 in the appendices. Total Hg emissions were 53.6 lb/yr. Detailed results for report calculations and nomenclature can be found in Appendix A.

Long-term 2

Long-term 2 testing was conducted under normal operating conditions while injecting H-PAC at approximately 1 lb/mmacf, however scrubber solids were re-routed to the tailings thickener. Results of the Long-term 2 sample event performed at SV014-SV017 on March 28-29, 2017 for mercury and particulate matter are provided in Table 1 in the appendices. Total Hg emissions were 34.3 lb/yr. Detailed results for report calculations and nomenclature can be found in Appendix A.

Baseline 2

Baseline 2 testing was conducted under normal operating conditions, however scrubber solids were re-routed to the tailings thickener. The ACI was stopped on April 7, 2017, and testing for Baseline 2 commenced on April 11, 2017. Results of the Baseline 2 sample event performed at SV014-SV017 on April 11-12, 2017 for mercury are provided in Table 1 in the appendices. Total Hg emissions were 39.4 lb/yr. Detailed results for report calculations and nomenclature can be found in Appendix A.

3.0 Process Description

ArcelorMittal mines taconite ore (magnetite) and produces iron pellets that are shipped to the company's blast furnace in Indiana.

Concentrate slurry flows to a storage tank where limestone is added to make flux pellets. The concentrate is dewatered by vacuum disk filters, mixed with bentonite and conveyed to balling disks. Green balls produced on the balling disks are transferred to a roll conveyor for additional removal of over and undersize material.

The green balls are distributed evenly across pallet cars, prior to entry into the pellet furnace. The pallet cars have a layer of fired pellets, called the hearth layer, on the bottom and sides of the car. The hearth layer acts as a buffer between the pallet car and the heat generated through the exothermic conversion of magnetite to hematite.

There is one natural gas fired furnace at ArcelorMittal's taconite plant. The straight grate furnace has several distinct zones. The first two stages are updraft and downdraft drying zones. The next zones are the preheat zone and firing zone. The temperature increases as the pellets pass through each zone reaching a peak in the firing zone. The pellets enter the after-firing zone, where the conversion of magnetite to hematite is completed. The last two zones are cooling zones that allow the pellets to be discharged at a temperature of around 120 degrees Fahrenheit.

Heated air discharged from the two cooling zones is recirculated to the drying, preheat and firing zones. Off-gases from the furnaces are vented primarily through two ducts, the hood exhaust that handles the drying and recirculated cooling gases, and the windbox exhaust, which handles the preheat, firing, and after-firing gases. The windbox exhaust flows through a multiclone, which protects the downstream fan, and then enters a common header shared with the hood exhaust stream. The exhaust gases are subsequently divided into four streams which lead to four venturi rod scrubbers and exhaust from individual stacks.

4.0 Stack Testing Procedures and Methods

The testing was performed from ports meeting U.S. EPA Method 1 criteria. Sample port locations are provided in Figures 1-2.

Table 4-1 EPA Method 1 Criteria

Stack Vent Number	Distance to Upstream Disturbances (Diameters)	Distance to Downstream Disturbances (Diameters)	Number of Ports	Number of Points
SV014	8.2	3.5	4	12
SV015	8.2	3.5	4	12
SV016	8.1	3.5	4	12
SV017	8.0	3.4	4	12

Volumetric airflow determinations were performed in accordance with U.S. EPA Method 2 using an S type pitot tube. Airflows were determined in conjunction with the EPA Method 5 and EPA 30B tests.

Stack gas oxygen and carbon dioxide compositions were determined using modified U.S. EPA Method 3A during the Baseline 1 and Screening tests. An integrated sample of dry stack gas was collected in a Tedlar bag during each test run. The stack gas was analyzed for oxygen and carbon dioxide concentrations using a Servomex Model 1440 analyzer calibrated with EPA protocol gases. Instrument calibration and analysis data are documented in the field data sheets in Appendix B. Calibration gas certifications are located in Appendix E. During Long-term 1, Long-term 2, and Baseline 2 oxygen and carbon dioxide concentrations were obtained from the CEMS and cross checked with a portable oxygen analyzer.

Stack gas moisture content was determined by the performance of U.S. EPA Method 4, in conjunction with the Method 30B, Ontario Hydro, and/or Method 5 tests.

Particulate matter concentrations and emission rates were determined in accordance with U.S. EPA Method 5 as allowed in ASTM D6784-16 Ontario Hydro method. Particulate matter laboratory analysis was performed at Barr.

Mercury concentrations and emission rates for Baseline 1, Screening, and Baseline 2 were determined in accordance with EPA Method 30B. Samples were analyzed on-site by Barr during the Baseline 1 and Screening tests. Samples were analyzed off site by Ohio Lumex of Solon, Ohio for the Baseline 2 test.

Mercury concentrations and emission rates for Long-term 1 and Long-term 2 were determined in accordance with ASTM D6784-16 Ontario Hydro. All glassware and reagent preparation was completed at Barr laboratory facilities. Potassium permanganate sample reagents were prepared on site daily. Sample recovery was completed within Barr’s lab trailer to minimize contamination. Mercury samples were analyzed by Element One of Wilmington, North Carolina. The average result of the sample analysis and duplicate analysis are used in the calculation of emissions.

Sample analysis results and chain of custody for all samples are located in Appendix C.

The test methods referenced above are found in 40 CFR Part 60, Appendix A and ASTM.

Tables

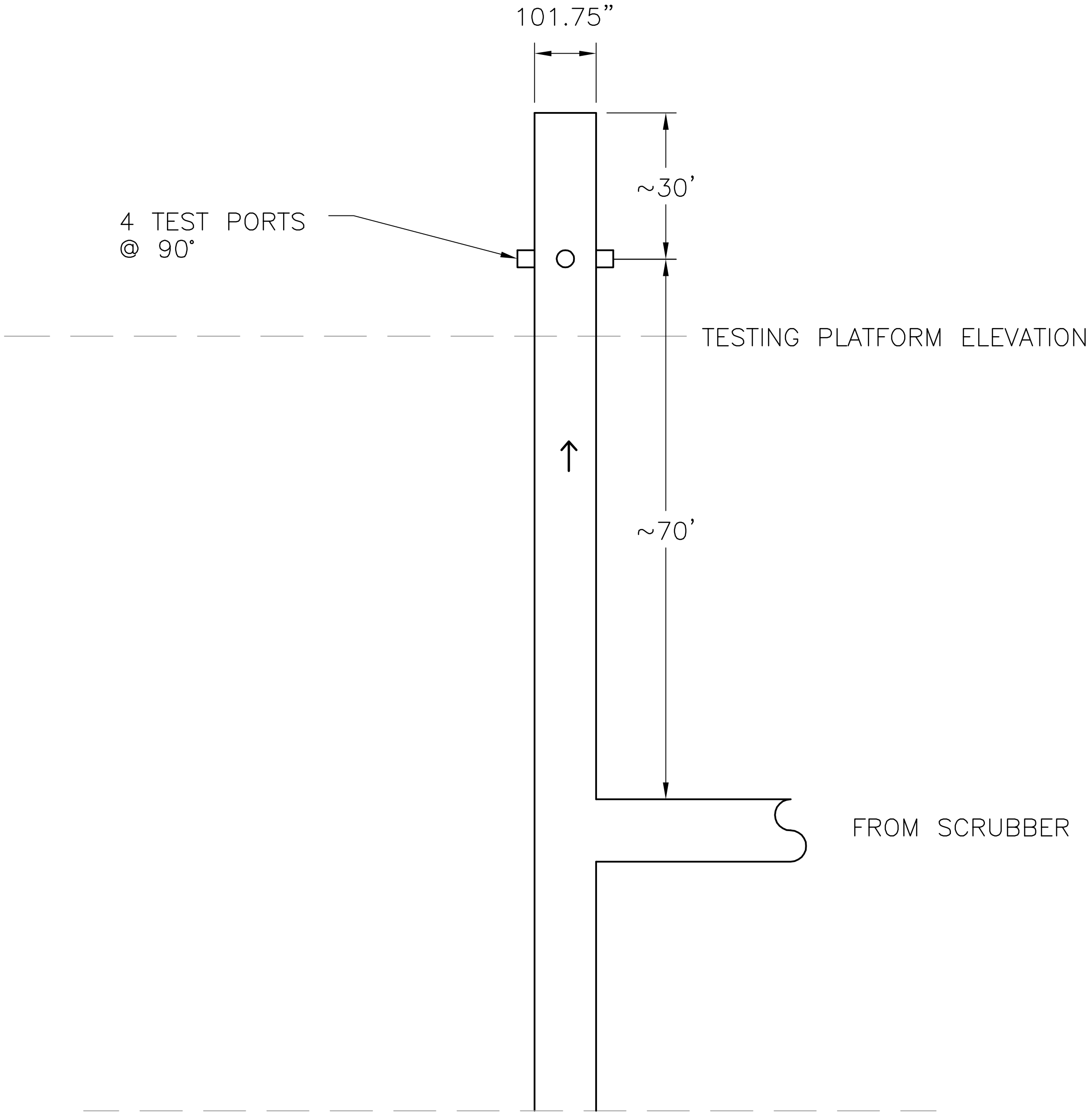
TABLE 1

Mercury Project Results Summary

Indurating Furnace Line

Parameter	Date of Test	EPA Method	Stack A	Stack B	Stack C	Stack D
Baseline 1 Results						
Hg, lb/yr	Dec 13-14 2016	30B	12.4	14.8	19.0	20.6
Total Hg, lb/yr				**66.8**		
Screening Results						
BPAC						
PM - Filterable, lb/hr	January 17-18, 2017	5	---	---	8.9	9.3
PM - Filterable, gr/dscf	January 17-18, 2017	5	---	---	0.0064	0.0074
Hg, lb/yr	January 17-18, 2017	30B	---	---	11.4	12.9
HPAC						
PM - Filterable, lb/hr	January 17-18, 2017	5	---	---	9.2	9.5
PM - Filterable, gr/dscf	January 17-18, 2017	5	---	---	0.0067	0.0078
Hg, lb/yr	January 17-18, 2017	30B	---	---	9.7	10.6
Longterm 1 Results						
PM - Filterable, lb/hr	February 8-9, 2017	5	6.3	6.7	8.1	8.2
PM - Filterable, gr/dscf	February 8-9, 2017	5	0.0046	0.0047	0.0059	0.0068
Hg, lb/yr	February 8-9, 2017	Ont-Hydro	10.6	11.5	14.4	17.2
Total Hg, lb/yr				**53.6**		
Longterm 2 Results						
PM - Filterable, lb/hr	March 28-29, 2017	5	6.0	6.4	7.4	7.4
PM - Filterable, gr/dscf	March 28-29, 2017	5	0.0045	0.0047	0.0056	0.0064
Hg, lb/yr	March 28-29, 2017	Ont-Hydro	7.3	7.5	10.2	9.3
Total Hg, lb/yr				**34.3**		
Baseline 2 Results						
Hg, lb/yr	April 11-12, 2017	30B	6.4	8.1	12.1	12.8
Total Hg, lb/yr				**39.4**		

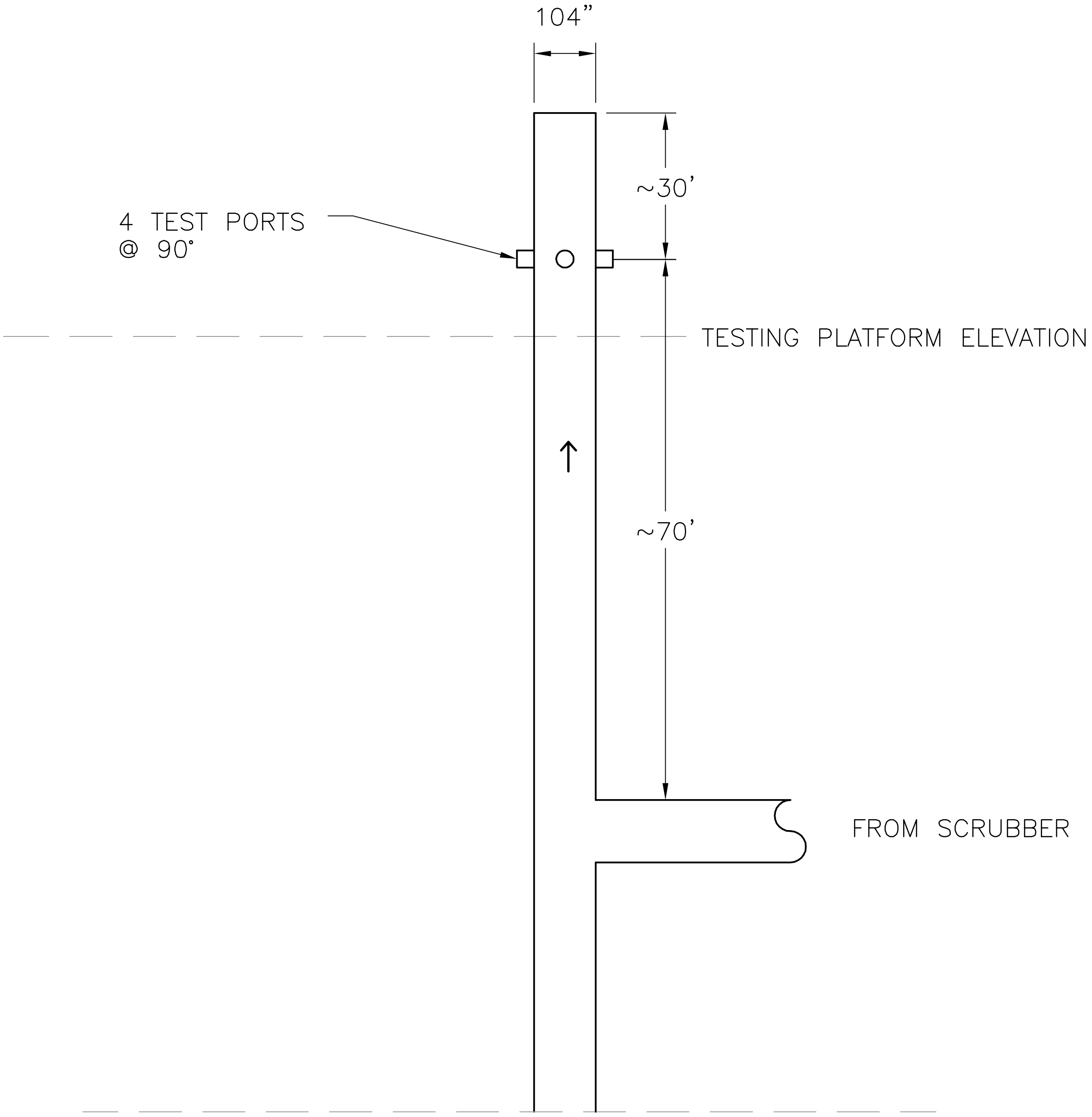
Figures



TEST PORT LOCATIONS
ARCELORMITTAL MINORCA MINE INC.
VIRGINIA, MINNESOTA
A & B INDURATING FURNACE STACKS (SV014) & (SV015)

NOT TO SCALE

FIGURE 1



TEST PORT LOCATIONS
ARCELORMITTAL MINORCA MINE, INC.
VIRGINIA, MINNESOTA
C & D INDURATING FURNACE STACKS (SV016) & (SV017)

NOT TO SCALE

FIGURE 2

Appendices

Appendix A

Report Calculations and Nomenclature

Indurating Furnace Stack A (SV014)
Determination of Volumetric Airflow Rate, Gas Composition and Moisture Content
Baseline 1

Data Entry	Symbol	Units	Run 1	Run 2	Run 3
Test Date	-	-	12/13/2016	12/13/2016	12/13/2016
Test Period	-	-	1205-1217	1355-1408	1640-1655
Number of Sample Ports	-	-	2	2	2
Number of Traverse Points	-	-	12	12	12
Duct Dimensions (diameter for circular duct)	D	inches	101.75	101.75	101.75
Barometric Pressure	Pbar	in. Hg	28.20	28.20	28.20
Stack Static Pressure	Pg	in. H_2O	-0.60	-0.60	-0.60
Stack Temperature, dry bulb	Tsf	degrees F	102	101	102
Stack Temperature, wet bulb bulb	Twb	degrees F	102	101	102
Pitot Tube Coefficient	Cp	-	0.84	0.84	0.84
Average Square Root of Velocity Head	(ΔP)^0.5	-	0.902	0.901	0.917
Orsat Results, Dry Basis (EPA Method 3A)					
Carbon Dioxide	$\%CO_2$	%v/v	0.9	0.7	0.6
Oxygen	$\%O_2$	%v/v	19.9	20.0	20.1
Carbon Monoxide + Nitrogen	-	%v/v	79.2	79.3	79.3
Calculated Data	Symbol	Units	Run 1	Run 2	Run 3
Duct Area A = (D/24)^2 x PI (Circular Duct)	A	sq ft	56.47	56.47	56.47
Stack Pressure Ps = Pbar + Pg/13.6	Ps	in Hg	28.16	28.16	28.16
Average Moisture Content of Stack Gas	MC	% Vol	8.8	7.8	7.1
Molecular Weight of Stack Gas, dry Md = (0.44 x ($\%CO_2$))+(0.32 x ($\%O_2$))+(0.28 x ($\%N_2$+%CO))	Md	lb/lbmol	28.94	28.91	28.90
Molecular Weight of Stack Gas, wet Ms = Md x (1-(MC/100))+18 x (MC/100)	Ms	lb/lbmol	27.97	28.06	28.13
Average Stack Gas Velocity Vs = 85.49 x Cp x (ΔP)^0.5 x ((Ts/Ps x Ms)^0.5)	Vs	ft/sec	54.74	54.54	55.47
Actual Volumetric Flowrate Qa = 60 x Vs x A	Qa	acfm	185,500	184,800	187,900
Volumetric Flowrate at Standard Conditions Qs = Qa x (528/(Ts+460)) x (Ps/29.92)	Qs	scfm	164,000	163,600	166,000
Dry Volumetric Flowrate at Standard Conditions Qd = Qa x (1-(MC/100)) x (528/(Ts+460)) x (Ps/29.92)	Qd	dscfm	149,500	150,900	154,300

Indurating Furnace Stack B (SV015)
Determination of Volumetric Airflow Rate, Gas Composition and Moisture Content
Baseline 1

Data Entry	Symbol	Units	Run 1	Run 2	Run 3
Test Date	-	-	12/13/2016	12/13/2016	12/13/2016
Test Period	-	-	1228-1240	1420-1444	1700-1705
Number of Sample Ports	-	-	2	2	2
Number of Traverse Points	-	-	12	12	12
Duct Dimensions (diameter for circular duct)	D	inches	101.75	101.75	101.75
Barometric Pressure	Pbar	in. Hg	28.20	28.20	28.20
Stack Static Pressure	Pg	in. H_2O	-0.77	-0.75	-0.74
Stack Temperature, dry bulb	Tsf	degrees F	107	106	107
Stack Temperature, wet bulb bulb	Twb	degrees F	107	106	107
Pitot Tube Coefficient	Cp	-	0.84	0.84	0.84
Average Square Root of Velocity Head	(ΔP)^0.5	-	0.958	0.949	0.949
Orsat Results, Dry Basis (EPA Method 3A)					
Carbon Dioxide	%CO_2	%v/v	1.3	1.4	1.1
Oxygen	%O_2	%v/v	19.4	19.3	19.5
Carbon Monoxide + Nitrogen	-	%v/v	79.3	79.3	79.4

Calculated Data	Symbol	Units	Run 1	Run 2	Run 3
Duct Area A = (D/24)^2 x PI (Circular Duct)	A	sq ft	56.47	56.47	56.47
Stack Pressure Ps = Pbar + Pg/13.6	Ps	in Hg	28.14	28.14	28.15
Average Moisture Content of Stack Gas	MC	% Vol	6.6	6.9	8.0
Molecular Weight of Stack Gas, dry Md = (0.44 x (%CO_2))+(0.32 x (%O_2))+(0.28 x (%N_2+%CO))	Md	lb/lbmol	28.98	29.00	28.96
Molecular Weight of Stack Gas, wet Ms = Md x (1-(MC/100))+18 x (MC/100)	Ms	lb/lbmol	28.26	28.23	28.08
Average Stack Gas Velocity Vs = 85.49 x Cp x (ΔP)^0.5 x ((Ts/Ps x Ms)^0.5)	Vs	ft/sec	58.07	57.53	57.70
Actual Volumetric Flowrate Qa = 60 x Vs x A	Qa	acfm	196,700	194,900	195,500
Volumetric Flowrate at Standard Conditions Qs = Qa x (528/(Ts+460)) x (Ps/29.92)	Qs	scfm	172,400	171,000	171,200
Dry Volumetric Flowrate at Standard Conditions Qd = Qa x (1-(MC/100)) x (528/(Ts+460)) x (Ps/29.92)	Qd	dscfm	161,100	159,100	157,500

Indurating Furnace Stack C (SV016)
Determination of Volumetric Airflow Rate, Gas Composition and Moisture Content
Baseline 1

Data Entry	Symbol	Units	Run 1	Run 2	Run 3
Test Date	-	-	12/14/2016	12/14/2016	12/14/2016
Test Period	-	-	1130-1148	1425-1438	1610-1622
Number of Sample Ports	-	-	2	2	2
Number of Traverse Points	-	-	12	12	12
Duct Dimensions (diameter for circular duct)	D	inches	104	104	104
Barometric Pressure	Pbar	in. Hg	28.21	28.21	28.21
Stack Static Pressure	Pg	in. H_2O	-0.75	-0.80	-0.80
Stack Temperature, dry bulb	Tsf	degrees F	109	112	111
Stack Temperature, wet bulb bulb	Twb	degrees F	109	112	111
Pitot Tube Coefficient	Cp	-	0.84	0.84	0.84
Average Square Root of Velocity Head	(ΔP)^0.5	-	0.928	0.929	0.929
Orsat Results, Dry Basis (EPA Method 3A)					
Carbon Dioxide	%CO_2	%v/v	1.8	2.0	1.9
Oxygen	%O_2	%v/v	18.9	18.7	18.9
Carbon Monoxide + Nitrogen	-	%v/v	79.3	79.3	79.2
Calculated Data	**Symbol**	**Units**	**Run 1**	**Run 2**	**Run 3**
Duct Area A = (D/24)^2 x PI (Circular Duct)	A	sq ft	58.99	58.99	58.99
Stack Pressure Ps = Pbar + Pg/13.6	Ps	in Hg	28.15	28.15	28.15
Average Moisture Content of Stack Gas	MC	% Vol	10.1	10.2	11.6
Molecular Weight of Stack Gas, dry Md = (0.44 x (%CO_2))+(0.32 x (%O_2))+(0.28 x (%N_2+%CO))	Md	lb/lbmol	29.04	29.07	29.06
Molecular Weight of Stack Gas, wet Ms = Md x (1-(MC/100))+18 x (MC/100)	Ms	lb/lbmol	27.93	27.94	27.78
Average Stack Gas Velocity Vs = 85.49 x Cp x (ΔP)^0.5 x ((Ts/Ps x Ms)^0.5)	Vs	ft/sec	56.70	56.85	57.02
Actual Volumetric Flowrate Qa = 60 x Vs x A	Qa	acfm	200,700	201,200	201,800
Volumetric Flowrate at Standard Conditions Qs = Qa x (528/(Ts+460)) x (Ps/29.92)	Qs	scfm	175,200	174,800	175,500
Dry Volumetric Flowrate at Standard Conditions Qd = Qa x (1-(MC/100)) x (528/(Ts+460)) x (Ps/29.92)	Qd	dscfm	157,500	157,000	155,200

Indurating Furnace Stack D (SV017)
Determination of Volumetric Airflow Rate, Gas Composition and Moisture Content
Baseline 1

Data Entry	Symbol	Units	Run 1	Run 2	Run 3
Test Date	-	-	12/14/2016	12/14/2016	12/14/2016
Test Period	-	-	1201-1217	1447-1501	1630-1645
Number of Sample Ports	-	-	2	2	2
Number of Traverse Points	-	-	12	12	12
Duct Dimensions (diameter for circular duct)	D	inches	104	104	104
Barometric Pressure	Pbar	in. Hg	28.20	28.20	28.20
Stack Static Pressure	Pg	in. H_2O	-0.55	-0.66	-0.60
Stack Temperature, dry bulb	Tsf	degrees F	115	117	115
Stack Temperature, wet bulb bulb	Twb	degrees F	115	117	115
Pitot Tube Coefficient	Cp	-	0.84	0.84	0.84
Average Square Root of Velocity Head	(ΔP)^0.5	-	0.828	0.813	0.819
Orsat Results, Dry Basis (EPA Method 3A)					
Carbon Dioxide	$\%CO_2$	%v/v	2.2	2.2	2.3
Oxygen	$\%O_2$	%v/v	18.4	18.4	18.3
Carbon Monoxide + Nitrogen	-	%v/v	79.4	79.4	79.4
Calculated Data	Symbol	Units	Run 1	Run 2	Run 3
Duct Area A = (D/24)^2 x PI (Circular Duct)	A	sq ft	58.99	58.99	58.99
Stack Pressure Ps = Pbar + Pg/13.6	Ps	in Hg	28.16	28.15	28.16
Average Moisture Content of Stack Gas	MC	% Vol	10.3	10.7	9.7
Molecular Weight of Stack Gas, dry Md = (0.44 x ($\%CO_2$))+(0.32 x ($\%O_2$))+(0.28 x ($\%N_2$+%CO))	Md	lb/lbmol	29.09	29.09	29.10
Molecular Weight of Stack Gas, wet Ms = Md x (1-(MC/100))+18 x (MC/100)	Ms	lb/lbmol	27.95	27.90	28.02
Average Stack Gas Velocity Vs = 85.49 x Cp x (ΔP)^0.5 x ((Ts/Ps x Ms)^0.5)	Vs	ft/sec	50.84	50.03	50.24
Actual Volumetric Flowrate Qa = 60 x Vs x A	Qa	acfm	179,900	177,100	177,800
Volumetric Flowrate at Standard Conditions Qs = Qa x (528/(Ts+460)) x (Ps/29.92)	Qs	scfm	155,600	152,500	153,600
Dry Volumetric Flowrate at Standard Conditions Qd = Qa x (1-(MC/100)) x (528/(Ts+460)) x (Ps/29.92)	Qd	dscfm	139,500	136,300	138,700

EPA Method 30B Calculation Summary
Determination of Total Vapor Phase Mercury Emissions

Indurating Furnace Stack A (SV014)
Baseline 1

Data Entry	Symbol	Units	Run 1	Run 2	Run 3	Test Average
Test Date	-	-	12/13/2016	12/13/2016	12/13/2016	---
Test Period	-	-	1148-1248	1350-1450	1634-1734	---
Barometric Pressure	P_{bar}	in. Hg	28.20	28.20	28.20	28.20
Dry Volumetric Flowrate at Standard Conditions (EPA Method 2)	Q_d	dscfm	149,500	150,900	154,300	151,567

Trap A Results

	Symbol	Units	Run 1	Run 2	Run 3	Test Average
Actual Dry Gas Meter Volume	V_{mA}	liters	16.502	28.703	28.334	24.513
Dry Gas Meter Calibration Factor	Y_A	-	0.9904	0.9904	0.9904	0.9904
Average Meter Temperature	T_{mfA}	degrees F	76	79	80	78
Average Absolute Meter Temperature (R) $T_{mrA} = T_{mfA} + 460$	T_{mrA}	degrees R	536	539	540	538
Meter Volume at Standard Conditions $V_{mstd\ A} = 17.64 \times (V_{mA} \times 0.03531) \times Y_A \times P_{bar} / T_{mrA}$	$V_{mstd\ A}$	cubic feet	0.536	0.926	0.913	0.792
Laboratory Results						
Trap ID	---	---	OLC035280	OLC035377	OLC035418	---
Mercury Sorbent Trap, Section 1	$M_{1\ A}$	ng	41.5	71.2	50.6	54.4
Mercury Sorbent Trap, Section 2	$M_{2\ A}$	ng	1.17	2.26	2.32	1.91
Mercury, Total amount collected	M_A	ng	42.7	73.4	52.9	56.4
Amount of Mercury in spiked traps-from laboratory	$M_{spike\ A}$	ng	0	0	0	---
Mercury Stack Concentration $C_{(\mu g)A} = (M_A - M_{spikeA}) / 1000 / V_{mstdA} \times 0.0283168$	$C_{(\mu g)A}$	µg/dscm	2.815	2.802	2.047	2.554
Mercury Emission Rate $E_{(lb/hr)A} = (M_A - M_{spike\ A}) \times (2.2046 \times 10^{-12}\ (lb/ng)) \times Qd \times 60 / V_{mstd\ A}$	$E_{(lb/hr)A}$	lb/hr	0.00158	0.00158	0.00118	0.00145
Mercury Emission Rate $E_{(lb/yr)A} = E_{(lb/hr)A} \times 8760$ hr/yr	$E_{(lb/yr)A}$	lb/yr	13.8	13.9	10.4	12.7

Trap B Results

	Symbol	Units	Run 1	Run 2	Run 3	Test Average
Actual Dry Gas Meter Volume	V_{mB}	liters	24.560	11.491	35.306	23.786
Dry Gas Meter Calibration Factor	Y_B	-	0.9846	0.9846	0.9846	0.9846
Average Meter Temperature	T_{mfB}	degrees F	76	79	80	78
Average Absolute Meter Temperature (R) $T_{mrB} = T_{mfB} + 460$	T_{mrB}	degrees R	536	539	540	538
Meter Volume at Standard Conditions $V_{mstd\ B} = 17.64 \times (V_{mB} \times 0.03531) \times Y \times P_{bar} / T_{mrB}$	$V_{mstd\ B}$	cubic feet	0.792	0.368	1.131	0.764
Laboratory Results						
Trap ID	---	---	OLC632147	OL390546	OL390502	---
Mercury Sorbent Trap, Section 1	$M_{1\ B}$	ng	220	169	212	200
Mercury Sorbent Trap, Section 2	$M_{2\ B}$	ng	2.71	1.67	3.23	2.54
Mercury, Total amount collected	M_B	ng	222	171	215	203
Amount of Mercury in spiked traps-from laboratory	$M_{spike\ B}$	ng	150	150	150	---
Mercury Stack Concentration $C_{(\mu g)B} = (M_B - M_{spikeB}) / 1000 / V_{mstdB} \times 0.0283168$	$C_{(\mu g)B}$	µg/dscm	3.231	2.027	2.040	2.432
Mercury Emission Rate $E_{(lb/hr)B} = (M_B - M_{spike\ B}) \times (2.2046 \times 10^{-12}\ (lb/ng)) \times Qd \times 60 / V_{mstd\ B}$	$E_{(lb/hr)B}$	lb/hr	0.00181	0.00115	0.00118	0.00138
Mercury Emission Rate $E_{(lb/yr)B} = E_{(lb/hr)B} \times 8760$ hr/yr	$E_{(lb/yr)B}$	lb/yr	15.8	10.0	10.3	12.1

EPA Method 30B QA/QC Data

	Symbol	Units	Run 1	Run 2	Run 3	Test Average
A Train Breakthrough -- each run <10% $B_A = M_{2\ A} / M_{1\ A} \times 100$	B_A	%	2.8	3.2	4.6	3.5
B Train Breakthrough -- each run <10% $B_B = M_{2\ B} / M_{1\ B} \times 100$	B_B	%	1.2	1.0	1.5	1.2
Sample volume agreement -- each run +/- 20% $SV = 100 - ((V_{mstd\ A} / V_{mstd\ B}) \times 100)$	SV	%	32.4	-151.3	19.3	-33.2
Field Recovery Test -- 3 run avg 85%< R >115% $R = (M_A / V_{mstd\ A} - M_B / V_{mstd\ B}) \times V_{mstd\ A} / M_{spike\ A} \times 100$	R	%	106.2	94.6	99.8	100.2
Paired Trap Agreement -- each run <10% $RD = ((C_{\mu gA} - C_{\mu gB}) / (C_{\mu gA} + C_{\mu gB}))$ X 100	RD	%	6.9	16.0	0.2	7.7

EPA Method 30B Calculation Summary
Determination of Total Vapor Phase Mercury Emissions

Indurating Furnace Stack B (SV015)
Baseline 1

Data Entry	Symbol	Units	Run 1	Run 2	Run 3	Test Average
Test Date	-	-	12/13/2016	12/13/2016	12/13/2016	---
Test Period	-	-	1148-1248	1350-1450	1634-1734	---
Barometric Pressure	P_{bar}	in. Hg	28.20	28.20	28.20	28.20
Dry Volumetric Flowrate at Standard Conditions (EPA Method 2)	Q_d	dscfm	161,100	159,100	157,500	159,233

Trap A Results

	Symbol	Units	Run 1	Run 2	Run 3	Test Average
Actual Dry Gas Meter Volume	V_{mA}	liters	20.556	26.204	30.382	25.714
Dry Gas Meter Calibration Factor	Y_A	-	1.0002	1.0002	1.0002	1.0002
Average Meter Temperature	T_{mfA}	degrees F	77	82	83	80
Average Absolute Meter Temperature (R) $T_{mrA} = T_{mfA} + 460$	T_{mrA}	degrees R	537	542	543	540
Meter Volume at Standard Conditions $V_{mstd\ A} = 17.64 \times (V_{mA} \times 0.03531) \times Y_A \times P_{bar} / T_{mrA}$	$V_{mstd\ A}$	cubic feet	0.673	0.850	0.984	0.835
Laboratory Results						
Trap ID	---	---	OLC035312	OLC035276	OLC035395	---
Mercury Sorbent Trap, Section 1	$M_{1\ A}$	ng	54.9	77.9	65.4	66.1
Mercury Sorbent Trap, Section 2	$M_{2\ A}$	ng	2.21	1.74	2.04	2.00
Mercury, Total amount collected	M_A	ng	57.2	79.6	67.4	68.1
Amount of Mercury in spiked traps-from laboratory	$M_{spike\ A}$	ng	0	0	0	---
Mercury Stack Concentration $C_{(\mu g)A} = (M_A - M_{spikeA}) / 1000 / V_{mstdA} \times 0.0283168$	$C_{(\mu g)A}$	µg/dscm	3.000	3.310	2.420	2.910
Mercury Emission Rate $E_{(lb/hr)A} = (M_A - M_{spike\ A}) \times (2.2046\text{x}10^{-12}\ (lb/ng)) \times Qd\ \text{x}60 / V_{mstd\ A}$	$E_{(lb/hr)A}$	lb/hr	0.00181	0.00197	0.00143	0.00174
Mercury Emission Rate $E_{(lb/yr)A} = E_{(lb/hr)A} \times 8760$ hr/yr	$E_{(lb/yr)A}$	lb/yr	15.9	17.3	12.5	15.2

Trap B Results

	Symbol	Units	Run 1	Run 2	Run 3	Test Average
Actual Dry Gas Meter Volume	V_{mB}	liters	18.675	25.157	18.555	20.796
Dry Gas Meter Calibration Factor	Y_B	-	1.0069	1.0069	1.0069	1.0069
Average Meter Temperature	T_{mfB}	degrees F	77	82	83	80
Average Absolute Meter Temperature (R) $T_{mrB} = T_{mfB} + 460$	T_{mrB}	degrees R	537	542	543	540
Meter Volume at Standard Conditions $V_{mstd\ B} = 17.64 \times (V_{mB} \times 0.03531) \times Y \times P_{bar} / T_{mrB}$	$V_{mstd\ B}$	cubic feet	0.615	0.821	0.605	0.680
Laboratory Results						
Trap ID	---	---	OLC032030	OL390537	OLC032133	---
Mercury Sorbent Trap, Section 1	$M_{1\ B}$	ng	198	228	182	203
Mercury Sorbent Trap, Section 2	$M_{2\ B}$	ng	2.06	1.31	0.87	1.41
Mercury, Total amount collected	M_B	ng	200	230	183	204
Amount of Mercury in spiked traps-from laboratory	$M_{spike\ B}$	ng	150	150	150	---
Mercury Stack Concentration $C_{(\mu g)B} = (M_B - M_{spikeB}) / 1000 / V_{mstdB} \times 0.0283168$	$C_{(\mu g)B}$	µg/dscm	2.886	3.428	1.948	2.754
Mercury Emission Rate $E_{(lb/hr)B} = (M_B - M_{spike\ B}) \times (2.2046\text{x}10^{-12}\ (lb/ng)) \times Qd\ \text{x}60 / V_{mstd\ B}$	$E_{(lb/hr)B}$	lb/hr	0.00174	0.00204	0.00115	0.00164
Mercury Emission Rate $E_{(lb/yr)B} = E_{(lb/hr)B} \times 8760$ hr/yr	$E_{(lb/yr)B}$	lb/yr	15.3	17.9	10.1	14.4

EPA Method 30B QA/QC Data

	Symbol	Units	Run 1	Run 2	Run 3	Test Average
A Train Breakthrough -- each run <10% $B_A = M_{2\ A} / M_{1\ A} \times 100$	B_A	%	4.0	2.2	3.1	3.1
B Train Breakthrough -- each run <10% $B_B = M_{2\ B} / M_{1\ B} \times 100$	B_B	%	1.0	0.6	0.5	0.7
Sample volume agreement -- each run +/- 20% $SV = 100 - ((V_{mstd\ A} / V_{mstd\ B}) \times 100)$	SV	%	-9.3	-3.5	-62.7	-25.2
Field Recovery Test -- 3 run avg 85%< R >115% $R = (M_A / V_{mstd\ A} - M_B / V_{mstd\ B}) \times V_{mstd\ A} / M_{spike\ A} \times 100$	R	%	98.7	101.8	94.6	98.4
Paired Trap Agreement -- each run <10% $RD = ((C_{\mu gA} - C_{\mu gB}) / (C_{\mu gA} + C_{\mu gB}))\ \text{X}\ 100$	RD	%	1.9	1.8	10.8	4.8

EPA Method 30B Calculation Summary
Determination of Total Vapor Phase Mercury Emissions

Indurating Furnace Stack C (SV016)
Baseline 1

Data Entry	Symbol	Units	Run 1	Run 2	Run 3	Test Average
Test Date	-	-	12/14/2016	12/14/2016	12/14/2016	---
Test Period	-	-	1122-1222	1422-1522	1604-1704	---
Barometric Pressure	P_{bar}	in. Hg	28.21	28.21	28.21	28.21
Dry Volumetric Flowrate at Standard Conditions (EPA Method 2)	Q_d	dscfm	157,500	157,000	155,200	156,567

Trap A Results

	Symbol	Units	Run 1	Run 2	Run 3	Test Average
Actual Dry Gas Meter Volume	V_{mA}	liters	27.725	28.917	28.854	28.499
Dry Gas Meter Calibration Factor	Y_A	-	0.9904	0.9904	0.9904	0.9904
Average Meter Temperature	T_{mfA}	degrees F	77	78	80	78
Average Absolute Meter Temperature (R) $T_{mrA} = T_{mfA} + 460$	T_{mrA}	degrees R	537	538	540	538
Meter Volume at Standard Conditions $V_{mstd\ A}$ = 17.64 x (V_{mA} x 0.03531) x Y_A x P_{bar} / T_{mrA}	$V_{mstd\ A}$	cubic feet	0.898	0.935	0.931	0.921
Laboratory Results						
Trap ID	---	---	OLC035270	OLC035362	OLC035381	---
Mercury Sorbent Trap, Section 1	$M_{1\ A}$	ng	91.6	90.7	104.9	95.7
Mercury Sorbent Trap, Section 2	$M_{2\ A}$	ng	4.70	4.82	2.10	3.87
Mercury, Total amount collected	M_A	ng	96.3	95.5	107.0	99.6
Amount of Mercury in spiked traps-from laboratory	$M_{spike\ A}$	ng	0	0	0	---
Mercury Stack Concentration $C_{(\mu g)A}$ = (M_A - M_{spikeA}) / 1000 / V_{mstdA} x 0.0283168	$C_{(\mu g)A}$	µg/dscm	3.787	3.609	4.060	3.819
Mercury Emission Rate $E_{(lb/hr)A}$ = (M_A-$M_{spike\ A}$) x (2.2046x10^{-12} (lb/ng)) x Qd x60 / $V_{mstd\ A}$	$E_{(lb/hr)A}$	lb/hr	0.00223	0.00212	0.00236	0.00224
Mercury Emission Rate $E_{(lb/yr)A}$ = $E_{(lb/hr)A}$ x 8760 hr/yr	$E_{(lb/yr)A}$	lb/yr	19.6	18.6	20.7	19.6

Trap B Results

	Symbol	Units	Run 1	Run 2	Run 3	Test Average
Actual Dry Gas Meter Volume	V_{mB}	liters	27.690	34.442	31.047	31.060
Dry Gas Meter Calibration Factor	Y_B	-	0.9846	0.9846	0.9846	0.9846
Average Meter Temperature	T_{mfB}	degrees F	49	52	57	53
Average Absolute Meter Temperature (R) $T_{mrB} = T_{mfB} + 460$	T_{mrB}	degrees R	509	512	517	513
Meter Volume at Standard Conditions $V_{mstd\ B}$ = 17.64 x (V_{mB} x 0.03531) x Y x P_{bar} / T_{mrB}	$V_{mstd\ B}$	cubic feet	0.941	1.164	1.040	1.048
Laboratory Results						
Trap ID	---	---	OLC032010	OLC032055	OL390556	---
Mercury Sorbent Trap, Section 1	$M_{1\ B}$	ng	226	273	264	254
Mercury Sorbent Trap, Section 2	$M_{2\ B}$	ng	2.29	3.36	3.15	2.93
Mercury, Total amount collected	M_B	ng	228	277	267	257
Amount of Mercury in spiked traps-from laboratory	$M_{spike\ B}$	ng	150	150	150	---
Mercury Stack Concentration $C_{(\mu g)B}$ = (M_B - M_{spikeB}) / 1000 / V_{mstdB} x 0.0283168	$C_{(\mu g)B}$	µg/dscm	2.933	3.841	3.965	3.579
Mercury Emission Rate $E_{(lb/hr)B}$ = (M_B-$M_{spike\ B}$) x (2.2046x10^{-12} (lb/ng)) x Qd x60 / $V_{mstd\ B}$	$E_{(lb/hr)B}$	lb/hr	0.00173	0.00226	0.00230	0.00210
Mercury Emission Rate $E_{(lb/yr)B}$ = $E_{(lb/hr)B}$ x 8760 hr/yr	$E_{(lb/yr)B}$	lb/yr	15.2	19.8	20.2	18.4

EPA Method 30B QA/QC Data

	Symbol	Units	Run 1	Run 2	Run 3	Test Average
A Train Breakthrough -- each run <10% B_A= $M_{2\ A}$ / $M_{1\ A}$ x 100	B_A	%	5.1	5.3	2.0	4.1
B Train Breakthrough -- each run <10% B_B= $M_{2\ B}$ / $M_{1\ B}$ x 100	B_B	%	1.0	1.2	1.2	1.1
Sample volume agreement -- each run +/- 20% SV= 100 - (($V_{mstd\ A}$ / $V_{mstd\ B}$) x 100)	SV	%	4.6	19.7	10.5	11.6
Field Recovery Test -- 3 run avg 85%< R >115% R = (M_A / $V_{mstd\ A}$ - M_B / $V_{mstd\ B}$) x $V_{mstd\ A}$ / $M_{spike\ A}$ x 100	R	%	84.8	105.1	98.1	96.0
Paired Trap Agreement -- each run <10% RD = (($C_{\mu gA}$ - $C_{\mu gB}$) / ($C_{\mu gA}$ + $C_{\mu gB}$)) X 100	RD	%	12.7	3.1	1.2	5.7

EPA Method 30B Calculation Summary
Determination of Total Vapor Phase Mercury Emissions

Indurating Furnace Stack D (SV017)
Baseline 1

Data Entry	Symbol	Units	Run 1	Run 2	Run 3	Test Average
Test Date	-	-	12/14/2016	12/14/2016	12/14/2016	---
Test Period	-	-	1122-1222	1422-1522	1604-1704	---
Barometric Pressure	P_{bar}	in. Hg	28.20	28.20	28.20	28.20
Dry Volumetric Flowrate at Standard Conditions (EPA Method 2)	Q_d	dscfm	139,500	136,300	138,700	138,167

Trap A Results

	Symbol	Units	Run 1	Run 2	Run 3	Test Average
Actual Dry Gas Meter Volume	V_{mA}	liters	30.503	30.933	29.779	30.405
Dry Gas Meter Calibration Factor	Y_A	-	1.0069	1.0069	1.0069	1.0069
Average Meter Temperature	T_{mfA}	degrees F	77	77	78	78
Average Absolute Meter Temperature (R) $T_{mrA} = T_{mfA} + 460$	T_{mrA}	degrees R	537	537	538	538
Meter Volume at Standard Conditions $V_{mstd\ A}$ = 17.64 x (V_{mA} x 0.03531) x Y_A x P_{bar} / T_{mrA}	$V_{mstd\ A}$	cubic feet	1.004	1.019	0.978	1.000
Laboratory Results						
Trap ID	---	---	OLC035311	OLC035286	OLC035259	---
Mercury Sorbent Trap, Section 1	$M_{1\ A}$	ng	131	139	133	134
Mercury Sorbent Trap, Section 2	$M_{2\ A}$	ng	1.37	1.13	1.40	1.30
Mercury, Total amount collected	M_A	ng	133	140	135	136
Amount of Mercury in spiked traps-from laboratory	$M_{spike\ A}$	ng	0	0	0	---
Mercury Stack Concentration $C_{(\mu g)A}$ = (M_A - M_{spikeA}) / 1000 / V_{mstdA} x 0.0283168	$C_{(\mu g)A}$	µg/dscm	4.665	4.849	4.867	4.794
Mercury Emission Rate $E_{(lb/hr)A}$ = (M_A-$M_{spike\ A}$) x (2.2046x10^{-12} (lb/ng)) x Qd x60 / $V_{mstd\ A}$	$E_{(lb/hr)A}$	lb/hr	0.00244	0.00248	0.00253	0.00248
Mercury Emission Rate $E_{(lb/yr)A}$ = $E_{(lb/hr)A}$ x 8760 hr/yr	$E_{(lb/yr)A}$	lb/yr	21.4	21.7	22.1	21.7

Trap B Results

	Symbol	Units	Run 1	Run 2	Run 3	Test Average
Actual Dry Gas Meter Volume	V_{mB}	liters	19.840	30.683	29.820	26.781
Dry Gas Meter Calibration Factor	Y_B	-	1.0002	1.0002	1.0002	1.0002
Average Meter Temperature	T_{mfB}	degrees F	77	77	78	78
Average Absolute Meter Temperature (R) $T_{mrB} = T_{mfB} + 460$	T_{mrB}	degrees R	537	537	538	538
Meter Volume at Standard Conditions $V_{mstd\ B}$ = 17.64 x (V_{mB} x 0.03531) x Y x P_{bar} / T_{mrB}	$V_{mstd\ B}$	cubic feet	0.649	1.004	0.973	0.875
Laboratory Results						
Trap ID	---	---	OLC032026	OL3905509	OLC032056	---
Mercury Sorbent Trap, Section 1	$M_{1\ B}$	ng	220	281	270	257
Mercury Sorbent Trap, Section 2	$M_{2\ B}$	ng	0.99	0.84	0.77	0.87
Mercury, Total amount collected	M_B	ng	221	282	271	258
Amount of Mercury in spiked traps-from laboratory	$M_{spike\ B}$	ng	150	150	150	---
Mercury Stack Concentration $C_{(\mu g)B}$ = (M_B - M_{spikeB}) / 1000 / V_{mstdB} x 0.0283168	$C_{(\mu g)B}$	µg/dscm	3.857	4.627	4.384	4.289
Mercury Emission Rate $E_{(lb/hr)B}$ = (M_B-$M_{spike\ B}$) x (2.2046x10^{-12} (lb/ng)) x Qd x60 / $V_{mstd\ B}$	$E_{(lb/hr)B}$	lb/hr	0.00202	0.00236	0.00228	0.00222
Mercury Emission Rate $E_{(lb/yr)B}$ = $E_{(lb/hr)B}$ x 8760 hr/yr	$E_{(lb/yr)B}$	lb/yr	17.7	20.7	19.9	19.4

EPA Method 30B QA/QC Data

	Symbol	Units	Run 1	Run 2	Run 3	Test Average
A Train Breakthrough -- each run <10% B_A= $M_{2\ A}$ / $M_{1\ A}$ x 100	B_A	%	1.0	0.8	1.0	1.0
B Train Breakthrough -- each run <10% B_B= $M_{2\ B}$ / $M_{1\ B}$ x 100	B_B	%	0.5	0.3	0.3	0.3
Sample volume agreement -- each run +/- 20% SV= 100 - (($V_{mstd\ A}$ / $V_{mstd\ B}$) x 100)	SV	%	-54.8	-1.5	-0.5	-18.9
Field Recovery Test -- 3 run avg 85%< R >115% R = (M_A / $V_{mstd\ A}$ - M_B / $V_{mstd\ B}$) x $V_{mstd\ A}$ / $M_{spike\ A}$ x 100	R	%	90.1	95.8	91.1	92.3
Paired Trap Agreement -- each run <10% RD = (($C_{\mu gA}$ - $C_{\mu gB}$) / ($C_{\mu gA}$ + $C_{\mu gB}$)) X 100	RD	%	9.5	2.3	5.2	5.7

Determination of Volumetric Air Flow Rate, Gas Composition, Moisture Content, and Particulate Matter Emissions

EPA Methods 2, 3, 4 and 5
Indurating Furnace Stack C (SV016)
BPAC Screening

Input Data	Symbol	Units	Run 1	Run 2	Run 3
Test Date	-	-	1/17/2017	1/17/2017	1/17/2017
Test Period	-	-	1007 - 1041	1116 - 1147	1216 - 1249
Number of Sample Ports	-	-	2	2	2
Number of Traverse Points	-	-	6	6	6
Duct Dimensions (diameter or Length x Width)	D, L X W	inches	104.00	104.00	104.00
Barometric Pressure	Pbar	in. Hg	28.24	28.24	28.24
Stack Static Pressure	Pg	in. H_2O	-0.80	-0.80	-0.80
Average Stack Temperature	Tsf	degrees F	114	116	115
Actual Dry Gas Meter Volume	Vm	cubic feet	22.13	21.05	22.71
Dry Gas Meter Calibration Factor	Y	-	0.9852	0.9852	0.9852
Average Orifice Meter Pressure Drop	DH	in H_2O	1.65	1.65	1.75
Average Meter Temperature	Tmf	degrees F	82	84	86
Pitot Tube Coefficient	Cp	-	0.84	0.84	0.84
Average Square Root of Velocity Head	(DP)^0.5	-	0.963	0.935	0.953
Volume of Water Vapor Condensed in Impingers	Vwc	ml	38	30	48
Mass of Water Vapor Collected in Desiccant	Vwsg	g	4	5	5
Orsat Results, Dry Basis					
Oxygen	%O2	%v/v	18.9	18.8	18.8
Carbon Dioxide	%CO2	%v/v	1.6	1.6	1.6
Nitrogen + Carbon Monoxide	%N2 + %CO	%v/v	79.5	79.6	79.6
Nozzle Diameter	Dn	inches	0.214	0.214	0.214
Run Time	theta	minutes	30	30	30
Particulate Loading (From Lab Results)					
PM - Filterable	M_{PM}	g	0.00812	0.00790	0.00872
Calculated Data	Symbol	Units	Run 1	Run 2	Run 3
Average Absolute Stack Temperature Tsr = Tsf + 460	Tsr	degrees R	574	576	575
Stack Pressure Ps = Pbar + Pg / 13.6	Ps	in. Hg	28.18	28.18	28.18
Duct Area A = 3.14 x D^2 / (4 x 144) or A = L x W / 144	A	Sq. ft	58.992	58.992	58.992
Meter Volume at Standard Conditions Vmstd = 17.64 x Vm x Y x ((Pbar + (DH / 13.6)) / (Tmf + 460))	Vmstd	cubic feet	20.13	19.09	20.51
Average Moisture Content of Stack Gas MC = ((0.04707 x Vwc + 0.04715 x Vwsg) / ((0.04707 x Vwc + 0.04715 x Vwsg) + (Vmstd)) x 100	MC	% Vol	8.94	7.95	10.69 see note
Molecular Weight of Stack Gas, dry Md = (0.44 x %CO2) + (0.32 x %O2) + (0.28 x (%N2 + %CO))	Md	lb/lbmol	29.01	29.01	29.01
Molecular Weight of Stack Gas, wet Ms = Md x (1-(MC/100))+18 x (MC/100)	Ms	lb/lbmol	28.03	28.13	27.83
Average Stack Gas Velocity Vs = 85.49 x Cp x (dP)^0.5 x ((Tsr/(Ps x Ms))^0.5)	Vs	ft/sec	58.97	57.23	58.60
Actual Volumetric Air Flow Rate Qa = 60 x Vs x A	Qa	acfm	208,722	202,582	207,434
Volumetric Air Flow Rate at Standard Conditions Qs = Qa x (528 / (Ts + 460)) x (Ps / 29.92)	Qs	scfm	180,837	175,009	179,304
Dry Volumetric Air Flow Rate at Standard Conditions Qd = Qa x (1 - (MC / 100)) x (528 / Tsr) x (Ps / 29.92)	Qd	dscfm	164,662	161,102	160,140
Nozzle Cross-Sectional Area An =(3.14 x Dn^2) /(4 x 144)	An	sq. ft	0.000250	0.000250	0.000250
Isokinetic Variation I = (0.0945 x Tsr x Vmstd) / (Ps x Vs x An x theta x (1 - (MC / 100)))	I	%	96.3	93.4	100.9
PARTICULATE CONCENTRATION					
PM - Filterable C_{sPM} = 15.432 x M_{PM} / V_{mstd}	C_{sPM}	gr/dscf	0.0062	0.0064	0.0066
PARTICULATE EMISSION RATE					
PM - Filterable E_{dry}(lb/hr) = C_{sPM} x Q_d x 60 / 7000	E_{dry}	lb/hr	8.8	8.8	9.0

Note: Moisture Content limited to moisture at saturation

Determination of Volumetric Air Flow Rate, Gas Composition, Moisture Content, and Particulate Matter Emissions
EPA Methods 2, 3, 4 and 5
Indurating Furnace Stack D (SV017)
BPAC Screening

Input Data	Symbol	Units	Run 1	Run 2	Run 3
Test Date	-	-	1/17/2017	1/17/2017	1/17/2017
Test Period	-	-	1007 - 1041	1116 - 1147	1216 - 1249
Number of Sample Ports	-	-	2	2	2
Number of Traverse Points	-	-	6	6	6
Duct Dimensions (diameter or Length x Width)	D, L X W	inches	104.00	104.00	104.00
Barometric Pressure	Pbar	in. Hg	28.24	28.24	28.24
Stack Static Pressure	Pg	in. H_2O	-0.70	-0.70	-0.70
Average Stack Temperature	Tsf	degrees F	116	117	116
Actual Dry Gas Meter Volume	Vm	cubic feet	19.59	20.31	20.97
Dry Gas Meter Calibration Factor	Y	-	0.9973	0.9973	0.9973
Average Orifice Meter Pressure Drop	DH	in H_2O	1.39	1.43	1.59
Average Meter Temperature	Tmf	degrees F	73	74	75
Pitot Tube Coefficient	Cp	-	0.84	0.84	0.84
Average Square Root of Velocity Head	(DP)^0.5	-	0.854	0.862	0.910
Volume of Water Vapor Condensed in Impingers	Vwc	ml	44	48	44
Mass of Water Vapor Collected in Desiccant	Vwsg	g	3	4	5
Orsat Results, Dry Basis					
Oxygen	%O2	%v/v	18.4	18.4	18.4
Carbon Dioxide	%CO2	%v/v	2.0	2.0	2.0
Nitrogen + Carbon Monoxide	%N2 + %CO	%v/v	79.6	79.6	79.6
Nozzle Diameter	Dn	inches	0.217	0.217	0.217
Run Time	theta	minutes	30	30	30
Particulate Loading (From Lab Results)					
PM - Filterable	M_{PM}	g	0.00963	0.00895	0.00866

Calculated Data	Symbol	Units	Run 1	Run 2	Run 3
Average Absolute Stack Temperature Tsr = Tsf + 460	Tsr	degrees R	576	577	576
Stack Pressure Ps = Pbar + Pg / 13.6	Ps	in. Hg	28.19	28.19	28.19
Duct Area A = 3.14 x D^2 / (4 x 144) or A = L x W / 144	A	Sq. ft	58.992	58.992	58.992
Meter Volume at Standard Conditions Vmstd = 17.64 x Vm x Y x ((Pbar + (DH / 13.6)) / (Tmf + 460))	Vmstd	cubic feet	18.32	18.98	19.54
Average Moisture Content of Stack Gas MC = ((0.04707 x Vwc + 0.04715 x Vwsg) / ((0.04707 x Vwc + 0.04715 x Vwsg) + (Vmstd)) x 100	MC	% Vol	10.78	11.09 see note	10.56
Molecular Weight of Stack Gas, dry Md = (0.44 x %CO2) + (0.32 x %O2) + (0.28 x (%N2 + %CO))	Md	lb/lbmol	29.06	29.06	29.06
Molecular Weight of Stack Gas, wet Ms = Md x (1-(MC/100))+18 x (MC/100)	Ms	lb/lbmol	27.86	27.83	27.89
Average Stack Gas Velocity Vs = 85.49 x Cp x (dP)^0.5 x ((Tsr/(Ps x Ms))^0.5)	Vs	ft/sec	52.52	53.09	55.95
Actual Volumetric Air Flow Rate Qa = 60 x Vs x A	Qa	acfm	185,900	187,912	198,030
Volumetric Air Flow Rate at Standard Conditions Qs = Qa x (528 / (Ts + 460)) x (Ps / 29.92)	Qs	scfm	160,640	162,097	170,924
Dry Volumetric Air Flow Rate at Standard Conditions Qd = Qa x (1 - (MC / 100)) x (528 / Tsr) x (Ps / 29.92)	Qd	dscfm	143,328	144,112	152,874
Nozzle Cross-Sectional Area An =(3.14 x Dn^2) /(4 x 144)	An	sq. ft	0.000257	0.000257	0.000257
Isokinetic Variation I = (0.0945 x Tsr x Vmstd) / (Ps x Vs x An x theta x (1 - (MC / 100)))	I	%	97.9	100.9	97.9
PARTICULATE CONCENTRATION					
PM - Filterable C_{sPM} = 15.432 x M_{PM} / V_{mstd}	C_{sPM}	gr/dscf	0.0081	0.0073	0.0068
PARTICULATE EMISSION RATE					
PM - Filterable E_{dry}(lb/hr) = C_{sPM} x Q_d x 60 / 7000	E_{dry}	lb/hr	10.0	9.0	9.0

Note: Moisture Content limited to moisture at saturation

Determination of Volumetric Air Flow Rate, Gas Composition, Moisture Content, and Particulate Matter Emissions
EPA Methods 2, 3, 4 and 5
Indurating Furnace Stack C (SV016)
HPAC Screening

Input Data	Symbol	Units	Run 1	Run 2	Run 3
Test Date	-	-	1/18/2017	1/18/2017	1/18/2017
Test Period	-	-	901 - 934	1009 - 1041	1116 - 1148
Number of Sample Ports	-	-	2	2	2
Number of Traverse Points	-	-	6	6	6
Duct Dimensions (diameter or Length x Width)	D, L X W	inches	104.00	104.00	104.00
Barometric Pressure	Pbar	in. Hg	28.07	28.07	28.07
Stack Static Pressure	Pg	in. H_2O	-0.80	-0.80	-0.80
Average Stack Temperature	Tsf	degrees F	115	114	115
Actual Dry Gas Meter Volume	Vm	cubic feet	21.99	21.83	22.18
Dry Gas Meter Calibration Factor	Y	-	0.9852	0.9852	0.9852
Average Orifice Meter Pressure Drop	DH	in H_2O	1.67	1.67	1.67
Average Meter Temperature	Tmf	degrees F	67	78	84
Pitot Tube Coefficient	Cp	-	0.84	0.84	0.84
Average Square Root of Velocity Head	(DP)^0.5	-	0.967	0.960	0.948
Volume of Water Vapor Condensed in Impingers	Vwc	ml	48	42	44
Mass of Water Vapor Collected in Desiccant	Vwsg	g	3	4	5
Orsat Results, Dry Basis					
Oxygen	%O2	%v/v	18.8	18.8	18.8
Carbon Dioxide	%CO2	%v/v	1.7	1.7	1.6
Nitrogen + Carbon Monoxide	%N2 + %CO	%v/v	79.5	79.5	79.6
Nozzle Diameter	Dn	inches	0.214	0.214	0.214
Run Time	theta	minutes	30	30	30
Particulate Loading (From Lab Results)					
PM - Filterable	M_{PM}	g	0.00924	0.00855	0.00824

Calculated Data	Symbol	Units	Run 1	Run 2	Run 3
Average Absolute Stack Temperature Tsr = Tsf + 460	Tsr	degrees R	575	574	575
Stack Pressure Ps = Pbar + Pg / 13.6	Ps	in. Hg	28.01	28.01	28.01
Duct Area A = 3.14 x D^2 / (4 x 144) or A = L x W / 144	A	Sq. ft	58.992	58.992	58.992
Meter Volume at Standard Conditions Vmstd = 17.64 x Vm x Y x ((Pbar + (DH / 13.6)) / (Tmf + 460))	Vmstd	cubic feet	20.45	19.89	19.99
Average Moisture Content of Stack Gas MC = ((0.04707 x Vwc + 0.04715 x Vwsg) / ((0.04707 x Vwc + 0.04715 x Vwsg) + (Vmstd)) x 100	MC	% Vol	10.51	9.82	10.34
Molecular Weight of Stack Gas, dry Md = (0.44 x %CO2) + (0.32 x %O2) + (0.28 x (%N2 + %CO))	Md	lb/lbmol	29.02	29.02	29.01
Molecular Weight of Stack Gas, wet Ms = Md x (1-(MC/100))+18 x (MC/100)	Ms	lb/lbmol	27.87	27.94	27.87
Average Stack Gas Velocity Vs = 85.49 x Cp x (dP)^0.5 x ((Tsr/(Ps x Ms))^0.5)	Vs	ft/sec	59.60	59.04	58.39
Actual Volumetric Air Flow Rate Qa = 60 x Vs x A	Qa	acfm	210,943	208,988	206,662
Volumetric Air Flow Rate at Standard Conditions Qs = Qa x (528 / (Ts + 460)) x (Ps / 29.92)	Qs	scfm	181,290	179,871	177,766
Dry Volumetric Air Flow Rate at Standard Conditions Qd = Qa x (1 - (MC / 100)) x (528 / Tsr) x (Ps / 29.92)	Qd	dscfm	162,244	162,208	159,378
Nozzle Cross-Sectional Area An =(3.14 x Dn^2) /(4 x 144)	An	sq. ft	0.000250	0.000250	0.000250
Isokinetic Variation I = (0.0945 x Tsr x Vmstd) / (Ps x Vs x An x theta x (1 - (MC / 100)))	I	%	99.3	96.6	98.8
PARTICULATE CONCENTRATION					
PM - Filterable C_{sPM} = 15.432 x M_{PM} / V_{mstd}	C_{sPM}	gr/dscf	0.0070	0.0066	0.0064
PARTICULATE EMISSION RATE					
PM - Filterable E_{dry}(lb/hr) = C_{sPM} x Q_d x 60 / 7000	E_{dry}	lb/hr	9.7	9.2	8.7

Determination of Volumetric Air Flow Rate, Gas Composition, Moisture Content, and Particulate Matter Emissions

EPA Methods 2, 3, 4 and 5

Indurating Furnace Stack D (SV017)

HPAC Screening

Input Data	Symbol	Units	Run 1	Run 2	Run 3
Test Date	-	-	1/18/2017	1/18/2017	1/18/2017
Test Period	-	-	901 - 934	1009 - 1041	1116 - 1148
Number of Sample Ports	-	-	2	2	2
Number of Traverse Points	-	-	6	6	6
Duct Dimensions (diameter or Length x Width)	D, L X W	inches	104.00	104.00	104.00
Barometric Pressure	Pbar	in. Hg	28.07	28.07	28.07
Stack Static Pressure	Pg	in. H_2O	-0.70	-0.70	-0.70
Average Stack Temperature	Tsf	degrees F	117	117	116
Actual Dry Gas Meter Volume	Vm	cubic feet	19.63	19.73	20.30
Dry Gas Meter Calibration Factor	Y	-	0.9973	0.9973	0.9973
Average Orifice Meter Pressure Drop	DH	in H_2O	1.37	1.37	1.43
Average Meter Temperature	Tmf	degrees F	60	70	74
Pitot Tube Coefficient	Cp	-	0.84	0.84	0.84
Average Square Root of Velocity Head	(DP)^0.5	-	0.856	0.854	0.857
Volume of Water Vapor Condensed in Impingers	Vwc	ml	46	40	44
Mass of Water Vapor Collected in Desiccant	Vwsg	g	4	3	6
Orsat Results, Dry Basis					
Oxygen	%O2	%v/v	18.3	18.3	18.3
Carbon Dioxide	%CO2	%v/v	2.0	2.0	2.0
Nitrogen + Carbon Monoxide	%N2 + %CO	%v/v	79.7	79.7	79.7
Nozzle Diameter	Dn	inches	0.217	0.217	0.217
Run Time	theta	minutes	30	30	30
Particulate Loading (From Lab Results)					
PM - Filterable	M_{PM}	g	0.01022	0.00892	0.00904

Calculated Data	Symbol	Units	Run 1	Run 2	Run 3
Average Absolute Stack Temperature Tsr = Tsf + 460	Tsr	degrees R	577	577	576
Stack Pressure Ps = Pbar + Pg / 13.6	Ps	in. Hg	28.02	28.02	28.02
Duct Area A = 3.14 x D^2 / (4 x 144) or A = L x W / 144	A	Sq. ft	58.992	58.992	58.992
Meter Volume at Standard Conditions Vmstd = 17.64 x Vm x Y x ((Pbar + (DH / 13.6)) / (Tmf + 460))	Vmstd	cubic feet	18.69	18.46	18.84
Average Moisture Content of Stack Gas MC = ((0.04707 x Vwc + 0.04715 x Vwsg) / ((0.04707 x Vwc + 0.04715 x Vwsg) + (Vmstd)) x 100	MC	% Vol	11.18	9.88	10.95 see note
Molecular Weight of Stack Gas, dry Md = (0.44 x %CO2) + (0.32 x %O2) + (0.28 x (%N2 + %CO))	Md	lb/lbmol	29.05	29.05	29.05
Molecular Weight of Stack Gas, wet Ms = Md x (1-(MC/100))+18 x (MC/100)	Ms	lb/lbmol	27.82	27.96	27.84
Average Stack Gas Velocity Vs = 85.49 x Cp x (dP)^0.5 x ((Tsr/(Ps x Ms))^0.5)	Vs	ft/sec	52.92	52.63	52.90
Actual Volumetric Air Flow Rate Qa = 60 x Vs x A	Qa	acfm	187,324	186,272	187,230
Volumetric Air Flow Rate at Standard Conditions Qs = Qa x (528 / (Ts + 460)) x (Ps / 29.92)	Qs	scfm	160,430	159,713	160,720
Dry Volumetric Air Flow Rate at Standard Conditions Qd = Qa x (1 - (MC / 100)) x (528 / Tsr) x (Ps / 29.92)	Qd	dscfm	142,488	143,929	143,114
Nozzle Cross-Sectional Area An =(3.14 x Dn^2) /(4 x 144)	An	sq. ft	0.000257	0.000257	0.000257
Isokinetic Variation I = (0.0945 x Tsr x Vmstd) / (Ps x Vs x An x theta x (1 - (MC / 100)))	I	%	100.5	98.3	100.9
PARTICULATE CONCENTRATION					
PM - Filterable C_{sPM} = 15.432 x M_{PM} / V_{mstd}	C_{sPM}	gr/dscf	0.0084	0.0075	0.0074
PARTICULATE EMISSION RATE					
PM - Filterable E_{dry}(lb/hr) = C_{sPM} x Q_d x 60 / 7000	E_{dry}	lb/hr	10.3	9.2	9.1

Note: Moisture Content limited to moisture at saturation

EPA Method 30B Calculation Summary
Determination of Total Vapor Phase Mercury Emissions

Indurating Furnact Stack C SV016
BPAC Screening

Data Entry	Symbol	Units	Run 1	Run 2	Run 3	Test Average
Test Date	-	-	1/17/2017	1/17/2017	1/17/2017	---
Test Period	-	-	1007 - 1041	1116 - 1147	1216 - 1249	---
Barometric Pressure	P_{bar}	in. Hg	28.24	28.24	28.24	28.24
Dry Volumetric Flowrate at Standard Conditions (EPA Method 2)	Q_d	dscfm	164,662	161,102	160,140	161,968

Trap A Results

	Symbol	Units	Run 1	Run 2	Run 3	Test Average
Actual Dry Gas Meter Volume	V_{mA}	liters	30.376	29.556	30.769	30.234
Dry Gas Meter Calibration Factor	Y_A	-	1.0069	1.0069	1.0069	1.0069
Average Meter Temperature	T_{mfA}	degrees F	74.3	77.8	78.8	77
Average Absolute Meter Temperature (R) $T_{mrA} = T_{mfA} + 460$	T_{mrA}	degrees R	534	538	539	537
Meter Volume at Standard Conditions $V_{mstd\ A} = 17.64 \times (V_{mA} \times 0.03531) \times Y_A \times P_{bar} / T_{mrA}$	$V_{mstd\ A}$	cubic feet	1.007	0.973	1.011	0.997
Laboratory Results						
Trap ID	---	---	399746	394752	391536	---
Mercury Sorbent Trap, Section 1	$M_{1\ A}$	ng	55.36	58.65	56.12	56.71
Mercury Sorbent Trap, Section 2	$M_{2\ A}$	ng	4.40	4.95	4.83	4.73
Mercury, Total amount collected	M_A	ng	59.76	63.60	60.95	61.44
Amount of Mercury in spiked traps-from laboratory	$M_{spike\ A}$	ng	0	0	0	---
Mercury Stack Concentration $C_{(\mu g)A} = (M_A - M_{spikeA}) / 1000 / V_{mstdA} \times 0.0283168$	$C_{(\mu g)A}$	µg/dscm	2.096	2.308	2.128	2.177
Mercury Emission Rate $E_{(lb/hr)A} = (M_A - M_{spike\ A}) \times (2.2046 \times 10^{-12}$ (lb/ng)) x Qd x60 / $V_{mstd\ A}$	$E_{(lb/hr)A}$	lb/hr	0.00129	0.00139	0.00128	0.00132
Mercury Emission Rate $E_{(lb/yr)A} = E_{(lb/hr)A} \times 8760$ hr/yr	$E_{(lb/yr)A}$	lb/yr	11.3	12.2	11.2	11.6

Trap B Results

	Symbol	Units	Run 1	Run 2	Run 3	Test Average
Actual Dry Gas Meter Volume	V_{mB}	liters	31.895	29.355	30.898	30.716
Dry Gas Meter Calibration Factor	Y_B	-	1.0002	1.0002	1.0002	1.0002
Average Meter Temperature	T_{mfB}	degrees F	74.0	76.8	78.0	76
Average Absolute Meter Temperature (R) $T_{mrB} = T_{mfB} + 460$	T_{mrB}	degrees R	534	537	538	536
Meter Volume at Standard Conditions $V_{mstd\ B} = 17.64 \times (V_{mB} \times 0.03531) \times Y \times P_{bar} / T_{mrB}$	$V_{mstd\ B}$	cubic feet	1.051	0.962	1.010	1.008
Laboratory Results						
Trap ID	---	---	391640	391663	391890	---
Mercury Sorbent Trap, Section 1	$M_{1\ B}$	ng	104.40	106.93	105.41	105.58
Mercury Sorbent Trap, Section 2	$M_{2\ B}$	ng	5.62	4.62	4.88	5.04
Mercury, Total amount collected	M_B	ng	110.02	111.54	110.29	110.62
Amount of Mercury in spiked traps-from laboratory	$M_{spike\ B}$	ng	50	50	50	---
Mercury Stack Concentration $C_{(\mu g)B} = (M_B - M_{spikeB}) / 1000 / V_{mstdB} \times 0.0283168$	$C_{(\mu g)B}$	µg/dscm	2.017	2.259	2.107	2.128
Mercury Emission Rate $E_{(lb/hr)B} = (M_B - M_{spike\ B}) \times (2.2046 \times 10^{-12}$ (lb/ng)) x Qd x60 / $V_{mstd\ B}$	$E_{(lb/hr)B}$	lb/hr	0.00124	0.00136	0.00126	0.00129
Mercury Emission Rate $E_{(lb/yr)B} = E_{(lb/hr)B} \times 8760$ hr/yr	$E_{(lb/yr)B}$	lb/yr	10.9	11.9	11.1	11.3

EPA Method 30B QA/QC Data

	Symbol	Units	Run 1	Run 2	Run 3	Test Average
A Train Breakthrough -- each run <10% $B_A = M_{2\ A} / M_{1\ A} \times 100$	B_A	%	8.0	8.4	8.6	8.3
B Train Breakthrough -- each run <10% $B_B = M_{2\ B} / M_{1\ B} \times 100$	B_B	%	5.4	4.3	4.6	4.8
Sample volume agreement -- each run +/- 20% $SV = 100 - ((V_{mstd\ A} / V_{mstd\ B}) \times 100)$	SV	%	4.2	-1.2	-0.1	1.0
Field Recovery Test -- 3 run avg 85%< R >115% $R = (M_A / V_{mstd\ A} - M_B / V_{mstd\ B}) \times V_{mstd\ A} / M_{spike\ A} \times 100$	R	%	95.3	97.4	98.8	97.2
Paired Trap Agreement -- each run <10% $RD = ((C_{\mu gA} - C_{\mu gB}) / (C_{\mu gA} + C_{\mu gB}))$ X 100	RD	%	1.9	1.1	0.5	1.2

EPA Method 30B Calculation Summary
Determination of Total Vapor Phase Mercury Emissions

Indurating Furnace Stack D (SV017)
BPAC Screening

Data Entry	Symbol	Units	Run 1	Run 2	Run 3	Test Average
Test Date	-	-	1/17/2017	1/17/2017	1/17/2017	---
Test Period	-	-	1007 - 1041	1116 - 1147	1216 - 1249	---
Barometric Pressure	P_{bar}	in. Hg	28.24	28.24	28.24	28.24
Dry Volumetric Flowrate at Standard Conditions (EPA Method 2)	Q_d	dscfm	143,328	144,112	152,874	146,772

Trap A Results

	Symbol	Units	Run 1	Run 2	Run 3	Test Average
Actual Dry Gas Meter Volume	V_{mA}	liters	33.888	30.260	30.047	31.398
Dry Gas Meter Calibration Factor	Y_A	-	0.9904	0.9904	0.9904	0.9904
Average Meter Temperature	T_{mfA}	degrees F	75.2	77.8	79.5	77.5
Average Absolute Meter Temperature (R) $T_{mrA} = T_{mfA} + 460$	T_{mrA}	degrees R	535	538	540	538
Meter Volume at Standard Conditions $V_{mstd\ A} = 17.64 \times (V_{mA} \times 0.03531) \times Y_A \times P_{bar} / T_{mrA}$	$V_{mstd\ A}$	cubic feet	1.103	0.980	0.970	1.018
Laboratory Results						
Trap ID	---	---	394925	399693	394777	---
Mercury Sorbent Trap, Section 1	$M_{1\ A}$	ng	80.89	76.85	74.82	77.52
Mercury Sorbent Trap, Section 2	$M_{2\ A}$	ng	3.13	2.13	2.19	2.48
Mercury, Total amount collected	M_A	ng	84.02	78.98	77.01	80.00
Amount of Mercury in spiked traps-from laboratory	$M_{spike\ A}$	ng	0	0	0	---
Mercury Stack Concentration $C_{(\mu g)A} = (M_A - M_{spikeA}) / 1000 / V_{mstdA} \times 0.0283168$	$C_{(\mu g)A}$	µg/dscm	2.690	2.846	2.803	2.779
Mercury Emission Rate $E_{(lb/hr)A} = (M_A - M_{spike\ A}) \times (2.2046 \times 10^{-12}\ (lb/ng)) \times Qd \times 60 / V_{mstd\ A}$	$E_{(lb/hr)A}$	lb/hr	0.00144	0.00154	0.00161	0.00153
Mercury Emission Rate $E_{(lb/yr)A} = E_{(lb/hr)A} \times 8760$ hr/yr	$E_{(lb/yr)A}$	lb/yr	12.6	13.5	14.1	13.4

Trap B Results

	Symbol	Units	Run 1	Run 2	Run 3	Test Average
Actual Dry Gas Meter Volume	V_{mB}	liters	33.582	30.110	29.912	31.201
Dry Gas Meter Calibration Factor	Y_B	-	0.9846	0.9846	0.9846	0.9846
Average Meter Temperature	T_{mfB}	degrees F	75.3	77.8	79.5	78
Average Absolute Meter Temperature (R) $T_{mrB} = T_{mfB} + 460$	T_{mrB}	degrees R	535	538	540	538
Meter Volume at Standard Conditions $V_{mstd\ B} = 17.64 \times (V_{mB} \times 0.03531) \times Y \times P_{bar} / T_{mrB}$	$V_{mstd\ B}$	cubic feet	1.086	0.970	0.960	1.005
Laboratory Results						
Trap ID	---	---	391876	391866	391891	---
Mercury Sorbent Trap, Section 1	$M_{1\ B}$	ng	130.94	117.04	117.54	121.84
Mercury Sorbent Trap, Section 2	$M_{2\ B}$	ng	2.18	1.75	2.22	2.05
Mercury, Total amount collected	M_B	ng	133.12	118.79	119.76	123.89
Amount of Mercury in spiked traps-from laboratory	$M_{spike\ B}$	ng	50	50	50	---
Mercury Stack Concentration $C_{(\mu g)B} = (M_B - M_{spikeB}) / 1000 / V_{mstdB} \times 0.0283168$	$C_{(\mu g)B}$	µg/dscm	2.702	2.505	2.566	2.591
Mercury Emission Rate $E_{(lb/hr)B} = (M_B - M_{spike\ B}) \times (2.2046 \times 10^{-12}\ (lb/ng)) \times Qd \times 60 / V_{mstd\ B}$	$E_{(lb/hr)B}$	lb/hr	0.00145	0.00135	0.00147	0.00142
Mercury Emission Rate $E_{(lb/yr)B} = E_{(lb/hr)B} \times 8760$ hr/yr	$E_{(lb/yr)B}$	lb/yr	12.7	11.8	12.9	12.5

EPA Method 30B QA/QC Data

	Symbol	Units	Run 1	Run 2	Run 3	Test Average
A Train Breakthrough -- each run <10% $B_A = M_{2\ A} / M_{1\ A} \times 100$	B_A	%	3.9	2.8	2.9	3.2
B Train Breakthrough -- each run <10% $B_B = M_{2\ B} / M_{1\ B} \times 100$	B_B	%	1.7	1.5	1.9	1.7
Sample volume agreement -- each run +/- 20% $SV = 100 - ((V_{mstd\ A} / V_{mstd\ B}) \times 100)$	SV	%	-1.5	-1.1	-1.0	-1.2
Field Recovery Test -- 3 run avg 85%< R >115% $R = (M_A / V_{mstd\ A} - M_B / V_{mstd\ B}) \times V_{mstd\ A} / M_{spike\ A} \times 100$	R	%	100.7	81.3	87.1	89.7
Paired Trap Agreement -- each run <10% $RD = ((C_{\mu gA} - C_{\mu gB}) / (C_{\mu gA} + C_{\mu gB}))$ X 100	RD	%	0.2	6.4	4.4	3.7

EPA Method 30B Calculation Summary
Determination of Total Vapor Phase Mercury Emissions

Indurating Furnace Stack C (SV016)
HPAC Screening

Data Entry	Symbol	Units	Run 1	Run 2	Run 3	Test Average
Test Date	-	-	1/18/2017	1/18/2017	1/18/2017	---
Test Period	-	-	901-931	1009-1039	1116-1146	---
Barometric Pressure	P_{bar}	in. Hg	28.07	28.07	28.07	28.07
Dry Volumetric Flowrate at Standard Conditions (EPA Method 2)	Q_d	dscfm	162,244	162,208	159,378	161,277

Trap A Results

	Symbol	Units	Run 1	Run 2	Run 3	Test Average
Actual Dry Gas Meter Volume	V_{mA}	liters	30.602	29.845	29.978	30.142
Dry Gas Meter Calibration Factor	Y_A	-	1.0069	1.0069	1.0069	1.0069
Average Meter Temperature	T_{mfA}	degrees F	60	71	77	69
Average Absolute Meter Temperature (R) $T_{mrA} = T_{mfA} + 460$	T_{mrA}	degrees R	520	531	537	529
Meter Volume at Standard Conditions $V_{mstd\ A} = 17.64 \times (V_{mA} \times 0.03531) \times Y_A \times P_{bar} / T_{mrA}$	$V_{mstd\ A}$	cubic feet	1.036	0.990	0.983	1.003
Laboratory Results						
Trap ID	---	---	399654	399571	401323	---
Mercury Sorbent Trap, Section 1	$M_{1\ A}$	ng	54.45	47.08	47.31	49.61
Mercury Sorbent Trap, Section 2	$M_{2\ A}$	ng	5.23	4.30	4.48	4.67
Mercury, Total amount collected	M_A	ng	59.67	51.38	51.79	54.28
Amount of Mercury in spiked traps-from laboratory	$M_{spike\ A}$	ng	0	0	0	---
Mercury Stack Concentration $C_{(\mu g)A} = (M_A - M_{spikeA}) / 1000 / V_{mstdA} \times 0.0283168$	$C_{(\mu g)A}$	µg/dscm	2.034	1.832	1.860	1.909
Mercury Emission Rate $E_{(lb/hr)A} = (M_A - M_{spike\ A}) \times (2.2046 \times 10^{-12}\ (lb/ng)) \times Qd \times 60 / V_{mstd\ A}$	$E_{(lb/hr)A}$	lb/hr	0.00124	0.00111	0.00111	0.00115
Mercury Emission Rate $E_{(lb/yr)A} = E_{(lb/hr)A} \times 8760$ hr/yr	$E_{(lb/yr)A}$	lb/yr	10.8	9.8	9.7	10.1

Trap B Results

	Symbol	Units	Run 1	Run 2	Run 3	Test Average
Actual Dry Gas Meter Volume	V_{mB}	liters	30.393	30.026	30.208	30.209
Dry Gas Meter Calibration Factor	Y_B	-	1.0002	1.0002	1.0002	1.0002
Average Meter Temperature	T_{mfB}	degrees F	60	70	76	68
Average Absolute Meter Temperature (R) $T_{mrB} = T_{mfB} + 460$	T_{mrB}	degrees R	520	530	536	528
Meter Volume at Standard Conditions $V_{mstd\ B} = 17.64 \times (V_{mB} \times 0.03531) \times Y \times P_{bar} / T_{mrB}$	$V_{mstd\ B}$	cubic feet	1.023	0.991	0.986	1.000
Laboratory Results						
Trap ID	---	---	391879	401329	401282	---
Mercury Sorbent Trap, Section 1	$M_{1\ B}$	ng	98.91	91.06	96.05	95.34
Mercury Sorbent Trap, Section 2	$M_{2\ B}$	ng	4.55	4.93	4.58	4.68
Mercury, Total amount collected	M_B	ng	103.46	95.99	100.63	100.02
Amount of Mercury in spiked traps-from laboratory	$M_{spike\ B}$	ng	50	50	50	---
Mercury Stack Concentration $C_{(\mu g)B} = (M_B - M_{spikeB}) / 1000 / V_{mstdB} \times 0.0283168$	$C_{(\mu g)B}$	µg/dscm	1.846	1.639	1.814	1.766
Mercury Emission Rate $E_{(lb/hr)B} = (M_B - M_{spike\ B}) \times (2.2046 \times 10^{-12}\ (lb/ng)) \times Qd \times 60 / V_{mstd\ B}$	$E_{(lb/hr)B}$	lb/hr	0.00112	0.00100	0.00108	0.00107
Mercury Emission Rate $E_{(lb/yr)B} = E_{(lb/hr)B} \times 8760$ hr/yr	$E_{(lb/yr)B}$	lb/yr	9.8	8.7	9.5	9.3

EPA Method 30B QA/QC Data

	Symbol	Units	Run 1	Run 2	Run 3	Test Average
A Train Breakthrough -- each run <10% $B_A = M_{2\ A} / M_{1\ A} \times 100$	B_A	%	9.6	9.1	9.5	9.4
B Train Breakthrough -- each run <10% $B_B = M_{2\ B} / M_{1\ B} \times 100$	B_B	%	4.6	5.4	4.8	4.9
Sample volume agreement -- each run +/- 20% $SV = 100 - ((V_{mstd\ A} / V_{mstd\ B}) \times 100)$	SV	%	-1.3	0.1	0.3	-0.3
Field Recovery Test -- 3 run avg 85%< R >115% $R = (M_A / V_{mstd\ A} - M_B / V_{mstd\ B}) \times V_{mstd\ A} / M_{spike\ A} \times 100$	R	%	89.1	89.1	97.4	91.9
Paired Trap Agreement -- each run <10% $RD = ((C_{\mu gA} - C_{\mu gB}) / (C_{\mu gA} + C_{\mu gB}))$ X 100	RD	%	4.9	5.6	1.3	3.9

EPA Method 30B Calculation Summary
Determination of Total Vapor Phase Mercury Emissions

Indurating Furnace Stack D (SV017)
HPAC Screening

Data Entry	Symbol	Units	Run 1	Run 2	Run 3	Test Average
Test Date	-	-	1/18/2017	1/18/2017	1/18/2017	---
Test Period	-	-	901-931	1009-1039	1116-1146	---
Barometric Pressure	P_{bar}	in. Hg	28.07	28.07	28.07	28.07
Dry Volumetric Flowrate at Standard Conditions (EPA Method 2)	Q_d	dscfm	142,488	143,929	143,114	143,177

Trap A Results

	Symbol	Units	Run 1	Run 2	Run 3	Test Average
Actual Dry Gas Meter Volume	V_{mA}	liters	30.301	29.949	30.079	30.110
Dry Gas Meter Calibration Factor	Y_A	-	0.9904	0.9904	0.9904	0.9904
Average Meter Temperature	T_{mfA}	degrees F	56	66	73	65
Average Absolute Meter Temperature (R) $T_{mrA} = T_{mfA} + 460$	T_{mrA}	degrees R	516	526	533	525
Meter Volume at Standard Conditions $V_{mstd\ A} = 17.64 \times (V_{mA} \times 0.03531) \times Y_A \times P_{bar} / T_{mrA}$	$V_{mstd\ A}$	cubic feet	1.017	0.986	0.977	0.993
Laboratory Results						
Trap ID	---	---	399568	394870	401324	---
Mercury Sorbent Trap, Section 1	$M_{1\ A}$	ng	67.05	61.34	62.53	63.64
Mercury Sorbent Trap, Section 2	$M_{2\ A}$	ng	1.61	2.02	1.60	1.74
Mercury, Total amount collected	M_A	ng	68.65	63.36	64.13	65.38
Amount of Mercury in spiked traps-from laboratory	$M_{spike\ A}$	ng	0	0	0	---
Mercury Stack Concentration $C_{(\mu g)A} = (M_A - M_{spikeA}) / 1000 / V_{mstdA} \times 0.0283168$	$C_{(\mu g)A}$	µg/dscm	2.383	2.270	2.318	2.324
Mercury Emission Rate $E_{(lb/hr)A} = (M_A - M_{spike\ A}) \times (2.2046\times10^{-12}\ (lb/ng)) \times Qd \times 60 / V_{mstd\ A}$	$E_{(lb/hr)A}$	lb/hr	0.00127	0.00122	0.00124	0.00125
Mercury Emission Rate $E_{(lb/yr)A} = E_{(lb/hr)A} \times 8760$ hr/yr	$E_{(lb/yr)A}$	lb/yr	11.1	10.7	10.9	10.9

Trap B Results

	Symbol	Units	Run 1	Run 2	Run 3	Test Average
Actual Dry Gas Meter Volume	V_{mB}	liters	29.832	29.953	30.067	29.951
Dry Gas Meter Calibration Factor	Y_B	-	0.9846	0.9846	0.9846	0.9846
Average Meter Temperature	T_{mfB}	degrees F	57	66	74	65
Average Absolute Meter Temperature (R) $T_{mrB} = T_{mfB} + 460$	T_{mrB}	degrees R	517	526	534	525
Meter Volume at Standard Conditions $V_{mstd\ B} = 17.64 \times (V_{mB} \times 0.03531) \times Y \times P_{bar} / T_{mrB}$	$V_{mstd\ B}$	cubic feet	0.994	0.980	0.970	0.981
Laboratory Results						
Trap ID	---	---	401293	401281	401291	---
Mercury Sorbent Trap, Section 1	$M_{1\ B}$	ng	116.02	106.51	104.37	108.97
Mercury Sorbent Trap, Section 2	$M_{2\ B}$	ng	0.73	1.49	2.78	1.67
Mercury, Total amount collected	M_B	ng	116.75	108.00	107.15	110.64
Amount of Mercury in spiked traps-from laboratory	$M_{spike\ B}$	ng	50	50	50	---
Mercury Stack Concentration $C_{(\mu g)B} = (M_B - M_{spikeB}) / 1000 / V_{mstdB} \times 0.0283168$	$C_{(\mu g)B}$	µg/dscm	2.372	2.090	2.080	2.181
Mercury Emission Rate $E_{(lb/hr)B} = (M_B - M_{spike\ B}) \times (2.2046\times10^{-12}\ (lb/ng)) \times Qd \times 60 / V_{mstd\ B}$	$E_{(lb/hr)B}$	lb/hr	0.00127	0.00113	0.00112	0.00117
Mercury Emission Rate $E_{(lb/yr)B} = E_{(lb/hr)B} \times 8760$ hr/yr	$E_{(lb/yr)B}$	lb/yr	11.1	9.9	9.8	10.2

EPA Method 30B QA/QC Data

	Symbol	Units	Run 1	Run 2	Run 3	Test Average
A Train Breakthrough -- each run <10% $B_A = M_{2\ A} / M_{1\ A} \times 100$	B_A	%	2.4	3.3	2.6	2.7
B Train Breakthrough -- each run <10% $B_B = M_{2\ B} / M_{1\ B} \times 100$	B_B	%	0.6	1.4	2.7	1.6
Sample volume agreement -- each run +/- 20% $SV = 100 - ((V_{mstd\ A} / V_{mstd\ B}) \times 100)$	SV	%	-2.3	-0.6	-0.7	-1.2
Field Recovery Test -- 3 run avg 85%< R >115% $R = (M_A / V_{mstd\ A} - M_B / V_{mstd\ B}) \times V_{mstd\ A} / M_{spike\ A} \times 100$	R	%	99.3	90.0	86.9	92.1
Paired Trap Agreement -- each run <10% $RD = ((C_{\mu gA} - C_{\mu gB}) / (C_{\mu gA} + C_{\mu gB}))$ X 100	RD	%	0.2	4.1	5.4	3.3

ArcelorMittal Minorca Mine Inc.
Virginia, Minnesota

Barr Engineering Co.
August 1, 2017

Determination of Volumetric Airflow Rate, Gas Composition, Moisture Content, and Speciated Mercury Emissions
EPA Methods 2, 3, 4, 5, Ontario-Hydro
TEST 1
Indurating Furnace Stack A (SV014)
Longterm 1

Input Data	Symbol	Units	Run 1	Run 2	Run 3
Test Date	-	-	2/8/2017	2/8/2017	2/8/2017
Test Period	-	-	807 - 1020	1313 - 1313	1754 - 1754
Number of Sample Ports	-	-	4	4	4
Number of Traverse Points	-	-	12	12	12
Duct Dimensions (diameter or Length x Width)	D, L X W	inches	101.75	101.75	101.75
Barometric Pressure	Pbar	in. Hg	28.33	28.33	28.33
Stack Static Pressure	Pg	in. H2O	-1.00	-1.00	-1.00
Average Stack Temperature, dry bulb	Tsf	degrees F	104	104	105
Actual Dry Gas Meter Volume	Vm	cubic feet	85.93	91.21	87.61
Dry Gas Meter Calibration Factor	Y	-	1.0038	1.0038	1.0038
Average Orifice Meter Pressure Drop	ΔH	in H2O	1.65	1.82	1.72
Average Meter Temperature	Tmf	degrees F	68.90	74.38	67.85
Pitot Tube Coefficient	Cp	-	0.84	0.84	0.84
Average Square Root of Velocity Head	(ΔP)^0.5	-	0.951	0.965	0.934
Mass of Water Vapor Collected in Impingers and Desiccant	Vwc	g	148	141	147
Orsat Results, Dry Basis					
Oxygen	%O2	%v/v	19.6	19.6	19.6
Carbon Dioxide	%CO2	%v/v	1.2	1.2	1.2
Carbon Monoxide + Nitrogen	-	%v/v	79.2	79.2	79.2
Nozzle Diameter	Dn	in	0.215	0.215	0.215
Run Time	theta	min	120	120	120
Ontario Hydro Mercury Results					
Probe Rinse (0.1 N HNO3)	Hg_{pr}	μg	0.018	0.029	0.017
Filter	Hg_{filter}	μg	1.080	1.290	0.650
Oxydized Mercury (KCl)	Hg_{KCl}	μg	1.235	0.928	1.170
Elemental Mercury (HNO3/H2O2)	Hg_{H2O2}	μg	0.002	0.015	< 0.013
Elemental Mercury (KMnO4)	Hg_{KMnO4}	μg	2.52	2.73	2.72
Total Mercury	$Hg_{(total)}$	μg	4.85	4.99	4.56
Particulate Loading (From Lab Results)					
PM - Filterable	M_{PM}	g	0.02421	0.02680	0.02383
Calculated Data	Symbol	Units	Run 1	Run 2	Run 3
Average Absolute Stack Temperature (R) Tsr = Tsf + 460	Tsr	degrees R	564	564	565
Stack Pressure Ps = Pbar + Pg / 13.6	Ps	in Hg	28.26	28.26	28.26
Duct Area $A = (D/24)^2 \times \pi$	A	Sq. ft	56.467	56.467	56.467
Meter Volume at Standard Conditions Vmstd = 17.64 x Vm x Y x ((Pbar +(ΔH/13.6))/Tmr)	Vmstd	cubic feet	81.85	86.03	83.63
Average Moisture Content of Stack Gas MC = ((0.04715*Vwc)/((0.04715*Vwc) + (Vmstd)) x 100	MC	% Vol	7.70 see note	7.15	7.67
Molecular Weight of Stack Gas, dry Md = (0.44x(%CO2))+(0.32x(%O2))+(0.28x(%N2+%CO))	Md	lb/lbmol	28.98	28.98	28.98
Molecular Weight of Stack Gas, wet Ms = Md x (1-(MC/100))+18 x (MC/100)	Ms	lb/lbmol	28.13	28.19	28.13
Average Stack Gas Velocity Vs = 85.49 x Cp x (dP)^0.5 x ((Tsr/(Ps x Ms))^0.5)	Vs	ft/sec	57.51	58.34	56.52
Actual Volumetric Flowrate Qa = 60 x Vs x A	Qa	acfm	194,856	197,651	191,508
Volumetric Flowrate at Standard Conditions Qs = Qa x (528/(Ts+460)) x (Ps/29.92)	Qs	scfm	172,250	174,644	169,091
Dry Volumetric Flowrate at Standard Conditions Qd = Qa x (1-(MC/100)) x (528/Tsr) x (Ps/29.92)	Qd	dscfm	158,987	162,149	156,118
Nozzle Cross-Sectional Area An =(3.14 x Dn^2) /(4 x 144)	An	sq. ft	0.000252	0.000252	0.000252
Isokinetic Variation I = (0.0945xTsrxVmstd)/(PsxVsxAn x theta x(1-(MC/100)))	I	%	96.2	99.1	100.1
Mercury Concentrations					
Particulate Hg: $Hg^{tp} = (Hg_{pr} + Hg_{filter}) / (V_{mstd} / 35.314)$	Hg^{tp}	μg/dscm	0.474	0.541	0.281
Oxidized Hg: $Hg^{O} = Hg_{KCl} / (V_{mstd} / 35.314)$	Hg^{O}	μg/dscm	0.53	0.38	0.49
Elemental Hg: $Hg^{E} = (Hg_{H2O2} + Hg_{KMnO4}) / (V_{mstd} / 35.314)$	Hg^{E}	μg/dscm	1.1	1.1	1.2
Total Hg: $Hg^{tot} = Hg_{(total)} / (V_{mstd} / 35.314)$	Hg^{tot}	μg/dscm	2.1	2.0	1.9
Mercury Emission Rates					
Particulate Hg: $E\text{-}Hg^{tp} = Hg^{tp} \times 62.43 \times 10^{-12} \times 60 \times$ dscfm	$E\text{-}Hg^{tp}$	lb/hr	2.8E-04	3.3E-04	1.6E-04
Oxidized Hg: $E\text{-}Hg^{O} = Hg_{KCl} \times 62.43 \times 10^{-12} \times 60 \times$ dscfm	$E\text{-}Hg^{O}$	lb/hr	3.2E-04	2.3E-04	2.9E-04
Elemental Hg: $E\text{-}Hg^{E} = Hg_{H2O2} \times 62.43 \times 10^{-12} \times 60 \times$ dscfm	$E\text{-}Hg^{E}$	lb/hr	6.5E-04	6.8E-04	6.7E-04
Total Hg: $E\text{-}Hg^{tot} = Hg_{(total)} \times 62.43 \times 10^{-12} \times 60 \times$ dscfm	$E\text{-}Hg^{tot}$	lb/hr	1.2E-03	1.2E-03	1.1E-03
Estimated Annual Mercury Emissions					
$E\text{-}Hg^{tot} = 8{,}760$ hr/yr x $E\text{-}Hg^{tot}$	$E\text{-}Hg^{tot}$	lb/yr	10.9	10.9	9.9
PARTICULATE CONCENTRATION					
PM - Filterable $C_{sPM} = 15.432 \times M_{PM} / V_{mstd}$	C_{sPM}	gr/dscf	0.0046	0.0048	0.0044
PARTICULATE EMISSION RATE					
PM - Filterable E_{dry}(lb/hr) = $C_{sPM} \times Q_d \times 60 / 7000$	E_{dry}	lb/hr	6.2	6.7	5.9

Note: Moisture Content limited to moisture at saturation

Determination of Volumetric Airflow Rate, Gas Composition, Moisture Content, and Speciated Mercury Emissions
EPA Methods 2, 3, 4, 5, Ontario-Hydro
TEST 2
Indurating Furnace Stack B (SV015)
Longterm 1

Input Data	Symbol	Units	Run 1	Run 2	Run 3
Test Date	-	-	2/9/2017	2/9/2017	2/9/2017
Test Period	-	-	754 - 1030	1330 - 1330	1610 - 1610
Number of Sample Ports	-	-	4	4	4
Number of Traverse Points	-	-	12	12	12
Duct Dimensions (diameter or Length x Width)	D, L X W	inches	101.75	101.75	101.75
Barometric Pressure	Pbar	in. Hg	28.40	28.40	28.40
Stack Static Pressure	Pg	in. H2O	-0.90	-0.90	-0.90
Average Stack Temperature, dry bulb	Tsf	degrees F	107	106	107
Actual Dry Gas Meter Volume	Vm	cubic feet	88.00	93.66	95.52
Dry Gas Meter Calibration Factor	Y	-	1.0038	1.0038	1.0038
Average Orifice Meter Pressure Drop	ΔH	in H2O	1.77	1.98	2.03
Average Meter Temperature	Tmf	degrees F	56.52	69.50	74.35
Pitot Tube Coefficient	Cp	-	0.84	0.84	0.84
Average Square Root of Velocity Head	(ΔP)^0.5	-	0.959	0.994	1.011
Mass of Water Vapor Collected in Impingers and Desiccant	Vwc	g	122	167	166
Orsat Results, Dry Basis					
Oxygen	%O2	%v/v	19.3	19.3	19.3
Carbon Dioxide	%CO2	%v/v	1.5	1.5	1.5
Carbon Monoxide + Nitrogen	-	%v/v	79.2	79.2	79.2
Nozzle Diameter	Dn	in	0.215	0.215	0.215
Run Time	theta	min	120	120	120
Ontario Hydro Mercury Results					
Probe Rinse (0.1 N HNO3)	Hg_{pr}	μg	0.030	0.030	0.042
Filter	Hg_{filter}	μg	1.670	1.725	1.675
Oxydized Mercury (KCl)	Hg_{KCl}	μg	0.626	0.932	0.657
Elemental Mercury (HNO3/H2O2)	Hg_{H2O2}	μg	0.02	< 0.013	< 0.013
Elemental Mercury (KMnO4)	Hg_{KMnO4}	μg	2.46	3.05	2.98
Total Mercury	$Hg_{(total)}$	μg	4.81	5.74	5.36
Particulate Loading (From Lab Results)					
PM - Filterable	M_{PM}	g	0.02432	0.03134	0.02588

Calculated Data	Symbol	Units	Run 1	Run 2	Run 3
Average Absolute Stack Temperature (R) Tsr = Tsf + 460	Tsr	degrees R	567	566	567
Stack Pressure Ps = Pbar + Pg / 13.6	Ps	in Hg	28.33	28.33	28.33
Duct Area $A = (D/24)^2 \times \pi$	A	Sq. ft	56.467	56.467	56.467
Meter Volume at Standard Conditions Vmstd = 17.64 x Vm x Y x ((Pbar +(ΔH/13.6))/Tmr)	Vmstd	cubic feet	86.07	89.41	90.37
Average Moisture Content of Stack Gas MC = ((0.04715*Vwc)/((0.04715*Vwc) + (Vmstd)) x 100	MC	% Vol	6.27	8.10 see note	7.95
Molecular Weight of Stack Gas, dry Md = (0.44x(%CO2))+(0.32x(%O2))+(0.28x(%N2+%CO))	Md	lb/lbmol	29.01	29.01	29.01
Molecular Weight of Stack Gas, wet Ms = Md x (1-(MC/100))+18 x (MC/100)	Ms	lb/lbmol	28.32	28.12	28.14
Average Stack Gas Velocity Vs = 85.49 x Cp x (dP)^0.5 x ((Tsr/(Ps x Ms))^0.5)	Vs	ft/sec	57.92	60.18	61.23
Actual Volumetric Flowrate Qa = 60 x Vs x A	Qa	acfm	196,221	203,898	207,452
Volumetric Flowrate at Standard Conditions Qs = Qa x (528/(Ts+460)) x (Ps/29.92)	Qs	scfm	172,948	180,165	183,090
Dry Volumetric Flowrate at Standard Conditions Qd = Qa x (1-(MC/100)) x (528/Tsr) x (Ps/29.92)	Qd	dscfm	162,105	165,581	168,536
Nozzle Cross-Sectional Area An =(3.14 x Dn^2) /(4 x 144)	An	sq. ft	0.000252	0.000252	0.000252
Isokinetic Variation I = (0.0945xTsrxVmstd)/(PsxVsxAn x theta x(1-(MC/100)))	I	%	99.2	100.9	100.2
Mercury Concentrations					
Particulate Hg: $Hg^{tp} = (Hg_{pr} + Hg_{filter}) / (V_{mstd} / 35.314)$	Hg^{tp}	μg/dscm	0.698	0.693	0.671
Oxidized Hg: $Hg^{O} = Hg_{KCl} / (V_{mstd} / 35.314)$	Hg^{O}	μg/dscm	0.26	0.37	0.26
Elemental Hg: $Hg^{E} = (Hg_{H2O2} + Hg_{KMnO4}) / (V_{mstd} / 35.314)$	Hg^{E}	μg/dscm	1.0	1.2	1.2
Total Hg: $Hg^{tot} = Hg_{(total)} / (V_{mstd} / 35.314)$	Hg^{tot}	μg/dscm	2.0	2.3	2.1
Mercury Emission Rates					
Particulate Hg: $E\text{-}Hg^{tp} = Hg^{tp} \times 62.43\times10^{-12} \times 60 \times dscfm$	$E\text{-}Hg^{tp}$	lb/hr	4.2E-04	4.3E-04	4.2E-04
Oxidized Hg: $E\text{-}Hg^{O} = Hg_{KCl} \times 62.43\times10^{-12} \times 60 \times dscfm$	$E\text{-}Hg^{O}$	lb/hr	1.6E-04	2.3E-04	1.6E-04
Elemental Hg: $E\text{-}Hg^{E} = Hg_{H2O2} \times 62.43\times10^{-12} \times 60 \times dscfm$	$E\text{-}Hg^{E}$	lb/hr	6.2E-04	7.5E-04	7.4E-04
Total Hg: $E\text{-}Hg^{tot} = Hg_{(total)} \times 62.43\times10^{-12} \times 60 \times dscfm$	$E\text{-}Hg^{tot}$	lb/hr	1.2E-03	1.4E-03	1.3E-03
Estimated Annual Mercury Emissions					
$E\text{-}Hg^{tot} = 8{,}760\ hr/yr \times E\text{-}Hg^{tot}$	$E\text{-}Hg^{tot}$	lb/yr	10.5	12.3	11.6
PARTICULATE CONCENTRATION					
PM - Filterable $C_{sPM} = 15.432 \times M_{PM} / V_{mstd}$	C_{sPM}	gr/dscf	0.0044	0.0054	0.0044
PARTICULATE EMISSION RATE					
PM - Filterable $E_{dry}(lb/hr) = C_{sPM} \times Q_d \times 60 / 7000$	E_{dry}	lb/hr	6.1	7.7	6.4

Note: Moisture Content limited to moisture at saturation

Determination of Volumetric Airflow Rate, Gas Composition, Moisture Content, and Speciated Mercury Emissions
EPA Methods 2, 3, 4, 5, Ontario-Hydro
TEST 3
Indurating Furnace Stack C (SV016)
Longterm 1

Input Data	Symbol	Units	Run 1	Run 2	Run 3
Test Date	-	-	2/8/2017	2/8/2017	2/8/2017
Test Period	-	-	807 - 1020	1313 - 1313	1651 - 1651
Number of Sample Ports	-	-	4	4	4
Number of Traverse Points	-	-	12	12	12
Duct Dimensions (diameter or Length x Width)	D, L X W	inches	104.00	104.00	104.00
Barometric Pressure	Pbar	in. Hg	28.33	28.33	28.33
Stack Static Pressure	Pg	in. H2O	-0.85	-0.85	-0.85
Average Stack Temperature, dry bulb	Tsf	degrees F	113	113	113
Actual Dry Gas Meter Volume	Vm	cubic feet	85.04	89.35	87.48
Dry Gas Meter Calibration Factor	Y	-	0.9950	0.9950	0.9950
Average Orifice Meter Pressure Drop	ΔH	in H2O	1.68	1.81	1.73
Average Meter Temperature	Tmf	degrees F	68.56	76.17	79.06
Pitot Tube Coefficient	Cp	-	0.84	0.84	0.84
Average Square Root of Velocity Head	(ΔP)^0.5	-	0.954	0.959	0.929
Mass of Water Vapor Collected in Impingers and Desiccant	Vwc	g	166	195	190
Orsat Results, Dry Basis					
Oxygen	%O2	%v/v	18.5	18.5	18.5
Carbon Dioxide	%CO2	%v/v	2.2	2.2	2.2
Carbon Monoxide + Nitrogen	-	%v/v	79.3	79.3	79.3
Nozzle Diameter	Dn	in	0.214	0.214	0.214
Run Time	theta	min	120	120	120
Ontario Hydro Mercury Results					
Probe Rinse (0.1 N HNO3)	Hg_{pr}	µg	0.072	0.114	0.090
Filter	Hg_{filter}	µg	2.070	2.215	1.825
Oxydized Mercury (KCl)	Hg_{KCl}	µg	0.245	0.472	0.512
Elemental Mercury (HNO3/H2O2)	Hg_{H2O2}	µg	< 0.013	< 0.013	< 0.013
Elemental Mercury (KMnO4)	Hg_{KMnO4}	µg	3.15	4.28	3.77
Total Mercury	$Hg_{(total)}$	µg	5.55	7.09	6.20
Particulate Loading (From Lab Results)					
PM - Filterable	M_{PM}	g	0.02863	0.03382	0.03116

Calculated Data	Symbol	Units	Run 1	Run 2	Run 3
Average Absolute Stack Temperature (R) Tsr = Tsf + 460	Tsr	degrees R	573	573	573
Stack Pressure Ps = Pbar + Pg / 13.6	Ps	in Hg	28.27	28.27	28.27
Duct Area $A = (D/24)^2 \times \pi$	A	Sq. ft	58.992	58.992	58.992
Meter Volume at Standard Conditions Vmstd = 17.64 x Vm x Y x ((Pbar +(ΔH/13.6))/Tmr)	Vmstd	cubic feet	80.35	83.25	81.06
Average Moisture Content of Stack Gas MC = ((0.04715*Vwc)/((0.04715*Vwc) + (Vmstd)) x 100	MC	% Vol	8.89	9.95	9.93
Molecular Weight of Stack Gas, dry Md = (0.44x(%CO2))+(0.32x(%O2))+(0.28x(%N2+%CO))	Md	lb/lbmol	29.09	29.09	29.09
Molecular Weight of Stack Gas, wet Ms = Md x (1-(MC/100))+18 x (MC/100)	Ms	lb/lbmol	28.11	27.99	27.99
Average Stack Gas Velocity Vs = 85.49 x Cp x (dP)^0.5 x ((Tsr/(Ps x Ms))^0.5)	Vs	ft/sec	58.20	58.65	56.80
Actual Volumetric Flowrate Qa = 60 x Vs x A	Qa	acfm	205,991	207,611	201,047
Volumetric Flowrate at Standard Conditions Qs = Qa x (528/(Ts+460)) x (Ps/29.92)	Qs	scfm	179,252	180,635	174,950
Dry Volumetric Flowrate at Standard Conditions Qd = Qa x (1-(MC/100)) x (528/Tsr) x (Ps/29.92)	Qd	dscfm	163,314	162,670	157,572
Nozzle Cross-Sectional Area An =(3.14 x Dn^2) /(4 x 144)	An	sq. ft	0.000250	0.000250	0.000250
Isokinetic Variation I = (0.0945xTsrxVmstd)/(PsxVsxAn x theta x(1-(MC/100)))	I	%	96.9	100.8	101.3
Mercury Concentrations					
Particulate Hg: $Hg^{tp} = (Hg_{pr} + Hg_{filter}) / (V_{mstd} / 35.314)$	Hg^{tp}	µg/dscm	0.941	0.988	0.834
Oxidized Hg: $Hg^{O} = Hg_{KCl} / (V_{mstd} / 35.314)$	Hg^{O}	µg/dscm	0.11	0.20	0.22
Elemental Hg: $Hg^{E} = (Hg_{H2O2} + Hg_{KMnO4}) / (V_{mstd} / 35.314)$	Hg^{E}	µg/dscm	1.4	1.8	1.646
Total Hg: $Hg^{tot} = Hg_{(total)} / (V_{mstd} / 35.314)$	Hg^{tot}	µg/dscm	2.4	3.0	2.7
Mercury Emission Rates					
Particulate Hg: $E\text{-}Hg^{tp} = Hg^{tp} \times 62.43 \times 10^{-12} \times 60 \times dscfm$	$E\text{-}Hg^{tp}$	lb/hr	5.8E-04	6.0E-04	4.9E-04
Oxidized Hg: $E\text{-}Hg^{O} = Hg_{KCl} \times 62.43 \times 10^{-12} \times 60 \times dscfm$	$E\text{-}Hg^{O}$	lb/hr	6.6E-05	1.2E-04	1.3E-04
Elemental Hg: $E\text{-}Hg^{E} = Hg_{H2O2} \times 62.43 \times 10^{-12} \times 60 \times dscfm$	$E\text{-}Hg^{E}$	lb/hr	8.5E-04	1.1E-03	9.7E-04
Total Hg: $E\text{-}Hg^{tot} = Hg_{(total)} \times 62.43 \times 10^{-12} \times 60 \times dscfm$	$E\text{-}Hg^{tot}$	lb/hr	1.5E-03	1.8E-03	1.6E-03
Estimated Annual Mercury Emissions					
$E\text{-}Hg^{tot} = 8{,}760$ hr/yr x $E\text{-}Hg^{tot}$	$E\text{-}Hg^{tot}$	lb/yr	13.1	16.0	14.0
PARTICULATE CONCENTRATION					
PM - Filterable $C_{sPM} = 15.432 \times M_{PM} / V_{mstd}$	C_{sPM}	gr/dscf	0.0055	0.0063	0.0059
PARTICULATE EMISSION RATE					
PM - Filterable $E_{dry}(lb/hr) = C_{sPM} \times Q_d \times 60 / 7000$	E_{dry}	lb/hr	7.7	8.7	8.0

Determination of Volumetric Airflow Rate, Gas Composition, Moisture Content, and Speciated Mercury Emissions
EPA Methods 2, 3, 4, 5, Ontario-Hydro
TEST 4
Indurating Furnace Stack D (SV017)
Longterm 1

Input Data	Symbol	Units	Run 1	Run 2	Run 3
Test Date	-	-	2/9/2017	2/9/2017	2/9/2017
Test Period	-	-	1001 - 1221	1545 - 1545	1810 - 1810
Number of Sample Ports	-	-	4	4	4
Number of Traverse Points	-	-	12	12	12
Duct Dimensions (diameter or Length x Width)	D, L X W	inches	104.00	104.00	104.00
Barometric Pressure	Pbar	in. Hg	28.40	28.40	28.40
Stack Static Pressure	Pg	in. H2O	-0.95	-0.95	-0.95
Average Stack Temperature, dry bulb	Tsf	degrees F	116	118	118
Actual Dry Gas Meter Volume	Vm	cubic feet	72.64	77.74	76.11
Dry Gas Meter Calibration Factor	Y	-	0.9950	0.9950	0.9950
Average Orifice Meter Pressure Drop	ΔH	in H2O	1.28	1.41	1.35
Average Meter Temperature	Tmf	degrees F	63.42	76.85	76.98
Pitot Tube Coefficient	Cp	-	0.84	0.84	0.84
Average Square Root of Velocity Head	(ΔP)^0.5	-	0.837	0.844	0.839
Mass of Water Vapor Collected in Impingers and Desiccant	Vwc	g	144	189	187
Orsat Results, Dry Basis					
Oxygen	%O2	%v/v	18.0	18.0	18.0
Carbon Dioxide	%CO2	%v/v	2.7	2.7	2.7
Carbon Monoxide + Nitrogen	-	%v/v	79.3	79.3	79.3
Nozzle Diameter	Dn	in	0.214	0.214	0.214
Run Time	theta	min	120	120	120
Ontario Hydro Mercury Results					
Probe Rinse (0.1 N HNO3)	Hg_{pr}	μg	0.108	0.127	0.094
Filter	Hg_{filter}	μg	3.135	3.340	2.700
Oxydized Mercury (KCl)	Hg_{KCl}	μg	0.340	0.293	0.493
Elemental Mercury (HNO3/H2O2)	Hg_{H2O2}	μg	< 0.013	< 0.013	0.016
Elemental Mercury (KMnO4)	Hg_{KMnO4}	μg	3.60	3.83	4.26
Total Mercury	$Hg_{(total)}$	μg	7.20	7.60	7.56
Particulate Loading (From Lab Results)					
PM - Filterable	M_{PM}	g	0.03039	0.03217	0.03073

Calculated Data	Symbol	Units	Run 1	Run 2	Run 3
Average Absolute Stack Temperature (R) Tsr = Tsf + 460	Tsr	degrees R	576	578	578
Stack Pressure Ps = Pbar + Pg / 13.6	Ps	in Hg	28.33	28.33	28.33
Duct Area $A = (D/24)^2 \times \pi$	A	Sq. ft	58.992	58.992	58.992
Meter Volume at Standard Conditions Vmstd = 17.64 x Vm x Y x ((Pbar +(ΔH/13.6))/Tmr)	Vmstd	cubic feet	69.41	72.44	70.90
Average Moisture Content of Stack Gas MC = ((0.04715*Vwc)/((0.04715*Vwc) + (Vmstd)) x 100	MC	% Vol	8.92	10.96	11.07
Molecular Weight of Stack Gas, dry Md = (0.44x(%CO2))+(0.32x(%O2))+(0.28x(%N2+%CO))	Md	lb/lbmol	29.15	29.15	29.15
Molecular Weight of Stack Gas, wet Ms = Md x (1-(MC/100))+18 x (MC/100)	Ms	lb/lbmol	28.16	27.93	27.92
Average Stack Gas Velocity Vs = 85.49 x Cp x (dP)^0.5 x ((Tsr/(Ps x Ms))^0.5)	Vs	ft/sec	51.08	51.79	51.54
Actual Volumetric Flowrate Qa = 60 x Vs x A	Qa	acfm	180,786	183,322	182,414
Volumetric Flowrate at Standard Conditions Qs = Qa x (528/(Ts+460)) x (Ps/29.92)	Qs	scfm	156,836	158,633	157,712
Dry Volumetric Flowrate at Standard Conditions Qd = Qa x (1-(MC/100)) x (528/Tsr) x (Ps/29.92)	Qd	dscfm	142,852	141,249	140,260
Nozzle Cross-Sectional Area An =(3.14 x Dn^2) /(4 x 144)	An	sq. ft	0.000250	0.000250	0.000250
Isokinetic Variation I = (0.0945xTsrxVmstd)/(PsxVsxAn x theta x(1-(MC/100)))	I	%	95.7	101.0	99.6
Mercury Concentrations					
Particulate Hg: $Hg^{tp} = (Hg_{pr} + Hg_{filter}) / (V_{mstd} / 35.314)$	Hg^{tp}	μg/dscm	1.650	1.690	1.391
Oxidized Hg: $Hg^{O} = Hg_{KCl} / (V_{mstd} / 35.314)$	Hg^{O}	μg/dscm	0.17	0.14	0.25
Elemental Hg: $Hg^{E} = (Hg_{H2O2} + Hg_{KMnO4}) / (V_{mstd} / 35.314)$	Hg^{E}	μg/dscm	1.8	1.9	2.1
Total Hg: $Hg^{tot} = Hg_{(total)} / (V_{mstd} / 35.314)$	Hg^{tot}	μg/dscm	3.7	3.7	3.8
Mercury Emission Rates					
Particulate Hg: $E\text{-}Hg^{tp} = Hg^{tp} \times 62.43 \times 10^{-12} \times 60 \times dscfm$	$E\text{-}Hg^{tp}$	lb/hr	8.8E-04	8.9E-04	7.3E-04
Oxidized Hg: $E\text{-}Hg^{O} = Hg_{KCl} \times 62.43 \times 10^{-12} \times 60 \times dscfm$	$E\text{-}Hg^{O}$	lb/hr	9.2E-05	7.5E-05	1.3E-04
Elemental Hg: $E\text{-}Hg^{E} = Hg_{H2O2} \times 62.43 \times 10^{-12} \times 60 \times dscfm$	$E\text{-}Hg^{E}$	lb/hr	9.8E-04	9.9E-04	1.1E-03
Total Hg: $E\text{-}Hg^{tot} = Hg_{(total)} \times 62.43 \times 10^{-12} \times 60 \times dscfm$	$E\text{-}Hg^{tot}$	lb/hr	2.0E-03	2.0E-03	2.0E-03
Estimated Annual Mercury Emissions					
$E\text{-}Hg^{tot}$ = 8,760 hr/yr x $E\text{-}Hg^{tot}$	$E\text{-}Hg^{tot}$	lb/yr	17.2	17.2	17.3
PARTICULATE CONCENTRATION					
PM - Filterable $C_{sPM} = 15.432 \times M_{PM} / V_{mstd}$	C_{sPM}	gr/dscf	0.0068	0.0069	0.0067
PARTICULATE EMISSION RATE					
PM - Filterable $E_{dry}(lb/hr) = C_{sPM} \times Q_d \times 60 / 7000$	E_{dry}	lb/hr	8.3	8.3	8.0

Determination of Volumetric Airflow Rate, Gas Composition, Moisture Content, and Speciated Mercury Emissions
EPA Methods 2, 3, 4, 5, Ontario-Hydro
TEST 1
Indurating Furnace Stack A (SV014)
Longterm 2

Input Data	Symbol	Units	Run 1	Run 2	Run 3
Test Date	-	-	3/28/2017	3/28/2017	3/28/2017
Test Period	-	-	804 - 1011	1250 - 1250	1526 - 1526
Number of Sample Ports	-	-	4	4	4
Number of Traverse Points	-	-	12	12	12
Duct Dimensions (diameter or Length x Width)	D, L X W	inches	101.75	101.75	101.75
Barometric Pressure	Pbar	in. Hg	28.47	28.47	28.47
Stack Static Pressure	Pg	in. H2O	-1.00	-1.00	-1.00
Average Stack Temperature, dry bulb	Tsf	degrees F	112	114	116
Actual Dry Gas Meter Volume	Vm	cubic feet	83.41	84.85	84.09
Dry Gas Meter Calibration Factor	Y	-	1.0113	1.0113	1.0113
Average Orifice Meter Pressure Drop	ΔH	in H2O	1.71	1.72	1.68
Average Meter Temperature	Tmf	degrees F	52.25	64.83	69.50
Pitot Tube Coefficient	Cp	-	0.84	0.84	0.84
Average Square Root of Velocity Head	(ΔP)^0.5	-	0.955	0.962	0.949
Mass of Water Vapor Collected in Impingers and Desiccant	Vwc	g	184	183	175
Orsat Results, Dry Basis					
Oxygen	%O2	%v/v	19.6	19.6	19.6
Carbon Dioxide	%CO2	%v/v	1.2	1.2	1.2
Carbon Monoxide + Nitrogen	-	%v/v	79.2	79.2	79.2
Nozzle Diameter	Dn	in	0.213	0.213	0.213
Run Time	theta	min	120	120	120
Ontario Hydro Mercury Results					
Probe Rinse (0.1 N HNO3)	Hg_{pr}	μg	0.037	< 0.010	< 0.010
Filter	Hg_{filter}	μg	0.723	0.412	0.511
Oxydized Mercury (KCl)	Hg_{KCl}	μg	0.855	0.879	0.995
Elemental Mercury (HNO3/H2O2)	Hg_{H2O2}	μg	0.014	0.013	0.017
Elemental Mercury (KMnO4)	Hg_{KMnO4}	μg	1.78	1.80	1.86
Total Mercury	$Hg_{(total)}$	μg	3.41	3.11	3.39
Particulate Loading (From Lab Results)					
PM - Filterable	M_{PM}	g	0.02311	0.02279	0.02581

Calculated Data	Symbol	Units	Run 1	Run 2	Run 3
Average Absolute Stack Temperature (R) Tsr = Tsf + 460	Tsr	degrees R	572	574	576
Stack Pressure Ps = Pbar + Pg / 13.6	Ps	in Hg	28.40	28.40	28.40
Duct Area $A = (D/24)^2 \times \pi$	A	Sq. ft	56.467	56.467	56.467
Meter Volume at Standard Conditions Vmstd = 17.64 x Vm x Y x ((Pbar +(ΔH/13.6))/Tmr)	Vmstd	cubic feet	83.06	82.48	81.01
Average Moisture Content of Stack Gas MC = ((0.04715*Vwc)/((0.04715*Vwc) + (Vmstd)) x 100	MC	% Vol	9.48	9.48	9.23
Molecular Weight of Stack Gas, dry Md = (0.44x(%CO2))+(0.32x(%O2))+(0.28x(%N2+%CO))	Md	lb/lbmol	28.98	28.98	28.98
Molecular Weight of Stack Gas, wet Ms = Md x (1-(MC/100))+18 x (MC/100)	Ms	lb/lbmol	27.94	27.94	27.96
Average Stack Gas Velocity Vs = 85.49 x Cp x (dP)^0.5 x ((Tsr/(Ps x Ms))^0.5)	Vs	ft/sec	58.27	58.75	58.03
Actual Volumetric Flowrate Qa = 60 x Vs x A	Qa	acfm	197,408	199,057	196,592
Volumetric Flowrate at Standard Conditions Qs = Qa x (528/(Ts+460)) x (Ps/29.92)	Qs	scfm	172,907	173,755	171,082
Dry Volumetric Flowrate at Standard Conditions Qd = Qa x (1-(MC/100)) x (528/Tsr) x (Ps/29.92)	Qd	dscfm	156,523	157,283	155,284
Nozzle Cross-Sectional Area An =(3.14 x Dn^2) /(4 x 144)	An	sq. ft	0.000247	0.000247	0.000247
Isokinetic Variation I = (0.0945xTsrxVmstd)/(PsxVsxAn x theta x(1-(MC/100)))	I	%	101.3	100.1	99.6
Mercury Concentrations					
Particulate Hg: $Hg^{tp} = (Hg_{pr} + Hg_{filter}) / (V_{mstd} / 35.314)$	Hg^{tp}	μg/dscm	0.323	0.180	0.227
Oxidized Hg: $Hg^{O} = Hg_{KCl} / (V_{mstd} / 35.314)$	Hg^{O}	μg/dscm	0.363	0.376	0.434
Elemental Hg: $Hg^{E} = (Hg_{H2O2} + Hg_{KMnO4}) / (V_{mstd} / 35.314)$	Hg^{E}	μg/dscm	0.762	0.774	0.818
Total Hg: $Hg^{tot} = Hg_{(total)} / (V_{mstd} / 35.314)$	Hg^{tot}	μg/dscm	1.449	1.331	1.479
Mercury Emission Rates					
Particulate Hg: $E\text{-}Hg^{tp} = Hg^{tp} \times 62.43\times10^{-12} \times 60 \times dscfm$	$E\text{-}Hg^{tp}$	lb/hr	1.89E-04	1.06E-04	1.32E-04
Oxidized Hg: $E\text{-}Hg^{O} = Hg_{KCl} \times 62.43\times10^{-12} \times 60 \times dscfm$	$E\text{-}Hg^{O}$	lb/hr	2.13E-04	2.22E-04	2.52E-04
Elemental Hg: $E\text{-}Hg^{E} = Hg_{H2O2} \times 62.43\times10^{-12} \times 60 \times dscfm$	$E\text{-}Hg^{E}$	lb/hr	4.47E-04	4.56E-04	4.76E-04
Total Hg: $E\text{-}Hg^{tot} = Hg_{(total)} \times 62.43\times10^{-12} \times 60 \times dscfm$	$E\text{-}Hg^{tot}$	lb/hr	8.49E-04	7.84E-04	8.60E-04
Estimated Annual Mercury Emissions					
$E\text{-}Hg^{tot} = 8{,}760\ hr/yr \times E\text{-}Hg^{tot}$	$E\text{-}Hg^{tot}$	lb/yr	7.4	6.9	7.5
PARTICULATE CONCENTRATION					
PM - Filterable $C_{sPM} = 15.432 \times M_{PM} / V_{mstd}$	C_{sPM}	gr/dscf	0.00429	0.00426	0.00492
PARTICULATE EMISSION RATE					
PM - Filterable $E_{dry}(lb/hr) = C_{sPM} \times Q_d \times 60 / 7000$	E_{dry}	lb/hr	5.76	5.75	6.54

Determination of Volumetric Airflow Rate, Gas Composition, Moisture Content, and Speciated Mercury Emissions

EPA Methods 2, 3, 4, 5, Ontario-Hydro
TEST 2
Indurating Furnace Stack B (SV015)
Longterm 2

Input Data	Symbol	Units	Run 1	Run 2	Run 3
Test Date	-	-	3/29/2017	3/29/2017	3/29/2017
Test Period	-	-	745 - 952	1234 - 1234	1512 - 1512
Number of Sample Ports	-	-	4	4	4
Number of Traverse Points	-	-	12	12	12
Duct Dimensions (diameter or Length x Width)	D, L X W	inches	101.75	101.75	101.75
Barometric Pressure	Pbar	in. Hg	28.63	28.63	28.63
Stack Static Pressure	Pg	in. H2O	-0.90	-0.90	-0.90
Average Stack Temperature, dry bulb	Tsf	degrees F	113	112	112
Actual Dry Gas Meter Volume	Vm	cubic feet	83.98	85.81	85.45
Dry Gas Meter Calibration Factor	Y	-	1.0113	1.0113	1.0113
Average Orifice Meter Pressure Drop	ΔH	in H2O	1.74	1.76	1.74
Average Meter Temperature	Tmf	degrees F	53.71	67.85	69.08
Pitot Tube Coefficient	Cp	-	0.84	0.84	0.84
Average Square Root of Velocity Head	(ΔP)^0.5	-	0.974	0.967	0.955
Mass of Water Vapor Collected in Impingers and Desiccant	Vwc	g	191	192	197
Orsat Results, Dry Basis					
Oxygen	%O2	%v/v	19.3	19.3	19.3
Carbon Dioxide	%CO2	%v/v	1.5	1.5	1.5
Carbon Monoxide + Nitrogen	-	%v/v	79.2	79.2	79.2
Nozzle Diameter	Dn	in	0.213	0.213	0.213
Run Time	theta	min	120	120	120
Ontario Hydro Mercury Results					
Probe Rinse (0.1 N HNO3)	Hg_{pr}	μg	< 0.010	< 0.010	0.015
Filter	Hg_{filter}	μg	1.10	0.744	0.897
Oxydized Mercury (KCl)	Hg_{KCl}	μg	0.547	0.600	0.579
Elemental Mercury (HNO3/H2O2)	Hg_{H2O2}	μg	0.021	0.018	0.023
Elemental Mercury (KMnO4)	Hg_{KMnO4}	μg	1.96	1.96	1.82
Total Mercury	$Hg_{(total)}$	μg	3.63	3.33	3.33
Particulate Loading (From Lab Results)					
PM - Filterable	M_{PM}	g	0.02322	0.02605	0.02669

Calculated Data	Symbol	Units	Run 1	Run 2	Run 3
Average Absolute Stack Temperature (R) Tsr = Tsf + 460	Tsr	degrees R	573	572	572
Stack Pressure Ps = Pbar + Pg / 13.6	Ps	in Hg	28.56	28.56	28.56
Duct Area $A = (D/24)^2 \times \pi$	A	Sq. ft	56.467	56.467	56.467
Meter Volume at Standard Conditions Vmstd = 17.64 x Vm x Y x ((Pbar +(ΔH/13.6))/Tmr)	Vmstd	cubic feet	83.87	83.40	82.86
Average Moisture Content of Stack Gas MC = ((0.04715*Vwc)/((0.04715*Vwc) + (Vmstd)) x 100	MC	% Vol	9.69	9.58 see note	9.54 see note
Molecular Weight of Stack Gas, dry Md = (0.44x(%CO2))+(0.32x(%O2))+(0.28x(%N2+%CO))	Md	lb/lbmol	29.01	29.01	29.01
Molecular Weight of Stack Gas, wet Ms = Md x (1-(MC/100))+18 x (MC/100)	Ms	lb/lbmol	27.95	27.96	27.96
Average Stack Gas Velocity Vs = 85.49 x Cp x (dP)^0.5 x ((Tsr/(Ps x Ms))^0.5)	Vs	ft/sec	59.25	58.74	58.00
Actual Volumetric Flowrate Qa = 60 x Vs x A	Qa	acfm	200,752	199,009	196,508
Volumetric Flowrate at Standard Conditions Qs = Qa x (528/(Ts+460)) x (Ps/29.92)	Qs	scfm	176,576	175,387	173,221
Dry Volumetric Flowrate at Standard Conditions Qd = Qa x (1-(MC/100)) x (528/Tsr) x (Ps/29.92)	Qd	dscfm	159,470	158,586	156,687
Nozzle Cross-Sectional Area An =(3.14 x Dn^2) /(4 x 144)	An	sq. ft	0.000248	0.000248	0.000248
Isokinetic Variation I = (0.0945xTsrxVmstd)/(PsxVsxAn x theta x(1-(MC/100)))	I	%	99.8	99.8	100.3
Mercury Concentrations					
Particulate Hg: $Hg^{tp} = (Hg_{pr} + Hg_{filter}) / (V_{mstd} / 35.314)$	Hg^{tp}	μg/dscm	0.467	0.319	0.388
Oxidized Hg: $Hg^{O} = Hg_{KCl} / (V_{mstd} / 35.314)$	Hg^{O}	μg/dscm	0.230	0.254	0.247
Elemental Hg: $Hg^{E} = (Hg_{H2O2} + Hg_{KMnO4}) / (V_{mstd} / 35.314)$	Hg^{E}	μg/dscm	0.832	0.838	0.785
Total Hg: $Hg^{tot} = Hg_{(total)} / (V_{mstd} / 35.314)$	Hg^{tot}	μg/dscm	1.530	1.411	1.421
Mercury Emission Rates					
Particulate Hg: $E\text{-}Hg^{tp} = Hg^{tp} \times 62.43 \times 10^{-12} \times 60 \times$ dscfm	$E\text{-}Hg^{tp}$	lb/hr	2.79E-04	1.90E-04	2.28E-04
Oxidized Hg: $E\text{-}Hg^{O} = Hg_{KCl} \times 62.43 \times 10^{-12} \times 60 \times$ dscfm	$E\text{-}Hg^{O}$	lb/hr	1.38E-04	1.51E-04	1.45E-04
Elemental Hg: $E\text{-}Hg^{E} = Hg_{H2O2} \times 62.43 \times 10^{-12} \times 60 \times$ dscfm	$E\text{-}Hg^{E}$	lb/hr	4.97E-04	4.98E-04	4.61E-04
Total Hg: $E\text{-}Hg^{tot} = Hg_{(total)} \times 62.43 \times 10^{-12} \times 60 \times$ dscfm	$E\text{-}Hg^{tot}$	lb/hr	9.14E-04	8.38E-04	8.34E-04
Estimated Annual Mercury Emissions					
$E\text{-}Hg^{tot}$ = 8,760 hr/yr x $E\text{-}Hg^{tot}$	$E\text{-}Hg^{tot}$	lb/yr	8.0	7.3	7.3
PARTICULATE CONCENTRATION					
PM - Filterable $C_{sPM} = 15.432 \times M_{PM} / V_{mstd}$	C_{sPM}	gr/dscf	0.00427	0.00482	0.00497
PARTICULATE EMISSION RATE					
PM - Filterable E_{dry}(lb/hr) = $C_{sPM} \times Q_d \times 60 / 7000$	E_{dry}	lb/hr	5.84	6.55	6.68

Note: Moisture Content limited to moisture at saturation

Determination of Volumetric Airflow Rate, Gas Composition, Moisture Content, and Speciated Mercury Emissions
EPA Methods 2, 3 4, 5, Ontario-Hydro
TEST 3
Indurating Furnace Stack C (SV016)
Longterm 2

Input Data	Symbol	Units	Run 1	Run 2	Run 3
Test Date	-	-	3/28/2017	3/28/2017	3/28/2017
Test Period	-	-	804 - 0	1250 - 1250	1526 - 1526
Number of Sample Ports	-	-	4	4	4
Number of Traverse Points	-	-	12	12	12
Duct Dimensions (diameter or Length x Width)	D, L X W	inches	104.00	104.00	104.00
Barometric Pressure	Pbar	in. Hg	28.47	28.47	28.47
Stack Static Pressure	Pg	in. H2O	-0.85	-0.85	-0.85
Average Stack Temperature, dry bulb	Tsf	degrees F	118	117	119
Actual Dry Gas Meter Volume	Vm	cubic feet	78.39	79.10	77.00
Dry Gas Meter Calibration Factor	Y	-	1.0044	1.0044	1.0044
Average Orifice Meter Pressure Drop	ΔH	in H2O	1.47	1.47	1.38
Average Meter Temperature	Tmf	degrees F	51.60	63.25	67.08
Pitot Tube Coefficient	Cp	-	0.84	0.84	0.84
Average Square Root of Velocity Head	(ΔP)^0.5	-	0.933	0.936	0.903
Mass of Water Vapor Collected in Impingers and Desiccant	Vwc	g	212	207	206
Orsat Results, Dry Basis					
Oxygen	%O2	%v/v	18.5	18.5	18.5
Carbon Dioxide	%CO2	%v/v	2.2	2.2	2.2
Carbon Monoxide + Nitrogen	-	%v/v	79.3	79.3	79.3
Nozzle Diameter	Dn	in	0.210	0.210	0.210
Run Time	theta	min	120	120	120
Ontario Hydro Mercury Results					
Probe Rinse (0.1 N HNO3)	Hg_{pr}	μg	0.013	0.049	< 0.100
Filter	Hg_{filter}	μg	2.100	1.825	1.265
Oxydized Mercury (KCl)	Hg_{KCl}	μg	0.173	0.282	0.377
Elemental Mercury (HNO3/H2O2)	Hg_{H2O2}	μg	< 0.013	0.014	0.023
Elemental Mercury (KMnO4)	Hg_{KMnO4}	μg	2.11	2.18	2.47
Total Mercury	$Hg_{(total)}$	μg	4.40	4.34	4.24
Particulate Loading (From Lab Results)					
PM - Filterable	M_{PM}	g	0.02926	0.02911	0.02403

Calculated Data	Symbol	Units	Run 1	Run 2	Run 3
Average Absolute Stack Temperature (R) Tsr = Tsf + 460	Tsr	degrees R	578	577	579
Stack Pressure Ps = Pbar + Pg / 13.6	Ps	in Hg	28.41	28.41	28.41
Duct Area $A = (D/24)^2 \times \pi$	A	Sq. ft	58.992	58.992	58.992
Meter Volume at Standard Conditions Vmstd = 17.64 x Vm x Y x ((Pbar +(ΔH/13.6))/Tmr)	Vmstd	cubic feet	77.58	76.54	73.95
Average Moisture Content of Stack Gas MC = ((0.04715*Vwc)/((0.04715*Vwc) + (Vmstd)) x 100	MC	% Vol	11.30 see note	11.13 see note	11.59
Molecular Weight of Stack Gas, dry Md = (0.44x(%CO2))+(0.32x(%O2))+(0.28x(%N2+%CO))	Md	lb/lbmol	29.09	29.09	29.09
Molecular Weight of Stack Gas, wet Ms = Md x (1-(MC/100))+18 x (MC/100)	Ms	lb/lbmol	27.84	27.86	27.81
Average Stack Gas Velocity Vs = 85.49 x Cp x (dP)^0.5 x ((Tsr/(Ps x Ms))^0.5)	Vs	ft/sec	57.26	57.39	55.51
Actual Volumetric Flowrate Qa = 60 x Vs x A	Qa	acfm	202,690	203,119	196,486
Volumetric Flowrate at Standard Conditions Qs = Qa x (528/(Ts+460)) x (Ps/29.92)	Qs	scfm	175,923	176,461	170,219
Dry Volumetric Flowrate at Standard Conditions Qd = Qa x (1-(MC/100)) x (528/Tsr) x (Ps/29.92)	Qd	dscfm	156,050	156,828	150,492
Nozzle Cross-Sectional Area An =(3.14 x Dn^2) /(4 x 144)	An	sq. ft	0.000240	0.000240	0.000240
Isokinetic Variation I = (0.0945xTsrxVmstd)/(PsxVsxAn x theta x(1-(MC/100)))	I	%	101.7	99.8	100.5
Mercury Concentrations					
Particulate Hg: $Hg^{tp} = (Hg_{pr} + Hg_{filter}) / (V_{mstd} / 35.314)$	Hg^{tp}	μg/dscm	0.962	0.864	0.652
Oxidized Hg: $Hg^{O} = Hg_{KCl} / (V_{mstd} / 35.314)$	Hg^{O}	μg/dscm	0.079	0.130	0.180
Elemental Hg: $Hg^{E} = (Hg_{H2O2} + Hg_{KMnO4}) / (V_{mstd} / 35.314)$	Hg^{E}	μg/dscm	0.964	1.010	1.190
Total Hg: $Hg^{tot} = Hg_{(total)} / (V_{mstd} / 35.314)$	Hg^{tot}	μg/dscm	2.004	2.004	2.022
Mercury Emission Rates					
Particulate Hg: $E\text{-}Hg^{tp} = Hg^{tp} \times 62.43\text{x}10^{-12} \times 60 \times \text{dscfm}$	$E\text{-}Hg^{tp}$	lb/hr	5.62E-04	5.08E-04	3.67E-04
Oxidized Hg: $E\text{-}Hg^{O} = Hg_{KCl} \times 62.43\text{x}10^{-12} \times 60 \times \text{dscfm}$	$E\text{-}Hg^{O}$	lb/hr	4.60E-05	7.64E-05	1.01E-04
Elemental Hg: $E\text{-}Hg^{E} = Hg_{H2O2} \times 62.43\text{x}10^{-12} \times 60 \times \text{dscfm}$	$E\text{-}Hg^{E}$	lb/hr	5.64E-04	5.93E-04	6.71E-04
Total Hg: $E\text{-}Hg^{tot} = Hg_{(total)} \times 62.43\text{x}10^{-12} \times 60 \times \text{dscfm}$	$E\text{-}Hg^{tot}$	lb/hr	1.17E-03	1.18E-03	1.14E-03
Estimated Annual Mercury Emissions					
$E\text{-}Hg^{tot} = 8{,}760 \text{ hr/yr} \times E\text{-}Hg^{tot}$	$E\text{-}Hg^{tot}$	lb/yr	10.3	10.3	10.0
PARTICULATE CONCENTRATION					
PM - Filterable $C_{sPM} = 15.432 \times M_{PM} / V_{mstd}$	C_{sPM}	gr/dscf	0.00582	0.00587	0.00501
PARTICULATE EMISSION RATE					
PM - Filterable $E_{dry}(\text{lb/hr}) = C_{sPM} \times Q_d \times 60 / 7000$	E_{dry}	lb/hr	7.78	7.89	6.47

Note: Moisture Content limited to moisture at saturation

Determination of Volumetric Airflow Rate, Gas Composition, Moisture Content, and Speciated Mercury Emissions
EPA Methods 2, 3, 4, 5, Ontario-Hydro
TEST 4
Indurating Furnace Stack D (SV017)
Longterm 2

Input Data	Symbol	Units	Run 1	Run 2	Run 3
Test Date	-	-	3/29/2017	3/29/2017	3/29/2017
Test Period	-	-	745 - 952	1234 - 1234	1512 - 1512
Number of Sample Ports	-	-	4	4	4
Number of Traverse Points	-	-	12	12	12
Duct Dimensions (diameter or Length x Width)	D, L X W	inches	104.00	104.00	104.00
Barometric Pressure	Pbar	in. Hg	28.63	28.63	28.63
Stack Static Pressure	Pg	in. H2O	-0.95	-0.95	-0.95
Average Stack Temperature, dry bulb	Tsf	degrees F	123	123	123
Actual Dry Gas Meter Volume	Vm	cubic feet	67.80	70.45	68.24
Dry Gas Meter Calibration Factor	Y	-	1.0044	1.0044	1.0044
Average Orifice Meter Pressure Drop	ΔH	in H2O	1.11	1.14	1.08
Average Meter Temperature	Tmf	degrees F	52.54	71.10	72.08
Pitot Tube Coefficient	Cp	-	0.84	0.84	0.84
Average Square Root of Velocity Head	(ΔP)^0.5	-	0.832	0.827	0.809
Mass of Water Vapor Collected in Impingers and Desiccant	Vwc	g	198	199	197
Orsat Results, Dry Basis					
Oxygen	%O2	%v/v	18.0	18.0	18.0
Carbon Dioxide	%CO2	%v/v	2.7	2.7	2.7
Carbon Monoxide + Nitrogen	-	%v/v	79.3	79.3	79.3
Nozzle Diameter	Dn	in	0.210	0.210	0.210
Run Time	theta	min	120	120	120
Ontario Hydro Mercury Results					
Probe Rinse (0.1 N HNO3)	Hg_{pr}	μg	0.038	< 0.010	< 0.010
Filter	Hg_{filter}	μg	1.520	1.590	1.615
Oxydized Mercury (KCl)	Hg_{KCl}	μg	0.160	0.142	0.148
Elemental Mercury (HNO3/H2O2)	Hg_{H2O2}	μg	0.021	0.025	0.019
Elemental Mercury (KMnO4)	Hg_{KMnO4}	μg	2.39	2.03	2.11
Total Mercury	$Hg_{(total)}$	μg	4.12	3.80	3.90
Particulate Loading (From Lab Results)					
PM - Filterable	M_{PM}	g	0.02882	0.02610	0.02784

Calculated Data	Symbol	Units	Run 1	Run 2	Run 3
Average Absolute Stack Temperature (R) Tsr = Tsf + 460	Tsr	degrees R	583	583	583
Stack Pressure Ps = Pbar + Pg / 13.6	Ps	in Hg	28.56	28.56	28.56
Duct Area $A = (D/24)^2 \times \pi$	A	Sq. ft	58.992	58.992	58.992
Meter Volume at Standard Conditions Vmstd = 17.64 x Vm x Y x ((Pbar +(ΔH/13.6))/Tmr)	Vmstd	cubic feet	67.29	67.48	65.24
Average Moisture Content of Stack Gas MC = ((0.04715*Vwc)/((0.04715*Vwc) + (Vmstd)) x 100	MC	% Vol	12.19	12.20	12.47
Molecular Weight of Stack Gas, dry Md = (0.44x(%CO2))+(0.32x(%O2))+(0.28x(%N2+%CO))	Md	lb/lbmol	29.15	29.15	29.15
Molecular Weight of Stack Gas, wet Ms = Md x (1-(MC/100))+18 x (MC/100)	Ms	lb/lbmol	27.79	27.79	27.76
Average Stack Gas Velocity Vs = 85.49 x Cp x (dP)^0.5 x ((Tsr/(Ps x Ms))^0.5)	Vs	ft/sec	51.25	50.91	49.82
Actual Volumetric Flowrate Qa = 60 x Vs x A	Qa	acfm	181,385	180,203	176,336
Volumetric Flowrate at Standard Conditions Qs = Qa x (528/(Ts+460)) x (Ps/29.92)	Qs	scfm	156,718	155,807	152,387
Dry Volumetric Flowrate at Standard Conditions Qd = Qa x (1-(MC/100)) x (528/Tsr) x (Ps/29.92)	Qd	dscfm	137,608	136,805	133,377
Nozzle Cross-Sectional Area An =(3.14 x Dn^2) /(4 x 144)	An	sq. ft	0.000240	0.000240	0.000240
Isokinetic Variation I = (0.0945xTsrxVmstd)/(PsxVsxAn x theta x(1-(MC/100)))	I	%	100.0	100.9	100.0
Mercury Concentrations					
Particulate Hg: $Hg^{tp} = (Hg_{pr} + Hg_{filter}) / (V_{mstd} / 35.314)$	Hg^{tp}	μg/dscm	0.817	0.837	0.880
Oxidized Hg: $Hg^{O} = Hg_{KCl} / (V_{mstd} / 35.314)$	Hg^{O}	μg/dscm	0.084	0.074	0.080
Elemental Hg: $Hg^{E} = (Hg_{H2O2} + Hg_{KMnO4}) / (V_{mstd} / 35.314)$	Hg^{E}	μg/dscm	1.262	1.075	1.152
Total Hg: $Hg^{tot} = Hg_{(total)} / (V_{mstd} / 35.314)$	Hg^{tot}	μg/dscm	2.164	1.987	2.112
Mercury Emission Rates					
Particulate Hg: $E\text{-}Hg^{tp} = Hg^{tp} \times 62.43 \times 10^{-12} \times 60 \times$ dscfm	$E\text{-}Hg^{tp}$	lb/hr	4.21E-04	4.29E-04	4.39E-04
Oxidized Hg: $E\text{-}Hg^{O} = Hg_{KCl} \times 62.43 \times 10^{-12} \times 60 \times$ dscfm	$E\text{-}Hg^{O}$	lb/hr	4.33E-05	3.81E-05	4.00E-05
Elemental Hg: $E\text{-}Hg^{E} = Hg_{H2O2} \times 62.43 \times 10^{-12} \times 60 \times$ dscfm	$E\text{-}Hg^{E}$	lb/hr	6.51E-04	5.51E-04	5.76E-04
Total Hg: $E\text{-}Hg^{tot} = Hg_{(total)} \times 62.43 \times 10^{-12} \times 60 \times$ dscfm	$E\text{-}Hg^{tot}$	lb/hr	1.12E-03	1.02E-03	1.06E-03
Estimated Annual Mercury Emissions					
$E\text{-}Hg^{tot} = 8{,}760$ hr/yr x $E\text{-}Hg^{tot}$	$E\text{-}Hg^{tot}$	lb/yr	9.8	8.9	9.2
PARTICULATE CONCENTRATION					
PM - Filterable $C_{sPM} = 15.432 \times M_{PM} / V_{mstd}$	C_{sPM}	gr/dscf	0.00661	0.00597	0.00659
PARTICULATE EMISSION RATE					
PM - Filterable E_{dry}(lb/hr) = $C_{sPM} \times Q_d \times 60 / 7000$	E_{dry}	lb/hr	7.80	7.00	7.53

Indurating Furnace Stack A (SV014)
Determination of Volumetric Airflow Rate, Gas Composition and Moisture Content
Baseline 2

Data Entry	Symbol	Units	Run 1	Run 2	Run 3
Test Date	-	-	4/11/2017	4/11/2017	4/11/2017
Test Period	-	-	830-930	1000-1100	1200-1300
Number of Sample Ports	-	-	4	4	4
Number of Traverse Points	-	-	12	12	12
Duct Dimensions (diameter for circular duct)	D	inches	101.75	101.75	101.75
Barometric Pressure	Pbar	in. Hg	28.40	28.40	28.40
Stack Static Pressure	Pg	in. H_2O	-0.90	-0.90	-0.90
Stack Temperature, dry bulb	Tsf	degrees F	110	111	110
Pitot Tube Coefficient	Cp	-	0.84	0.84	0.84
Average Square Root of Velocity Head	(ΔP)^0.5	-	0.948	0.953	0.944
Orsat Results, Dry Basis (EPA Method 3A)					
Carbon Dioxide	%CO_2	%v/v	1.0	1.0	1.0
Oxygen	%O_2	%v/v	19.4	19.4	19.4
Carbon Monoxide + Nitrogen	-	%v/v	79.6	79.6	79.6
Calculated Data	Symbol	Units	Run 1	Run 2	Run 3
Duct Area A = (D/24)^2 x PI (Circular Duct)	A	sq ft	56.47	56.47	56.47
Stack Pressure Ps = Pbar + Pg/13.6	Ps	in Hg	28.33	28.33	28.33
Average Moisture Content of Stack Gas	MC	% Vol	8.5	9.3	7.6
Molecular Weight of Stack Gas, dry Md = (0.44 x (%CO_2))+(0.32 x (%O_2))+(0.28 x (%N_2+%CO))	Md	lb/lbmol	28.94	28.94	28.94
Molecular Weight of Stack Gas, wet Ms = Md x (1-(MC/100))+18 x (MC/100)	Ms	lb/lbmol	28.00	27.92	28.11
Average Stack Gas Velocity Vs = 85.49 x Cp x (ΔP)^0.5 x ((Ts/Ps x Ms)^0.5)	Vs	ft/sec	57.70	58.14	57.39
Actual Volumetric Flowrate Qa = 60 x Vs x A	Qa	acfm	195,500	197,000	194,400
Volumetric Flowrate at Standard Conditions Qs = Qa x (528/(Ts+460)) x (Ps/29.92)	Qs	scfm	171,500	172,700	170,500
Dry Volumetric Flowrate at Standard Conditions Qd = Qa x (1-(MC/100)) x (528/(Ts+460)) x (Ps/29.92)	Qd	dscfm	156,900	156,700	157,600

Indurating Furnace Stack B (SV015)
Determination of Volumetric Airflow Rate, Gas Composition and Moisture Content
Baseline 2

Data Entry	Symbol	Units	Run 1	Run 2	Run 3
Test Date	-	-	4/12/2017	4/12/2017	4/12/2017
Test Period	-	-	736-836	906-1006	1030-1130
Number of Sample Ports	-	-	4	4	4
Number of Traverse Points	-	-	12	12	12
Duct Dimensions (diameter for circular duct)	D	inches	101.75	101.75	101.75
Barometric Pressure	Pbar	in. Hg	28.43	28.43	28.43
Stack Static Pressure	Pg	in. H_2O	-0.75	-0.75	-0.75
Stack Temperature, dry bulb	Tsf	degrees F	111	112	113
Pitot Tube Coefficient	Cp	-	0.84	0.84	0.84
Average Square Root of Velocity Head	(ΔP)^0.5	-	0.991	0.990	0.995
Orsat Results, Dry Basis (EPA Method 3A)					
Carbon Dioxide	$\%CO_2$	%v/v	0.9	0.9	0.9
Oxygen	$\%O_2$	%v/v	19.3	19.3	19.3
Carbon Monoxide + Nitrogen	-	%v/v	79.8	79.8	79.8
Calculated Data	Symbol	Units	Run 1	Run 2	Run 3
Duct Area A = (D/24)^2 x PI (Circular Duct)	A	sq ft	56.47	56.47	56.47
Stack Pressure Ps = Pbar + Pg/13.6	Ps	in Hg	28.37	28.37	28.37
Average Moisture Content of Stack Gas	MC	% Vol	9.4 *	7.5	10.0 *
Molecular Weight of Stack Gas, dry Md = (0.44 x ($\%CO_2$))+(0.32 x ($\%O_2$))+(0.28 x ($\%N_2$+%CO))	Md	lb/lbmol	28.92	28.92	28.92
Molecular Weight of Stack Gas, wet Ms = Md x (1-(MC/100))+18 x (MC/100)	Ms	lb/lbmol	27.88	28.09	27.82
Average Stack Gas Velocity Vs = 85.49 x Cp x (ΔP)^0.5 x ((Ts/Ps x Ms)^0.5)	Vs	ft/sec	60.45	60.24	60.88
Actual Volumetric Flowrate Qa = 60 x Vs x A	Qa	acfm	204,800	204,100	206,300
Volumetric Flowrate at Standard Conditions Qs = Qa x (528/(Ts+460)) x (Ps/29.92)	Qs	scfm	179,500	178,700	180,200
Dry Volumetric Flowrate at Standard Conditions Qd = Qa x (1-(MC/100)) x (528/(Ts+460)) x (Ps/29.92)	Qd	dscfm	162,600	165,200	162,200

Indurating Furnace Stack C (SV016)
Determination of Volumetric Airflow Rate, Gas Composition and Moisture Content
Baseline 2

Data Entry	Symbol	Units	Run 1	Run 2	Run 3
Test Date	-	-	4/11/2017	4/11/2017	4/11/2017
Test Period	-	-	830-930	1000-1100	1200-1300
Number of Sample Ports	-	-	4	4	4
Number of Traverse Points	-	-	12	12	12
Duct Dimensions (diameter for circular duct)	D	inches	104	104	104
Barometric Pressure	Pbar	in. Hg	28.40	28.40	28.40
Stack Static Pressure	Pg	in. H_2O	-0.80	-0.80	-0.80
Stack Temperature, dry bulb	Tsf	degrees F	122	122	122
Pitot Tube Coefficient	Cp	-	0.84	0.84	0.84
Average Square Root of Velocity Head	(ΔP)^0.5	-	0.946	0.932	0.941
Orsat Results, Dry Basis (EPA Method 3A)					
Carbon Dioxide	$\%CO_2$	%v/v	0.8	0.8	0.8
Oxygen	$\%O_2$	%v/v	19.7	19.7	19.7
Carbon Monoxide + Nitrogen	-	%v/v	79.5	79.5	79.5
Calculated Data	**Symbol**	**Units**	**Run 1**	**Run 2**	**Run 3**
Duct Area A = (D/24)^2 x PI (Circular Duct)	A	sq ft	58.99	58.99	58.99
Stack Pressure Ps = Pbar + Pg/13.6	Ps	in Hg	28.34	28.34	28.34
Average Moisture Content of Stack Gas	MC	% Vol	9.2	11.5	12.9 *
Molecular Weight of Stack Gas, dry Md = (0.44 x ($\%CO_2$))+(0.32 x ($\%O_2$))+(0.28 x ($\%N_2$+%CO))	Md	lb/lbmol	28.92	28.92	28.92
Molecular Weight of Stack Gas, wet Ms = Md x (1-(MC/100))+18 x (MC/100)	Ms	lb/lbmol	27.91	27.66	27.51
Average Stack Gas Velocity Vs = 85.49 x Cp x (ΔP)^0.5 x ((Ts/Ps x Ms)^0.5)	Vs	ft/sec	58.27	57.65	58.41
Actual Volumetric Flowrate Qa = 60 x Vs x A	Qa	acfm	206,200	204,100	206,800
Volumetric Flowrate at Standard Conditions Qs = Qa x (528/(Ts+460)) x (Ps/29.92)	Qs	scfm	177,200	175,500	177,600
Dry Volumetric Flowrate at Standard Conditions Qd = Qa x (1-(MC/100)) x (528/(Ts+460)) x (Ps/29.92)	Qd	dscfm	160,800	155,300	154,700

Indurating Furnace Stack D (SV017)
Determination of Volumetric Airflow Rate, Gas Composition and Moisture Content
Baseline 2

Data Entry	Symbol	Units	Run 1	Run 2	Run 3
Test Date	-	-	4/12/2017	4/12/2017	4/12/2017
Test Period	-	-	736-836	906-1006	1030-1130
Number of Sample Ports	-	-	4	4	4
Number of Traverse Points	-	-	12	12	12
Duct Dimensions (diameter for circular duct)	D	inches	104	104	104
Barometric Pressure	Pbar	in. Hg	28.43	28.43	28.43
Stack Static Pressure	Pg	in. H_2O	-0.90	-0.90	-0.90
Stack Temperature, dry bulb	Tsf	degrees F	126	126	126
Pitot Tube Coefficient	Cp	-	0.84	0.84	0.84
Average Square Root of Velocity Head	(ΔP)^0.5	-	0.821	0.823	0.829
Orsat Results, Dry Basis (EPA Method 3A)					
Carbon Dioxide	$\%CO_2$	%v/v	2.2	2.2	2.2
Oxygen	$\%O_2$	%v/v	17.9	17.9	17.9
Carbon Monoxide + Nitrogen	-	%v/v	79.9	79.9	79.9
Calculated Data	Symbol	Units	Run 1	Run 2	Run 3
Duct Area A = (D/24)^2 x PI (Circular Duct)	A	sq ft	58.99	58.99	58.99
Stack Pressure Ps = Pbar + Pg/13.6	Ps	in Hg	28.36	28.36	28.36
Average Moisture Content of Stack Gas	MC	% Vol	11.6	12.1	12.3
Molecular Weight of Stack Gas, dry Md = (0.44 x ($\%CO_2$))+(0.32 x ($\%O_2$))+(0.28 x ($\%N_2$+%CO))	Md	lb/lbmol	29.07	29.07	29.07
Molecular Weight of Stack Gas, wet Ms = Md x (1-(MC/100))+18 x (MC/100)	Ms	lb/lbmol	27.79	27.72	27.70
Average Stack Gas Velocity Vs = 85.49 x Cp x (ΔP)^0.5 x ((Ts/Ps x Ms)^0.5)	Vs	ft/sec	50.86	51.01	51.41
Actual Volumetric Flowrate Qa = 60 x Vs x A	Qa	acfm	180,000	180,600	182,000
Volumetric Flowrate at Standard Conditions Qs = Qa x (528/(Ts+460)) x (Ps/29.92)	Qs	scfm	153,700	154,300	155,500
Dry Volumetric Flowrate at Standard Conditions Qd = Qa x (1-(MC/100)) x (528/(Ts+460)) x (Ps/29.92)	Qd	dscfm	135,900	135,500	136,300

EPA Method 30B Calculation Summary
Determination of Total Vapor Phase Mercury Emissions

Indurating Furnace Stack A (SV014)
Baseline 2

Data Entry	Symbol	Units	Run 1	Run 2	Run 3	Test Average
Test Date	-	-	4/11/2017	4/11/2017	4/11/2017	---
Test Period	-	-	830-930	1000-1100	1200-1300	---
Barometric Pressure	P_{bar}	in. Hg	28.60	28.60	28.60	28.60
Dry Volumetric Flowrate at Standard Conditions (EPA Method 2)	Q_d	dscfm	156,900	156,700	157,600	157,067

Trap A Results

	Symbol	Units	Run 1	Run 2	Run 3	Test Average
Actual Dry Gas Meter Volume	V_{mA}	liters	36.084	35.316	34.362	35.254
Dry Gas Meter Calibration Factor	Y_A	-	1.0176	1.0176	1.0176	1.0176
Average Meter Temperature	T_{mfA}	degrees F	67	72	76	72
Average Absolute Meter Temperature (R) $T_{mrA} = T_{mfA} + 460$	T_{mrA}	degrees R	527	532	536	532
Meter Volume at Standard Conditions $V_{mstd\ A} = 17.64 \times (V_{mA} \times 0.03531) \times Y_A \times P_{bar} / T_{mrA}$	$V_{mstd\ A}$	cubic feet	1.241	1.203	1.162	1.202
Laboratory Results						
Trap ID	---	---	OLC043081	OLC043452	OLC043076	---
Mercury Sorbent Trap, Section 1	$M_{1\ A}$	ng	39.4	33.6	42.3	38.4
Mercury Sorbent Trap, Section 2	$M_{2\ A}$	ng	4.40	3.30	4.70	4.13
Mercury, Total amount collected	M_A	ng	43.8	36.9	47.0	42.6
Amount of Mercury in spiked traps-from laboratory	$M_{spike\ A}$	ng	0	0	0	---
Mercury Stack Concentration $C_{(\mu g)A} = (M_A - M_{spikeA}) / 1000 / V_{mstdA} \times 0.0283168$	$C_{(\mu g)A}$	μg/dscm	1.246	1.083	1.428	1.252
Mercury Emission Rate $E_{(lb/hr)A} = (M_A - M_{spike\ A}) \times (2.2046\times10^{-12}\ (lb/ng)) \times Qd\ x60 / V_{mstd\ A}$	$E_{(lb/hr)A}$	lb/hr	0.00073	0.00064	0.00084	0.00074
Mercury Emission Rate $E_{(lb/yr)A} = E_{(lb/hr)A} \times 8760$ hr/yr	$E_{(lb/yr)A}$	lb/yr	6.4	5.6	7.4	6.5

Trap B Results

	Symbol	Units	Run 1	Run 2	Run 3	Test Average
Actual Dry Gas Meter Volume	V_{mB}	liters	32.380	30.808	29.999	31.062
Dry Gas Meter Calibration Factor	Y_B	-	0.9857	0.9857	0.9857	0.9857
Average Meter Temperature	T_{mfB}	degrees F	67	72	76	72
Average Absolute Meter Temperature (R) $T_{mrB} = T_{mfB} + 460$	T_{mrB}	degrees R	527	532	536	532
Meter Volume at Standard Conditions $V_{mstd\ B} = 17.64 \times (V_{mB} \times 0.03531) \times Y \times P_{bar} / T_{mrB}$	$V_{mstd\ B}$	cubic feet	1.078	1.016	0.982	1.025
Laboratory Results						
Trap ID	---	---	OL411154	OL411134	OL411192	---
Mercury Sorbent Trap, Section 1	$M_{1\ B}$	ng	83.5	79.8	83.0	82
Mercury Sorbent Trap, Section 2	$M_{2\ B}$	ng	4.50	2.60	4.40	3.83
Mercury, Total amount collected	M_B	ng	88.0	82.4	87.4	85.9
Amount of Mercury in spiked traps-from laboratory	$M_{spike\ B}$	ng	50	50	50	---
Mercury Stack Concentration $C_{(\mu g)B} = (M_B - M_{spikeB}) / 1000 / V_{mstdB} \times 0.0283168$	$C_{(\mu g)B}$	μg/dscm	1.245	1.126	1.345	1.239
Mercury Emission Rate $E_{(lb/hr)B} = (M_B - M_{spike\ B}) \times (2.2046\times10^{-12}\ (lb/ng)) \times Qd\ x60 / V_{mstd\ B}$	$E_{(lb/hr)B}$	lb/hr	0.00073	0.00066	0.00079	0.00073
Mercury Emission Rate $E_{(lb/yr)B} = E_{(lb/hr)B} \times 8760$ hr/yr	$E_{(lb/yr)B}$	lb/yr	6.4	5.8	7.0	6.4

EPA Method 30B QA/QC Data

	Symbol	Units	Run 1	Run 2	Run 3	Test Average
A Train Breakthrough -- each run <10% $B_A = M_{2\ A} / M_{1\ A} \times 100$	B_A	%	11.2	9.8	11.1	10.7
B Train Breakthrough -- each run <10% $B_B = M_{2\ B} / M_{1\ B} \times 100$	B_B	%	5.4	3.3	5.3	4.6
Sample volume agreement -- each run +/- 20% $SV = 100 - ((V_{mstd\ A} / V_{mstd\ B}) \times 100)$	SV	%	-15.1	-18.4	-18.3	-17.3
Field Recovery Test -- 3 run avg 85%< R >115% $R = (M_A / V_{mstd\ A} - M_B / V_{mstd\ B}) \times V_{mstd\ A} / M_{spike\ A} \times 100$	R	%	99.9	102.5	95.4	99.3
Paired Trap Agreement -- each run <10% $RD = ((C_{\mu gA} - C_{\mu gB}) / (C_{\mu gA} + C_{\mu gB}))\ X\ 100$	RD	%	0.1	1.9	3.0	1.7

EPA Method 30B Calculation Summary
Determination of Total Vapor Phase Mercury Emissions

Indurating Furnace Stack B (SV015)
Baseline 2

Data Entry	Symbol	Units	Run 1	Run 2	Run 3	Test Average
Test Date	-	-	4/12/2017	4/12/2017	4/12/2017	---
Test Period	-	-	736-836	906-1006	1030-1130	---
Barometric Pressure	P_{bar}	in. Hg	28.43	28.43	28.43	28.43
Dry Volumetric Flowrate at Standard Conditions (EPA Method 2)	Q_d	dscfm	162,600	165,200	162,200	163,333

Trap A Results

	Symbol	Units	Run 1	Run 2	Run 3	Test Average
Actual Dry Gas Meter Volume	V_{mA}	liters	32.142	31.910	30.975	31.676
Dry Gas Meter Calibration Factor	Y_A	-	1.0176	1.0176	1.0176	1.0176
Average Meter Temperature	T_{mfA}	degrees F	77	81	80	79
Average Absolute Meter Temperature (R) $T_{mrA} = T_{mfA} + 460$	T_{mrA}	degrees R	537	541	540	539
Meter Volume at Standard Conditions $V_{mstd\ A} = 17.64 \text{ x } (V_{mA} \text{ x } 0.03531) \text{ x } Y_A \text{ x } P_{bar} / T_{mrA}$	$V_{mstd\ A}$	cubic feet	1.079	1.064	1.033	1.059
Laboratory Results						
Trap ID	---	---	OLC043153	OLC043415	OLC043121	---
Mercury Sorbent Trap, Section 1	$M_{1\ A}$	ng	43.8	43.9	41.1	42.9
Mercury Sorbent Trap, Section 2	$M_{2\ A}$	ng	3.30	2.80	2.80	2.97
Mercury, Total amount collected	M_A	ng	47.1	46.7	43.9	45.9
Amount of Mercury in spiked traps-from laboratory	$M_{spike\ A}$	ng	0	0	0	---
Mercury Stack Concentration $C_{(\mu g)A} = (M_A - M_{spikeA}) / 1000 / V_{mstdA} \text{ x } 0.0283168$	$C_{(\mu g)A}$	μg/dscm	1.541	1.550	1.501	1.531
Mercury Emission Rate $E_{(lb/hr)A} = (M_A\text{-}M_{spike\ A}) \text{ x } (2.2046\text{x}10^{-12} \text{ (lb/ng)) x Qd x60 / } V_{mstd\ A}$	$E_{(lb/hr)A}$	lb/hr	0.00094	0.00096	0.00091	0.00094
Mercury Emission Rate $E_{(lb/yr)A} = E_{(lb/hr)A} \text{ x 8760 hr/yr}$	$E_{(lb/yr)A}$	lb/yr	8.2	8.4	8.0	8.2

Trap B Results

	Symbol	Units	Run 1	Run 2	Run 3	Test Average
Actual Dry Gas Meter Volume	V_{mB}	liters	29.980	29.797	29.903	29.893
Dry Gas Meter Calibration Factor	Y_B	-	0.9857	0.9857	0.9857	0.9857
Average Meter Temperature	T_{mfB}	degrees F	77	81	81	80
Average Absolute Meter Temperature (R) $T_{mrB} = T_{mfB} + 460$	T_{mrB}	degrees R	537	541	541	540
Meter Volume at Standard Conditions $V_{mstd\ B} = 17.64 \text{ x } (V_{mB} \text{ x } 0.03531) \text{ x Y x } P_{bar} / T_{mrB}$	$V_{mstd\ B}$	cubic feet	0.974	0.961	0.964	0.967
Laboratory Results						
Trap ID	---	---	OL411174	OL411166	OL411193	---
Mercury Sorbent Trap, Section 1	$M_{1\ B}$	ng	89.8	85.4	86.6	87.3
Mercury Sorbent Trap, Section 2	$M_{2\ B}$	ng	3.20	3.60	3.30	3.37
Mercury, Total amount collected	M_B	ng	93.0	89.0	89.9	90.6
Amount of Mercury in spiked traps-from laboratory	$M_{spike\ B}$	ng	50	50	50	---
Mercury Stack Concentration $C_{(\mu g)B} = (M_B - M_{spikeB}) / 1000 / V_{mstdB} \text{ x } 0.0283168$	$C_{(\mu g)B}$	μg/dscm	1.558	1.433	1.461	1.484
Mercury Emission Rate $E_{(lb/hr)B} = (M_B\text{-}M_{spike\ B}) \text{ x } (2.2046\text{x}10^{-12} \text{ (lb/ng)) x Qd x60 / } V_{mstd\ B}$	$E_{(lb/hr)B}$	lb/hr	0.00095	0.00089	0.00089	0.00091
Mercury Emission Rate $E_{(lb/yr)B} = E_{(lb/hr)B} \text{ x 8760 hr/yr}$	$E_{(lb/yr)B}$	lb/yr	8.3	7.8	7.8	8.0

EPA Method 30B QA/QC Data

	Symbol	Units	Run 1	Run 2	Run 3	Test Average
A Train Breakthrough -- each run <10% $B_A = M_{2\ A} / M_{1\ A} \text{ x } 100$	B_A	%	7.5	6.4	6.8	6.9
B Train Breakthrough -- each run <10% $B_B = M_{2\ B} / M_{1\ B} \text{ x } 100$	B_B	%	3.6	4.2	3.8	3.9
Sample volume agreement -- each run +/- 20% $SV = 100 - ((V_{mstd\ A} / V_{mstd\ B}) \text{ x } 100)$	SV	%	-10.7	-10.7	-7.1	-9.5
Field Recovery Test -- 3 run avg 85%< R >115% $R = (M_A / V_{mstd\ A} - M_B / V_{mstd\ B}) \text{ x } V_{mstd\ A} / M_{spike\ A} \text{ x } 100$	R	%	100.9	93.6	97.8	97.4
Paired Trap Agreement -- each run <10% $RD = ((C_{\mu gA} - C_{\mu gB}) / (C_{\mu gA} + C_{\mu gB})) \text{ X } 100$	RD	%	0.6	3.9	1.4	1.9

EPA Method 30B Calculation Summary
Determination of Total Vapor Phase Mercury Emissions

Indurating Furnace Stack C (SV016)
Baseline 2

Data Entry	Symbol	Units	Run 1	Run 2	Run 3	Test Average
Test Date	-	-	4/11/2017	4/11/2017	4/11/2017	---
Test Period	-	-	830-930	1000-1100	1200-1300	---
Barometric Pressure	P_{bar}	in. Hg	28.40	28.40	28.40	28.40
Dry Volumetric Flowrate at Standard Conditions (EPA Method 2)	Q_d	dscfm	160,800	155,300	154,700	156,933

Trap A Results

	Symbol	Units	Run 1	Run 2	Run 3	Test Average
Actual Dry Gas Meter Volume	V_{mA}	liters	23.893	28.733	30.650	27.759
Dry Gas Meter Calibration Factor	Y_A	-	1.0141	1.0141	1.0141	1.0141
Average Meter Temperature	T_{mfA}	degrees F	69	74	79	74
Average Absolute Meter Temperature (R) $T_{mrA} = T_{mfA} + 460$	T_{mrA}	degrees R	529	534	539	534
Meter Volume at Standard Conditions $V_{mstd\ A} = 17.64 \text{ x } (V_{mA} \text{ x } 0.03531) \text{ x } Y_A \text{ x } P_{bar} / T_{mrA}$	$V_{mstd\ A}$	cubic feet	0.810	0.966	1.020	0.932
Laboratory Results						
Trap ID	---	---	OLC043459	OL413031	OLC043422	---
Mercury Sorbent Trap, Section 1	$M_{1\ A}$	ng	53.4	62.9	71.6	62.6
Mercury Sorbent Trap, Section 2	$M_{2\ A}$	ng	1.00	1.20	1.40	1.20
Mercury, Total amount collected	M_A	ng	54.4	64.1	73.0	63.8
Amount of Mercury in spiked traps-from laboratory	$M_{spike\ A}$	ng	0	0	0	---
Mercury Stack Concentration $C_{(\mu g)A} = (M_A - M_{spikeA}) / 1000 / V_{mstdA} \text{ x } 0.0283168$	$C_{(\mu g)A}$	µg/dscm	2.373	2.344	2.527	2.414
Mercury Emission Rate $E_{(lb/hr)A} = (M_A - M_{spike\ A}) \text{ x } (2.2046\text{x}10^{-12} \text{ (lb/ng)) x Qd x60 } / V_{mstd\ A}$	$E_{(lb/hr)A}$	lb/hr	0.00143	0.00136	0.00146	0.00142
Mercury Emission Rate $E_{(lb/yr)A} = E_{(lb/hr)A} \text{ x } 8760 \text{ hr/yr}$	$E_{(lb/yr)A}$	lb/yr	12.5	11.9	12.8	12.4

Trap B Results

	Symbol	Units	Run 1	Run 2	Run 3	Test Average
Actual Dry Gas Meter Volume	V_{mB}	liters	26.083	29.317	29.142	28.181
Dry Gas Meter Calibration Factor	Y_B	-	1.0063	1.0063	1.0063	1.0063
Average Meter Temperature	T_{mfB}	degrees F	49	52	57	53
Average Absolute Meter Temperature (R) $T_{mrB} = T_{mfB} + 460$	T_{mrB}	degrees R	509	512	517	513
Meter Volume at Standard Conditions $V_{mstd\ B} = 17.64 \text{ x } (V_{mB} \text{ x } 0.03531) \text{ x } Y \text{ x } P_{bar} / T_{mrB}$	$V_{mstd\ B}$	cubic feet	0.912	1.019	1.004	0.978
Laboratory Results						
Trap ID	---	---	OL411122	OL411171	OL411153	---
Mercury Sorbent Trap, Section 1	$M_{1\ B}$	ng	107.7	115.6	112.7	112.0
Mercury Sorbent Trap, Section 2	$M_{2\ B}$	ng	1.00	1.60	0.90	1.17
Mercury, Total amount collected	M_B	ng	108.7	117.2	113.6	113.2
Amount of Mercury in spiked traps-from laboratory	$M_{spike\ B}$	ng	50	50	50	---
Mercury Stack Concentration $C_{(\mu g)B} = (M_B - M_{spikeB}) / 1000 / V_{mstdB} \text{ x } 0.0283168$	$C_{(\mu g)B}$	µg/dscm	2.274	2.328	2.236	2.279
Mercury Emission Rate $E_{(lb/hr)B} = (M_B - M_{spike\ B}) \text{ x } (2.2046\text{x}10^{-12} \text{ (lb/ng)) x Qd x60 } / V_{mstd\ B}$	$E_{(lb/hr)B}$	lb/hr	0.00137	0.00135	0.00130	0.00134
Mercury Emission Rate $E_{(lb/yr)B} = E_{(lb/hr)B} \text{ x } 8760 \text{ hr/yr}$	$E_{(lb/yr)B}$	lb/yr	12.0	11.9	11.4	11.7

EPA Method 30B QA/QC Data

	Symbol	Units	Run 1	Run 2	Run 3	Test Average
A Train Breakthrough -- each run <10% $B_A = M_{2\ A} / M_{1\ A} \text{ x } 100$	B_A	%	1.9	1.9	2.0	1.9
B Train Breakthrough -- each run <10% $B_B = M_{2\ B} / M_{1\ B} \text{ x } 100$	B_B	%	0.9	1.4	0.8	1.0
Sample volume agreement -- each run +/- 20% $SV = 100 - ((V_{mstd\ A} / V_{mstd\ B}) \text{ x } 100)$	SV	%	11.2	5.3	-1.6	5.0
Field Recovery Test -- 3 run avg 85%< R >115% $R = (M_A / V_{mstd\ A} - M_B / V_{mstd\ B}) \text{ x } V_{mstd\ A} / M_{spike\ A} \text{ x } 100$	R	%	94.9	99.1	83.5	92.5
Paired Trap Agreement -- each run <10% $RD = ((C_{\mu gA} - C_{\mu gB}) / (C_{\mu gA} + C_{\mu gB})) \text{ X } 100$	RD	%	2.1	0.3	6.1	2.9

EPA Method 30B Calculation Summary
Determination of Total Vapor Phase Mercury Emissions

Indurating Furnace Stack D (SV017)
Baseline 2

Data Entry	Symbol	Units	Run 1	Run 2	Run 3	Test Average
Test Date	-	-	4/12/2017	4/12/2017	4/12/2017	---
Test Period	-	-	736-836	906-1006	1030-1130	---
Barometric Pressure	P_{bar}	in. Hg	28.65	28.65	28.65	28.65
Dry Volumetric Flowrate at Standard Conditions (EPA Method 2)	Q_d	dscfm	135,900	135,500	136,300	135,900

Trap A Results

	Symbol	Units	Run 1	Run 2	Run 3	Test Average
Actual Dry Gas Meter Volume	V_{mA}	liters	29.836	28.317	30.146	29.433
Dry Gas Meter Calibration Factor	Y_A	-	1.0141	1.0141	1.0141	1.0141
Average Meter Temperature	T_{mfA}	degrees F	78	82	80	80
Average Absolute Meter Temperature (R) $T_{mrA} = T_{mfA} + 460$	T_{mrA}	degrees R	538	542	540	540
Meter Volume at Standard Conditions $V_{mstd\ A} = 17.64 \times (V_{mA} \times 0.03531) \times Y_A \times P_{bar} / T_{mrA}$	$V_{mstd\ A}$	cubic feet	1.003	0.946	1.010	0.986
Laboratory Results						
Trap ID	---	---	OLC043472	OLC043364	OL413042	---
Mercury Sorbent Trap, Section 1	$M_{1\ A}$	ng	81.3	73.6	80.2	78
Mercury Sorbent Trap, Section 2	$M_{2\ A}$	ng	0.70	1.00	1.00	0.90
Mercury, Total amount collected	M_A	ng	82.0	74.6	81.2	79.3
Amount of Mercury in spiked traps-from laboratory	$M_{spike\ A}$	ng	0	0	0	---
Mercury Stack Concentration $C_{(\mu g)A} = (M_A - M_{spikeA}) / 1000 / V_{mstdA} \times 0.0283168$	$C_{(\mu g)A}$	µg/dscm	2.887	2.786	2.838	2.837
Mercury Emission Rate $E_{(lb/hr)A} = (M_A - M_{spike\ A}) \times (2.2046 \times 10^{-12}\ (lb/ng)) \times Qd \times 60 / V_{mstd\ A}$	$E_{(lb/hr)A}$	lb/hr	0.00147	0.00141	0.00145	0.00144
Mercury Emission Rate $E_{(lb/yr)A} = E_{(lb/hr)A} \times 8760$ hr/yr	$E_{(lb/yr)A}$	lb/yr	12.9	12.4	12.7	12.7

Trap B Results

	Symbol	Units	Run 1	Run 2	Run 3	Test Average
Actual Dry Gas Meter Volume	V_{mB}	liters	30.189	29.291	30.196	29.892
Dry Gas Meter Calibration Factor	Y_B	-	1.0063	1.0063	1.0063	1.0063
Average Meter Temperature	T_{mfB}	degrees F	78	81	80	80
Average Absolute Meter Temperature (R) $T_{mrB} = T_{mfB} + 460$	T_{mrB}	degrees R	538	541	540	540
Meter Volume at Standard Conditions $V_{mstd\ B} = 17.64 \times (V_{mB} \times 0.03531) \times Y \times P_{bar} / T_{mrB}$	$V_{mstd\ B}$	cubic feet	1.008	0.972	1.005	0.995
Laboratory Results						
Trap ID	---	---	OL411172	OL411102	OL411132	---
Mercury Sorbent Trap, Section 1	$M_{1\ B}$	ng	134.1	126.7	130.5	130
Mercury Sorbent Trap, Section 2	$M_{2\ B}$	ng	1.10	1.50	1.00	1.20
Mercury, Total amount collected	M_B	ng	135	128	132	132
Amount of Mercury in spiked traps-from laboratory	$M_{spike\ B}$	ng	50	50	50	---
Mercury Stack Concentration $C_{(\mu g)B} = (M_B - M_{spikeB}) / 1000 / V_{mstdB} \times 0.0283168$	$C_{(\mu g)B}$	µg/dscm	2.986	2.842	2.864	2.897
Mercury Emission Rate $E_{(lb/hr)B} = (M_B - M_{spike\ B}) \times (2.2046 \times 10^{-12}\ (lb/ng)) \times Qd \times 60 / V_{mstd\ B}$	$E_{(lb/hr)B}$	lb/hr	0.00152	0.00144	0.00146	0.00147
Mercury Emission Rate $E_{(lb/yr)B} = E_{(lb/hr)B} \times 8760$ hr/yr	$E_{(lb/yr)B}$	lb/yr	13.3	12.6	12.8	12.9

EPA Method 30B QA/QC Data

	Symbol	Units	Run 1	Run 2	Run 3	Test Average
A Train Breakthrough -- each run <10% $B_A = M_{2\ A} / M_{1\ A} \times 100$	B_A	%	0.9	1.4	1.2	1.2
B Train Breakthrough -- each run <10% $B_B = M_{2\ B} / M_{1\ B} \times 100$	B_B	%	0.8	1.2	0.8	0.9
Sample volume agreement -- each run +/- 20% $SV = 100 - ((V_{mstd\ A} / V_{mstd\ B}) \times 100)$	SV	%	0.4	2.7	-0.5	0.9
Field Recovery Test -- 3 run avg 85%< R >115% $R = (M_A / V_{mstd\ A} - M_B / V_{mstd\ B}) \times V_{mstd\ A} / M_{spike\ A} \times 100$	R	%	105.7	103.1	101.5	103.4
Paired Trap Agreement -- each run <10% $RD = ((C_{\mu gA} - C_{\mu gB}) / (C_{\mu gA} + C_{\mu gB}))\ X\ 100$	RD	%	1.7	1.0	0.4	1.0

Appendix B

Field Data Sheets

A TI

BARR

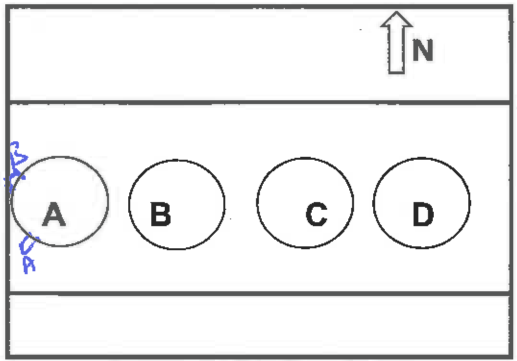
EPA METHOD 2
FIELD DATA SHEET

Project ArcelorMittal Minorca Mine
Sample Location Furnace Stack A
Date 12/13/16
Operators M. Norstrom
Duct Dimensions 101.75 inches
Port Length 4.5 inches
Pitot Tube No. 20 Cp 0.84
Manometer ID M-11 Bar. ID BA-28
Digital Therm ID ~~[illegible]~~ AS-01 T.C. ID TBS
UMB 200-2, T10#6200

	Run 1	Run 2	Run 3	Run 4
Bar Press (In Hg)	28.20	→	→	
Stat. Press (In H_2O)	-0.60	-0.60	-0.60	
Temp - Dry Bulb °F				
Temp - Wet Bulb °F	See Method 4			
Moist Content - %				
O_2 %	See Method 3			
Time of Meas.	1205-1217	1355-1408	1640-1655	

Pitot Leak Check Positive: ✓ Negative: ✓

Traverse Point Information			Cyclonic	Velocity Head - Inches H_2O				Stack Temperature - °F			
Point	Inches From:		Flow	Run 1	Run 2	Run 3	Run 4	Run 1	Run 2	Run 3	Run 4
Number	Wall	Port	∠°	ΔP	ΔP	ΔP	ΔP	Temp.	Temp.	Temp.	Temp.
A - 1	4.43	8.93		0.77	0.86	0.83					
2	14.90	19.40		6.85	0.84	0.85					
3	30.11	34.61		0.84	0.83	0.85		See Method 4			
4	71.64	76.14		0.78	0.78	0.81					
5	86.85	91.35		0.78	0.73	0.86					
6	97.32	101.82		0.76	0.73	0.82					
B - 1				0.76	0.76	0.84					
2				0.80	0.77	0.73					
3				0.80	0.82	0.82					
4				0.84	0.87	0.85					
5				0.85	0.85	0.91					
6				0.95	0.92	0.92					



Schematic of Duct Cross-Section

	Run 1	Run 2	Run 3	Run 4
Stack Pres. - In Hg				
Duct Area - Sq Ft.				
Mole Weight - Md				
Mole Weight - Ms				
Avg. Temp. - °F	See Appendix A			
Average $\sqrt{\Delta P}$				
Gas Vel - Ft/Sec				
ACFM				
SCFM				
DSCFM				

B T2

BARR

EPA METHOD 2
FIELD DATA SHEET

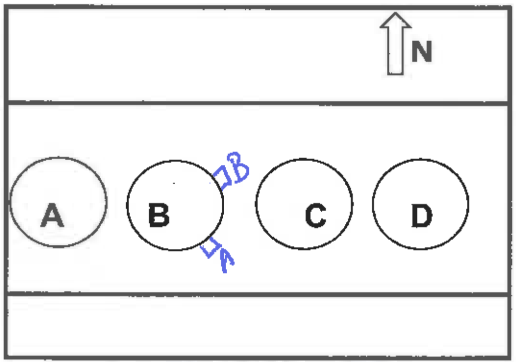
Project: ArcelorMittal Minorca Mine
Sample Location: Furnace Stack B
Date: 12/13/16
Operators: M. Norstrem
Duct Dimensions: 101.75 inches
Port Length: 4.5 inches
Pitot Tube No.: 20 Cp: 0.84
Manometer ID: M-11 Bar. ID: BA-28
Digital Therm ID: AS-01 T.C. ID: T91

UMB 300-3, T10#6268

	Run 1	Run 2	Run 3	Run 4
Bar Press (In Hg)	28.20	→	→	
Stat. Press (In H_2O)	-0.77	-0.75	-0.74	
Temp - Dry Bulb °F				
Temp - Wet Bulb °F	See Method 4			
Moist Content - %				
O_2 %	See Method 3			
Time of Meas.	1228-1240	1420-1444	1700-1715	

Pitot Leak Check Positive: ✓ Negative: ✓

Traverse Point Information			Cyclonic	Velocity Head - Inches H_2O				Stack Temperature - °F			
Point	Inches From:		Flow	Run 1	Run 2	Run 3	Run 4	Run 1	Run 2	Run 3	Run 4
Number	Wall	Port	∠°	ΔP	ΔP	ΔP	ΔP	Temp.	Temp.	Temp.	Temp.
A-1	4.43	8.93		0.99	0.96	0.95					
2	14.90	19.40		1.02	1.02	1.00					
3	30.11	34.61		0.95	0.98	0.95		See Method 4			
4	71.64	76.14		0.89	0.89	0.90					
5	86.85	91.35		0.83	0.81	0.82					
6	97.32	101.82		0.79	0.72	0.75					
B-1				0.90	0.88	0.90					
2				0.90	0.91	0.88					
3				0.94	0.88	0.88					
4				0.94	0.98	0.94					
5				0.94	0.92	0.94					
6				0.94	0.88	0.90					



Schematic of Duct Cross-Section

	Run 1	Run 2	Run 3	Run 4
Stack Pres. - In Hg				
Duct Area - Sq Ft.				
Mole Weight - Md				
Mole Weight - Ms				
Avg. Temp. - °F	See Appendix A			
Average $\sqrt{\Delta P}$				
Gas Vel - Ft/Sec				
ACFM				
SCFM				
DSCFM				

C T3

BARR

EPA METHOD 2
FIELD DATA SHEET

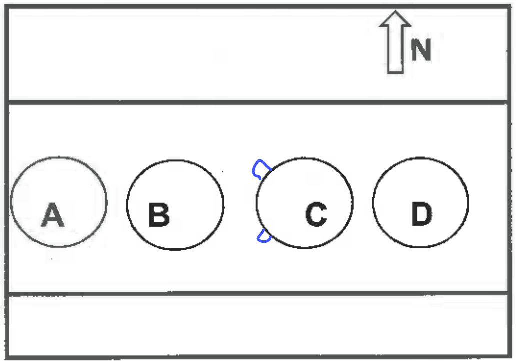
Project ArcelorMittal Minorca Mine
Sample Location Furnace Stack C
Date 12/14/16
Operators M. Petersen, M. Norstrom
Duct Dimensions 104.00 inches
Port Length 4.50 inches
Pitot Tube No. 20 Cp 0.84
Manometer ID M-11 Bar. ID BA-28
Digital Therm ID AS-01 T.C. ID T91

UMB 300-3, TI0#6268

	Run 1	Run 2	Run 3	Run 4
Bar Press (In Hg)	28.21	→	→	
Stat. Press (In H_2O)	-0.75	-0.80	-0.80	
Temp - Dry Bulb °F				
Temp - Wet Bulb °F	See Method 4			
Moist Content - %				
O_2 %	See Method 3			
Time of Meas.	1130 - 1148	1425- 1438	1610 - 1622	

Pitot Leak Check Positive: ✓ Negative: ✓

Traverse Point Information			Cyclonic	Velocity Head - Inches H_2O				Stack Temperature - °F			
Point	Inches From:		Flow	Run 1	Run 2	Run 3	Run 4	Run 1	Run 2	Run 3	Run 4
Number	Wall	Port	∠°	ΔP	ΔP	ΔP	ΔP	Temp.	Temp.	Temp.	Temp.
A - 1	4.53	9.03		0.85	0.86	0.86		See Method 4			
2	15.23	19.73		0.88	0.87	0.87					
3	30.77	35.27		0.90	0.86	0.88					
4	73.23	77.73		0.89	0.87	0.88					
5	88.77	93.27		0.83	0.84	0.84					
6	99.47	103.97		0.90	0.81	0.84					
B - 1				0.89	0.83	0.85					
2				0.84	0.87	0.87					
3				0.82	0.87	0.87					
4				0.88	0.89	0.88					
5				0.87	0.80	0.88					
6				0.79	0.88	0.84					



Schematic of Duct Cross-Section

	Run 1	Run 2	Run 3	Run 4
Stack Pres. - In Hg	See Appendix A			
Duct Area - Sq Ft.				
Mole Weight - Md				
Mole Weight - Ms				
Avg. Temp. - °F				
Average $\sqrt{\Delta P}$				
Gas Vel - Ft/Sec				
ACFM				
SCFM				
DSCFM				

BARR

D T4

EPA METHOD 2
FIELD DATA SHEET

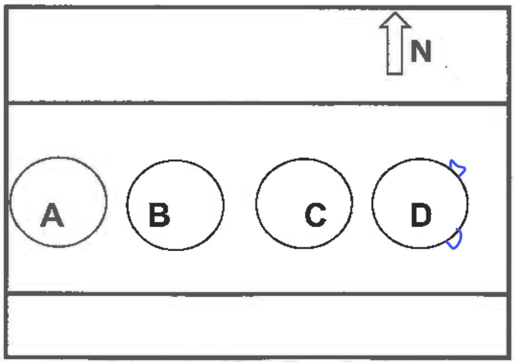
Project ArcelorMittal Minorca Mine
Sample Location Furnace Stack D
Date 12/14/16
Operators M. Peterson, M. Norstrem
Duct Dimensions 104.00 inches
Port Length 4.50 inches
Pitot Tube No. 20 Cp 0.84
Manometer ID M-11 Bar. ID BA-28
Digital Therm ID AS-01 T.C. ID 7-85

UMB 200-2, TID#6000

	Run 1	Run 2	Run 3	Run 4
Bar Press (In Hg)	28.21	→	▷	
Stat. Press (In H_2O)	-0.55	-0.66	-0.60	
Temp - Dry Bulb °F				
Temp - Wet Bulb °F	See Method 4			
Moist Content - %				
O_2 %	See Method 3			
Time of Meas.	1201 - 1217	1447- 1501	1630- 1645	

Pitot Leak Check Positive: ✓ Negative: ✓

Traverse Point Information			Cyclonic	Velocity Head - Inches H_2O				Stack Temperature - °F			
Point	Inches From:		Flow	Run 1	Run 2	Run 3	Run 4	Run 1	Run 2	Run 3	Run 4
Number	Wall	Port	∠°	ΔP	ΔP	ΔP	ΔP	Temp.	Temp.	Temp.	Temp.
A - 1	4.53	9.03		0.69	0.74	0.72					
2	15.23	19.73		0.73	0.65	0.68					
3	30.77	35.27		0.66	0.62	0.65		See Method 4			
4	73.23	77.73		0.71	0.65	0.65					
5	88.77	93.27		0.68	0.67	0.67					
6	99.47	103.97		0.73	0.68	0.68					
B - 1				0.73	0.65	0.70					
2				0.65	0.62	0.68					
3				0.66	0.64	0.65					
4				0.68	0.64	0.65					
5				0.68	0.64	0.65					
6				0.64	0.74	0.68					



Schematic of Duct Cross-Section

	Run 1	Run 2	Run 3	Run 4
Stack Pres. - In Hg				
Duct Area - Sq Ft.				
Mole Weight - Md				
Mole Weight - Ms				
Avg. Temp. - °F	See Appendix A			
Average $\sqrt{\Delta P}$				
Gas Vel - Ft/Sec				
ACFM				
SCFM				
DSCFM				

EPA METHOD 3A -- Instrument Analysis Data Sheet

Project ArcelorMittal - Hg Screening
Sample Location Furnace Stacks A and B / Tests 1, 2
Date 12/13/2016
Operators M. Petersen

Analyzer Make / Model / Serial No. Servomex 1440
Analyzer O_2 Range (span), %: 0-25%
Analyzer CO_2 Range (span), %: 0-25%

	Cylinder Serial No.	O2 Cert. Conc.	CO2 Cert. Conc.
Zero Gas	Nitrogen Lot#0317VC16	0.0	0.0
O2/CO2 Mid gas	CC116801	9.5	9.5
O2 High gas	CA03203	21.6	-
CO2 High gas	CC115022	-	18.9

PRETEST ANALYZER CALIBRATION DATA

	O2		CO2	
	Cylinder Value, %	Analyzer Calibration Response, %	Cylinder Value, %	Analyzer Calibration Response, %
Zero Gas	0.0	0	0.0	0
Mid-range:	9.5	9.5	9.5	9.6
High-range:	21.6	21.5	18.9	18.9

Time of Calibration___ 1000-1805

INTEGRATED BAG ANALYSIS

Location/Test No.	Furnace Stack A / Test 1			Furnace Stack B / Test 2		
Run No.	**1**	**2**	**3**	**1**	**2**	**3**
Time Sampled	1148-1248	1350-1450	1634-1734	1148-1248	1350-1450	1634-1734
Time Analyzed	1410	1640	1745	1415	1643	1747
O2, %	19.9	20	20.1	19.4	19.3	19.5
CO2,%	0.9	0.7	0.6	1.3	1.4	1.1

POSTTEST ANALYZER CALIBRATION DATA

	O2		CO2	
	Cylinder Value, %	Analyzer Calibration Response, %	Cylinder Value, %	Analyzer Calibration Response, %
Zero Gas	0.0	0	0.0	0
Mid-range:	9.5	9.5	9.5	9.5
High-range:	21.6	21.6	18.9	18.8

EPA METHOD 3A -- Instrument Analysis Data Sheet

Project	ArcelorMittal - Hg Screening
Sample Location	Furnace Stacks C and D / Tests 3, 4
Date	12/14/2016
Operators	M. Petersen

Analyzer Make / Model / Serial No. Servomex 1440

Analyzer O_2 Range (span), %: 0-25%

Analyzer CO_2 Range (span), %: 0-25%

	Cylinder Serial No.	O2 Cert. Conc.	CO2 Cert. Conc.
Zero Gas	Nitrogen Lot#0317VC16	0.0	0.0
O2/CO2 Mid gas	CC116801	9.5	9.5
O2 High gas	CA03203	21.6	-
CO2 High gas	CC115022	-	18.9

PRETEST ANALYZER CALIBRATION DATA

	O2		CO2	
	Cylinder Value, %	Analyzer Calibration Response, %	Cylinder Value, %	Analyzer Calibration Response, %
Zero Gas	0.0	0	0.0	0
Mid-range:	9.5	9.6	9.5	9.5
High-range:	21.6	21.6	18.9	18.8

Time of Calibration___ 1203-1545

INTEGRATED BAG ANALYSIS

Location/Test No.	Furnace Stack C / Test 3			Furnace Stack D / Test 4		
Run No.	**1**	**2**	**3**	**1**	**2**	**3**
Time Sampled	1122-1222	1422-1522	1604-1704	1122-1222	1422-1522	1604-1704
Time Analyzed	1430	1615	1715	1433	1618	1718
O2, %	18.9	18.7	18.9	18.4	18.4	18.3
CO2,%	1.8	2	1.9	2.2	2.2	2.3

POSTTEST ANALYZER CALIBRATION DATA

	O2		CO2	
	Cylinder Value, %	Analyzer Calibration Response, %	Cylinder Value, %	Analyzer Calibration Response, %
Zero Gas	0.0	0	0.0	0
Mid-range:	9.5	9.5	9.5	9.5
High-range:	21.6	21.7	18.9	18.8

ArcelorMittal Minorca Mine Inc.
Virginia, Minnesota

Barr Engineering Co.
August 1, 2017

RESULTS OF STACK MOISTURE DETERMINATIONS

Furnace Stack A (SV014)
Test Date: December 13, 2016
Baseline 1

Meter ID: AS-01 Meter Coefficient: 0.9919 Meter ΔH: 1.87

	RUN 1 (1148-1248)						RUN 2 (1350-1450)						RUN 3 (1634-1734)					
Run Time, Minutes	Meter Volume Vm, ft^3	Orifice ΔH, in H_2O	Stack Temp. Ts, °F	Impinger Temp. (°F)	Meter Inlet (°F)	Meter Outlet (°F)	Meter Volume Vm, ft^3	Orifice ΔH, in H_2O	Stack Temp. Ts, °F	Impinger Temp. (°F)	Meter Inlet (°F)	Meter Outlet (°F)	Meter Volume Vm, ft^3	Orifice ΔH, in H_2O	Stack Temp. Ts, °F	Impinger Temp. (°F)	Meter Inlet (°F)	Meter Outlet (°F)
	0.00						0.00						0.00					
5	3.56	1.87	102	30.7	77.4	-	3.05	1.87	101	37.9	79.9	-	3.90	1.87	102	33.8	78.6	-
10	7.42	1.87	102	33.3	77.4	-	7.02	1.87	100	40.5	80.4	-	7.83	1.87	102	36.1	79.2	-
15	11.23	1.87	102	35.1	77.4	-	10.97	1.87	101	42.3	80.4	-	11.77	1.87	102	38.7	79.9	-
20	15.04	1.87	103	37.4	78.1	-	14.91	1.87	101	45.1	81.0	-	15.71	1.87	103	41.5	79.9	-
25	18.84	1.87	102	40.5	78.6	-	18.84	1.87	101	46.9	81.5	-	19.65	1.87	102	44.1	80.4	-
30	22.65	1.87	102	42.8	79.2	-	22.78	1.87	102	48.7	81.5	-	23.59	1.87	102	46.4	81.0	-
35	26.45	1.87	103	45.1	79.9	-	26.68	1.87	102	50.0	82.2	-	27.54	1.87	103	49.5	81.0	-
40	30.26	1.87	102	47.7	80.4	-	30.63	1.87	101	51.3	82.2	-	31.50	1.87	103	51.3	81.5	-
45	34.06	1.87	102	48.7	81.0	-	34.58	1.87	101	51.8	82.8	-	35.40	1.87	103	54.1	82.2	-
50	37.84	1.87	102	50.5	81.5	-	38.53	1.87	101	52.3	82.8	-	39.42	1.87	102	54.9	82.2	-
55	41.68	1.87	102	52.3	81.5	-	42.47	1.87	101	54.1	83.3	-	43.38	1.87	102	56.7	82.8	-
60	45.52	1.87	102	54.9	81.0	-	46.42	1.87	102	55.9	83.3	-	47.35	1.87	103	58.5	82.8	-

Total Meter Volume Vm, ft^3	Average Orifice ΔH, in H_2O	Average Stack Temp. (°F)	Average Impinger Temp. (°F)	Average Meter Temp. (°F)	Total Meter Volume Vm, ft^3	Average Orifice ΔH, in H_2O	Average Stack Temp. (°F)	Average Impinger Temp. (°F)	Average Meter Temp. (°F)	Total Meter Volume Vm, ft^3	Average Orifice ΔH, in H_2O	Average Stack Temp. (°F)	Average Impinger Temp. (°F)	Average Meter Temp. (°F)
45.52	1.9	102	43	79.45	46.42	1.9	101	48	81.78	47.35	1.9	102	47	80.96

Moisture Recovery Data:

Impinger	1	2	3	Desiccant	Total	Impinger	1	2	3	Desiccant	Total	Impinger	1	2	3	Desiccant	Total
Final	140	132	4	950		Final	115	134	13	964		Final	122	128	2	982	
Initial	100	100	0	940		Initial	100	100	0	950		Initial	100	100	0	964	
Diff.	40	32	4	10	86	Diff.	15	34	13	14	76	Diff.	22	28	2	18	70

Standard Meter Volume	**Moisture Content (%v/v)**	Standard Meter Volume	**Moisture Content (%v/v)**	Standard Meter Volume	**Moisture Content (%v/v)**
42.55	**8.82**	43.20	**7.77**	44.13	**7.06**
Barometric Pressure (in Hg)	28.20	Barometric Pressure (in Hg)	28.20	Barometric Pressure (in Hg)	28.20
Meter Coefficient	0.9919	Meter Coefficient	0.9919	Meter Coefficient	0.9919

	Run 1				Run 2				Run 3			
	Vacuum:	7 in. Hg			Vacuum:	7 in. Hg			Vacuum:	6.6 in. Hg		
Leak	Pre-test:	0.000	at	10 in. Hg	Pre-test:	0.000	at	7 in. Hg	Pre-test:	0.000	at	8 in. Hg
Checks	Post-test:	0.000	at	9 in. Hg	Post-test:	0.000	at	16 in. Hg	Post-test:	0.000	at	12 in. Hg

ArcelorMittal Minorca Mine Inc.
Virginia, Minnesota

Barr Engineering Co.
August 1, 2017

RESULTS OF STACK MOISTURE DETERMINATIONS

Furnace Stack B (SV015)
Test Date: December 13, 2016
Baseline 1

Meter ID: C-7 Meter Coefficient: 1.0173 Meter ΔH: 1.8303

	RUN 1 (1148-1248)						RUN 2 (1350-1450)						RUN 3 (1634-1734)					
Run Time, Minutes	Meter Volume Vm, ft³	Orifice ΔH, in H_2O	Stack Temp. Ts, °F	Impinger Temp. (°F)	Meter Inlet (°F)	Meter Outlet (°F)	Meter Volume Vm, ft³	Orifice ΔH, in H_2O	Stack Temp. Ts, °F	Impinger Temp. (°F)	Meter Inlet (°F)	Meter Outlet (°F)	Meter Volume Vm, ft³	Orifice ΔH, in H_2O	Stack Temp. Ts, °F	Impinger Temp. (°F)	Meter Inlet (°F)	Meter Outlet (°F)
	800.91						848.35						889.10					
5	804.66	1.83	107	24.4	68	68	851.75	1.83	106	33.3	74	74	892.71	1.83	106	26.4	75	75
10	808.90	1.83	106	25.7	70	70	855.24	1.83	106	35.1	78	74	896.24	1.83	106	29.5	76	75
15	812.62	1.83	107	27.7	71	70	858.56	1.83	106	36.9	79	75	899.79	1.83	107	32.5	76	75
20	815.55	1.83	107	31.5	72	70	861.97	1.83	107	39.7	81	75	903.51	1.83	107	36.1	77	75
25	818.96	1.83	107	35.6	73	71	865.32	1.83	106	42.3	82	75	907.20	1.83	106	39.7	77	75
30	822.75	1.83	106	39.2	74	71	868.71	1.83	107	45.9	82	76	910.89	1.83	107	43.3	78	75
35	826.09	1.83	107	42.3	75	71	872.09	1.83	107	49.5	83	76	914.45	1.83	108	48.2	79	75
40	829.91	1.83	107	46.4	76	71	875.57	1.83	106	53.1	83	76	918.15	1.83	109	54.1	80	76
45	833.15	1.83	106	48.7	77	72	878.80	1.83	106	57.2	83	76	921.75	1.83	108	63.9	81	76
50	836.90	1.83	106	51.3	78	72	882.05	1.83	106	60.3	84	77	925.46	1.83	107	66.7	82	76
55	840.05	1.83	106	53.6	78	73	885.35	1.83	106	63.9	84	77	929.20	1.83	107	71.6	83	76
60	843.64	1.83	106	55.9	79	73	888.59	1.83	106	66.2	84	78	932.91	1.83	107	75.0	83	77

Total Meter Volume Vm, ft³	Average Orifice ΔH, in H_2O	Average Stack Temp. (°F)	Average Impinger Temp. (°F)	Average Meter Temp. (°F)	Total Meter Volume Vm, ft³	Average Orifice ΔH, in H_2O	Average Stack Temp. (°F)	Average Impinger Temp. (°F)	Average Meter Temp. (°F)	Total Meter Volume Vm, ft³	Average Orifice ΔH, in H_2O	Average Stack Temp. (°F)	Average Impinger Temp. (°F)	Average Meter Temp. (°F)
42.73	1.8	107	40	72.63	40.24	1.8	106	49	78.58	43.81	1.8	107	49	77.21

Moisture Recovery Data:

Impinger	1	2	3	Desiccant	Total
Final	110	133	10	928	
Initial	100	100	0	920	
Diff.	10	33	10	8	61

Standard Meter Volume	**Moisture Content (%v/v)**
41.48	**6.58**
Barometric Pressure (in Hg)	28.20
Meter Coefficient	1.0173

Moisture Recovery Data:

Impinger	1	2	3	Desiccant	Total
Final	112	133	12	943	
Initial	100	100	0	928	
Diff.	12	33	0	15	60

Standard Meter Volume	**Moisture Content (%v/v)**
38.63	**6.92**
Barometric Pressure (in Hg)	28.20
Meter Coefficient	1.0173

Moisture Recovery Data:

Impinger	1	2	3	Desiccant	Total
Final	113	138	16	953	
Initial	100	100	0	943	
Diff.	13	38	16	10	77

Standard Meter Volume	**Moisture Content (%v/v)**
42.17	**8.04**
Barometric Pressure (in Hg)	28.20
Meter Coefficient	1.0173

		Run 1				Run 2				Run 3			
	Vacuum:	8 in. Hg				8 in. Hg				9 in. Hg			
Leak	Pre-test:	0.000	at	8	in. Hg	0.000	at	9	in. Hg	0.000	at	10	in. Hg
Checks	Post-test:	0.000	at	10	in. Hg	0.000	at	10	in. Hg	0.000	at	10	in. Hg

RESULTS OF STACK MOISTURE DETERMINATIONS

Furnace Stack C (SV016)
Test Date: December 14, 2016
Baseline 1

Meter ID: C-7 Meter Coefficient: 1.0173 Meter ΔH: 1.8303

	RUN 1 (1122-1222)						RUN 2 (1422-1522)						RUN 3 (1604-1704)					
Run Time, Minutes	Meter Volume Vm, ft³	Orifice ΔH, in H_2O	Stack Temp. Ts, °F	Impinger Temp. (°F)	Meter Inlet (°F)	Meter Outlet (°F)	Meter Volume Vm, ft³	Orifice ΔH, in H_2O	Stack Temp. Ts, °F	Impinger Temp. (°F)	Meter Inlet (°F)	Meter Outlet (°F)	Meter Volume Vm, ft³	Orifice ΔH, in H_2O	Stack Temp. Ts, °F	Impinger Temp. (°F)	Meter Inlet (°F)	Meter Outlet (°F)
	933.65						978.42						21.17					
5	937.45	1.83	109	28.9	77	77	982.07	1.83	112	30.7	78	78	24.60	1.83	112	43.3	78	78
10	941.09	1.83	109	31.5	77	77	985.74	1.83	112	34.3	76	77	28.11	1.83	112	45.1	77	77
15	945.03	1.83	109	34.3	77	77	989.23	1.83	110	39.2	75	77	31.50	1.83	112	48.2	78	77
20	948.78	1.83	109	36.9	79	77	992.71	1.83	110	43.3	76	75	34.98	1.83	111	50.0	79	77
25	952.54	1.83	109	38.7	79	77	996.27	1.83	112	47.7	77	76	38.35	1.83	112	52.3	79	77
30	956.30	1.83	109	40.5	81	78	999.75	1.83	112	51.8	77	76	41.72	1.83	110	54.1	80	77
35	960.00	1.83	109	42.3	82	78	1003.17	1.83	112	55.9	78	76	45.08	1.83	112	56.7	80	77
40	963.68	1.83	109	44.1	82	78	1006.65	1.83	112	59.0	79	76	48.41	1.83	110	59.0	80	77
45	967.36	1.83	109	44.6	83	78	1009.99	1.83	112	62.1	79	76	51.70	1.83	110	60.8	80	77
50	970.68	1.83	110	45.9	83	78	1013.56	1.83	112	63.9	80	77	54.98	1.83	112	62.1	81	77
55	974.53	1.83	110	46.9	84	79	1017.20	1.83	112	66.2	81	77	58.45	1.83	110	63.9	81	77
60	978.17	1.83	110	47.7	84	79	1020.83	1.83	112	67.5	81	77	61.86	1.83	111	64.9	81	77
	Total Meter Volume Vm, ft³	Average Orifice ΔH, in H_2O	Average Stack Temp. (°F)	Average Impinger Temp. (°F)	Average Meter Temp. (°F)		Total Meter Volume Vm, ft³	Average Orifice ΔH, in H_2O	Average Stack Temp. (°F)	Average Impinger Temp. (°F)	Average Meter Temp. (°F)		Total Meter Volume Vm, ft³	Average Orifice ΔH, in H_2O	Average Stack Temp. (°F)	Average Impinger Temp. (°F)	Average Meter Temp. (°F)	
	44.52	1.8	109	40	79.21		42.41	1.8	112	52	77.29		40.69	1.8	111	55	78.29	

RUN 1 (1122-1222)

Moisture Recovery Data:

Impinger	1	2	3	Desiccant	Total
Final	150	134	6	936	
Initial	100	100	0	926	
Diff.	50	34	6	10	100

Standard Meter Volume	**Moisture Content (%v/v)**
42.71	**10.08**
Barometric Pressure (in Hg)	28.21
Meter Coefficient	1.0173

Vacuum: 9 in. Hg

Leak Checks
Pre-test: 0.000 at 10 in. Hg
Post-test: 0.000 at 10 in. Hg

RUN 2 (1422-1522)

Moisture Recovery Data:

Impinger	1	2	3	Desiccant	Total
Final	160	130	4	943	
Initial	100	100	0	936	
Diff.	60	30	0	7	97

Standard Meter Volume	**Moisture Content (%v/v)**
40.83	**10.21**
Barometric Pressure (in Hg)	28.21
Meter Coefficient	1.0173

Vacuum: 8 in. Hg

Pre-test: 0.000 at 10 in. Hg
Post-test: 0.000 at 12 in. Hg

RUN 3 (1604-1704)

Moisture Recovery Data:

Impinger	1	2	3	Desiccant	Total
Final	160	140	0	950	
Initial	100	100	0	943	
Diff.	60	40	0	7	107

Standard Meter Volume	**Moisture Content (%v/v)**
39.10	**11.58**
Barometric Pressure (in Hg)	28.21
Meter Coefficient	1.0173

Vacuum: 10 in. Hg

Pre-test: 0.000 at 11 in. Hg
Post-test: 0.000 at 12 in. Hg

RESULTS OF STACK MOISTURE DETERMINATIONS

Furnace Stack D (SV017)
Test Date: December 14, 2016
Baseline 1

Meter ID: AS-01 Meter Coefficient: 0.9919 Meter ΔH: 1.87

	RUN 1 (1122-1222)						RUN 2 (1422-1522)						RUN 3 (1604-1704)					
Run Time, Minutes	Meter Volume Vm, ft^3	Orifice ΔH, in H_2O	Stack Temp. Ts, °F	Impinger Temp. (°F)	Meter Inlet (°F)	Meter Outlet (°F)	Meter Volume Vm, ft^3	Orifice ΔH, in H_2O	Stack Temp. Ts, °F	Impinger Temp. (°F)	Meter Inlet (°F)	Meter Outlet (°F)	Meter Volume Vm, ft^3	Orifice ΔH, in H_2O	Stack Temp. Ts, °F	Impinger Temp. (°F)	Meter Inlet (°F)	Meter Outlet (°F)
	0.00						0.00						0.00					
5	3.30	1.87	114	30.2	78.6	-	0.36	0.06	117	30.7	73.9	-	3.84	0.06	116	46.9	78.6	-
10	7.22	1.87	115	32.5	79.9	-	0.62	0.01	117	34.3	73.9	-	7.73	0.06	116	48.7	78.6	-
15	11.14	1.87	114	37.4	79.9	-	0.89	0.01	115	36.1	74.5	-	11.63	0.06	117	51.8	78.6	-
20	15.05	1.87	114	43.3	79.9	-	1.16	0.01	116	36.1	75.0	-	15.53	0.06	116	56.7	78.6	-
25	18.98	1.87	114	51.8	80.4	-	1.46	0.02	117	35.6	75.7	-	19.43	0.06	116	63.9	79.2	-
30	22.91	1.87	114	62.1	81.0	-	1.76	0.02	117	35.1	75.7	-	23.33	0.06	113	70.3	78.6	-
35	26.84	1.87	115	71.1	81.0	-	2.26	0.02	117	39.2	76.3	-	27.25	0.06	117	74.7	78.6	-
40	30.77	1.87	115	76.5	81.0	-	6.09	1.87	117	36.9	76.8	-	31.17	0.06	114	77.0	78.6	-
45	34.70	1.87	114	78.3	81.0	-	10.01	1.87	117	38.7	78.1	-	35.09	0.06	113	78.3	78.1	-
50	38.64	1.87	115	78.8	81.5	-	13.93	1.87	117	44.1	78.6	-	39.01	0.06	116	78.8	77.4	-
55	42.58	1.87	116	78.8	81.5	-	17.86	1.87	117	51.8	79.2	-	42.93	0.06	114	79.3	77.4	-
60	46.51	1.87	116	78.3	81.5	-	21.78	1.87	117	62.6	79.2	-	46.85	0.06	114	80.1	76.8	-
	Total Meter Volume Vm, ft^3	Average Orifice ΔH, in H_2O	Average Stack Temp. (°F)	Average Impinger Temp. (°F)	Average Meter Temp. (°F)		Total Meter Volume Vm, ft^3	Average Orifice ΔH, in H_2O	Average Stack Temp. (°F)	Average Impinger Temp. (°F)	Average Meter Temp. (°F)		Total Meter Volume Vm, ft^3	Average Orifice ΔH, in H_2O	Average Stack Temp. (°F)	Average Impinger Temp. (°F)	Average Meter Temp. (°F)	
	46.51	1.9	115	60	80.60		21.78	0.8	117	40	76.41		46.85	0.1	115	67	78.26	

Moisture Recovery Data:

Impinger	1	2	3	Desiccant	Total	Impinger	1	2	3	Desiccant	Total	Impinger	1	2	3	Desiccant	Total
Final	134	140	14	983		Final	114	122	6	992		Final	112	170	0	1008	
Initial	100	100	0	967		Initial	100	100	0	983		Initial	100	100	0	992	
Diff.	34	40	14	16	104	Diff.	14	22	6	9	51	Diff.	12	70	0	16	98
Standard Meter Volume 43.38			**Moisture Content (%v/v)** **10.30**			Standard Meter Volume 20.42			**Moisture Content (%v/v)** **10.68**			Standard Meter Volume 43.67			**Moisture Content (%v/v)** **9.70**		
Barometric Pressure (in Hg)			28.20			Barometric Pressure (in Hg)			28.20			Barometric Pressure (in Hg)			28.20		
Meter Coefficient			0.9919			Meter Coefficient			0.9919			Meter Coefficient			0.9919		

	Run 1				Run 2				Run 3			
	Vacuum: 8 in. Hg				Vacuum: 6 in. Hg				Vacuum: 7 in. Hg			
Leak Checks	Pre-test: 0.000	at	7	in. Hg	Pre-test: 0.000	at	8	in. Hg	Pre-test: 0.000	at	12	in. Hg
	Post-test: 0.000	at	14	in. Hg	Post-test: 0.000	at	14	in. Hg	Post-test: 0.000	at	8	in. Hg

A T1/R1

BARR

EPA Method 30B
FIELD DATA SHEET

Project ArcelorMittal Minorca Mine

Sample Location Furnace Stack A

Date 12/13/16

Operators M. Petersen, M. Norstrom

Meter ID Dual Vost A

Meter A γ 0.9904 (1) unspiked

Meter B γ 0.9846 (2) spiked

Sample Rate 0.5 lpm

Bar. Press. 28.20 in. Hg

Test 1

Run 1

Sample Time ΔT	Meter A Volume Vma, liters unspiked	Meter B Volume Vmb, liters spiked	Stack Temp °F	Sample A Vacuum, (-) in Hg	Sample B Vacuum, (-) in Hg	Sorbent Ts, °F	Probe Tp, °F	Meter A Outlet Temp	Meter B Outlet Temp	Notes
(11:48)	0.000	0.000								
5	2.6	3.0	See Method 4	2	1.5	257	257	75	75	
10	5.2	6.0		2.5	2	258	258	75	75	
15	6.9	8.3		2.5	2	233	235	75	75	
20	8.6	10.6		2.5	2	218	218	75	75	
25	9.4	12.4		3	2	210	210	76	76	
30	10.5	14.2		3	2.5	208	205	76	76	
35	11.3	15.6		3	2.5	200	200	76	76	
40	12.3	17.1		3	2.5	200	200	76	76	
45	13.9	19.2		3.5	3.5	200	200	77	77	
50	15.1	20.9		4.5	4.5	200	200	77	77	
55	16.1	22.6		5	4.5	200	200	77	77	
60	16.502	24.56		5.5	5	200	200	78	78	
(12:48)										
Θ= 60	16.502	24.566	Ts= See M4					76	76	
	$\overline{Vma}$	$\overline{Vmb}$						$\overline{Tma}$	$\overline{Tmb}$	

Sample Train A Leak Rate (lpm)
Pretest 0.000 at 5 in Hg
Posttest 0.000 at 7 in Hg

Sample Train B Leak Rate (lpm)
Pretest 0.000 at 6 in Hg
Posttest 0.000 at 6 in Hg

Trap A ID 0LC035280
Spike Y/N No
Spike Level —

Trap B ID 0LC632147
Spike Y/N Yes
Spike Level 150ng

A +1/R2

BARR

EPA Method 30B
FIELD DATA SHEET

Project ArcelorMittal Minorca Mine
Sample Location Furnace Stack A
Date 12/13/10
Operators M. Peterson, M. Norstrom

Meter ID Dual Vost A
Meter A γ 0.9904 (1) unspiked
Meter B γ 0.9846 (2) spiked
Sample Rate 0.5 lpm
Bar. Press. 28.20 in. Hg

Test 1
Run 2

Sample Time ΔT	Meter A Volume Vma, liters (unspiked)	Meter B Volume Vmb, liters (spiked)	Stack Temp °F	Sample A Vacuum, (-) in Hg	Sample B Vacuum, (-) in Hg	Sorbent Ts, °F	Probe Tp, °F	Meter A Outlet Temp	Meter B Outlet Temp	Notes
(1350)	0.000	0.000								
5	2.7	2.9	See Method 4	2.5	2.5	260	260	79	79	
10	5.4	3.8		2.5	2.5	261	261	79	79	
15	8.0	4.8		2.5	5	260	260	79	79	
20	10.6	6.1		2.5	9	260	261	79	79	
25	13.2	8.3		2.5	15	261	261	79	79	
30	15.7	10.7		2.5	20	260	200	79	79	
35	17.9	11.4		2.5	20	261	260	79	79	
40	20.2	11.4		2.5	23	260	260	80	80	
45	22.4	11.4		2.5	23	260	260	80	80	
50	24.5	11.4		2.5	23	260	260	80	80	
55	26.7	11.46		2.3	23	260	260	80	80	
60	28.703	11.491		2.5	23	260	260	80	80	
(1450)										
Ø= 60	28.703	11.491	Ts= See M4					79	79	
	Vma	Vmb						Tma	Tmb	

Sample Train A Leak Rate (lpm)
Pretest 0.000 at 6.5 in Hg
Posttest 0.000 at 8 in Hg

Sample Train B Leak Rate (lpm)
Pretest 0.000 at 6 in Hg
Posttest 0.000 at 25 in Hg

Trap A ID 0LC039377
Spike Y/N NO
Spike Level —

Trap B ID 0L390546
Spike Y/N Yes
Spike Level 150ng

Spiked train icing up behind probe fighting to maintain flow (~10 minutes in) plugged at 35 minutes.

Ambient temp below zero.

A T1/R3

BARR

EPA Method 30B
FIELD DATA SHEET

Project ArcelorMittal Minorca Mine
Sample Location Furnace Stack
Date 12/13/16
Operators M. Petersen, M. Norstrom

Meter ID Dual Vost A
Meter A γ 0.9904 (1) unspiked
Meter B γ 0.9846 (2) spiked
Sample Rate 0.5 lpm
Bar. Press. 28.20 in. Hg

Test 1
Run 3

unspiked spiked

Sample Time ΔT	Meter A Volume Vma, liters	Meter B Volume Vmb, liters	Stack Temp °F	Sample A Vacuum, (-) in Hg	Sample B Vacuum, (-) in Hg	Sorbent Ts, °F	Probe Tp, °F	Meter A Outlet Temp	Meter B Outlet Temp	Notes
(1634)	0.000	0.000								
5	2.5	2.1	See Method 4	3	8	196	196	79	79	
10	5.0	3.7		3	9	200	200	79	79	spiked trap freezing up again
15	7.5	7.3		3	17	256	256	79	79	spike running better (dessicant)
20	9.9	10.1		3	11	260	260	79	79	now
25	12.3	12.8		3	11	260	260	79	79	
30	14.6	14.4		3	12.5	260	260	79	79	
35	16.9	17.3		3	22	260	260	80	80	~~Froze~~
40	19.2	21.6		3	19	260	260	80	80	unfroze, spiked
45	21.5	25.5		3	3	260	260	80	80	
50	23.8	28.1		3	3.5	260	264	80	80	
55	26.0	32.5		3	3.5	260	260	81	81	
60	28.334	35.306		3	3.5	260	260	81	81	
(1734)										
Ø= 60	28.351	35.306	Ts= See M4					80	80	
	Vma	Vmb						Tma	Tmb	

Sample Train A Leak Rate (lpm)
Pretest 0.002 at 5 in Hg
Posttest 0.000 at 5 in Hg

Sample Train B Leak Rate (lpm)
Pretest 0.002 at 7 in Hg
Posttest 0.000 at 23 in Hg

Trap A ID 0LC035418
Spike Y/N NO
Spike Level —

Trap B ID 0L390502
Spike Y/N Yes
Spike Level 150ng

B T2|R2

BARR

EPA Method 30B
FIELD DATA SHEET

Project ArcelorMittal Minorca Mine
Sample Location Furnace Stack B
Date 12/12/10
Operators M. Petersen, M. Norstrem

Meter ID Dual Vost B
Meter A γ 1.0002 (2) unspiked
Meter B γ 1.0069 (1) spiked
Sample Rate 0.5 lpm
Bar. Press. 28.20 in. Hg

Test 2
Run 1

Sample Time ΔT	Meter A Volume Vma, liters (unspiked)	Meter B Volume Vmb, liters (spiked)	Stack Temp °F	Sample A Vacuum, (-) in Hg	Sample B Vacuum, (-) in Hg	Sorbent Ts, °F	Probe Tp, °F	Meter A Outlet Temp	Meter B Outlet Temp	Notes
(1148)	0.000	0.000								
5	2.4	2.0	See Method 4	1.5	1.5	257	257	74	74	
10	4.6	4.1		2	2	210	240	75	75	
15	7.3	6.7		2	2	236	238	76	76	
20	9.8	8.7		2	2	225	225	76	76	
25	12.3	11.6		2	2	218	218	76	76	
30	14.2	12.8		2	2	206	205	77	77	
35	15.4	13.7		2	2	200	200	77	77	
40	16.6	14.6		2	2	200	200	77	77	
45	17.8	15.8		2	2	200	200	78	78	
50	18.9	16.8		4	3	200	200	78	78	
55	19.1	17.6		4	3	200	200	79	79	
60	20.556	18.675		4	3	200	200	79	79	
(1249)										
Ø= 60	20.556	18.675	Ts= See M4					77	77	
	Vma	Vmb						Tma	Tmb	

Sample Train A Leak Rate (lpm)
Pretest 0.002 at 12 in Hg
Posttest 0.000 at 6 in Hg

Sample Train B Leak Rate (lpm)
Pretest 0.000 at 6 in Hg
Posttest 0.000 at 6 in Hg

Trap A ID 0LC035312
Spike Y/N No
Spike Level —

Trap B ID 0LC032030
Spike Y/N Yes
Spike Level 150ng

B T2/R2

BARR

EPA Method 30B
FIELD DATA SHEET

Project ArcelorMittal Minorca Mine
Sample Location Furnace Stack B
Date 12/13/16
Operators M. Peterson, M. Norstrom

Meter ID Dual Vost B
Meter A γ 1.0662 (2) unspiked
Meter B γ 1.0069 (1) spiked
Sample Rate 0.5 lpm
Bar. Press. 28.20 in. Hg

Test 2
Run 2

Sample Time ΔT	Meter A Volume Vma, liters (unspiked)	Meter B Volume Vmb, liters (spiked)	Stack Temp °F	Sample A Vacuum, (-) in Hg	Sample B Vacuum, (-) in Hg	Sorbent Ts, °F	Probe Tp, °F	Meter A Outlet Temp	Meter B Outlet Temp	Notes
(1350)	0.000	0.000								
5	1.7	2.2	See Method 4	1	1	260	261	81	81	
10	3.6	4.7		1	1	261	261	81	81	
15	5.4	7.4		1	1	261	261	81	81	
20	7.2	9.9		1	1	260	260	81	81	
25	10.1	12.5		1	1	260	260	81	81	
30	13.2	14.9		1	1	260	260	82	82	
35	16.1	16.7		1	1	260	260	82	82	
40	18.6	18.4		1	1	260	260	82	82	
45	19.8	21.4		1	1	260	260	83	83	
50	23.4	21.5		1	1	260	260	83	82	
55	25.1	22.9		2.5	1	260	260	83	83	
60	26.204	25.157		3.5	1	260	260	83	83	
(1450)										
Θ= 60	26.204	25.157	$\overline{Ts}$= See M4					82	82	
	$\overline{V}$ma	$\overline{V}$mb						$\overline{T}$ma	$\overline{T}$mb	

Sample Train A Leak Rate (lpm)
Pretest 0.000 at 6.5 in Hg
Posttest 0.000 at 9 in Hg

Sample Train B Leak Rate (lpm)
Pretest 0.002 at 6 in Hg
Posttest 0.000 at 17 in Hg

Trap A ID OLC0352716
Spike Y/N No
Spike Level —

Trap B ID OL390537
Spike Y/N Yes
Spike Level 150ng

B T2/R3

BARR

EPA Method 30B
FIELD DATA SHEET

Project ArcelorMittal Minorca Mine

Sample Location Furnace Stack B

Date 12/13/16

Operators M. Peterson, M. Norstrom

Meter ID Dual Vost B

Meter A γ 1.0062 (2) unspiked

Meter B γ 1.0069 (1) spiked

Sample Rate 0.5 lpm

Bar. Press. 28.20 in. Hg

Test 2

Run 3

unspiked spiked

Sample Time ΔT	Meter A Volume Vma, liters	Meter B Volume Vmb, liters	Stack Temp °F	Sample A Vacuum, (-) in Hg	Sample B Vacuum, (-) in Hg	Sorbent Ts, °F	Probe Tp, °F	Meter A Outlet Temp	Meter B Outlet Temp	Notes
(1634)	0.000	0.000								
5	2.3	1.7	See Method 4	2.5	2.5	260	260	82	82	
10	4.9	3.4		2.5	2.5	260	260	82	82	
15	7.5	5.3		2	2.5	260	260	82	82	
20	10.0	7.3		2	2.5	260	260	82	82	
25	12.3	8.3		2	13	260	260	82	82	plugged up/spiked from
30	14.8	8.6		2	17.5	260	260	82	82	spike - frozen, hairdryer
35	17.6	8.6		2	21	260	260	83	83	
40	20.2	9.5		2	21	260	260	83	83	
45	22.8	11.5		2	2	260	260	83	83	unfroze spiked
50	25.4	13.9		2	2	260	260	83	83	
55	27.9	16.3		2	2	260	260	83	83	
60	30.382	18.555		2	2	260	260	83	83	
(1734)										
Ø= 60	30.382	18.575	Ts= See M4					83	83	
	Vma	Vmb						Tma	Tmb	

Sample Train A Leak Rate (lpm)

Pretest 0.000 at 6 in Hg

Posttest 0.000 at 5 in Hg

Sample Train B Leak Rate (lpm)

Pretest 0.000 at 6 in Hg

Posttest 0.001 at 21 in Hg

Trap A ID 0LC035395

Spike Y/N No

Spike Level —

Trap B ID 0LC032133

Spike Y/N Yes

Spike Level 150ng

C T3/R1

EPA Method 30B
FIELD DATA SHEET

Project ArcelorMittal Minorca Mine
Sample Location Furnace Stack C
Date 12/14/16
Operators M. Petersen, M. Norstrem

Meter ID Dual Vost A
Meter A γ 0.9904 (1) unspiked
Meter B γ 0.9846 (2) spiked
Sample Rate 0.5 lpm
Bar. Press. 28.21 in. Hg

Test 3
Run 1

Sample Time ΔT	unspiked Meter A Volume Vma, liters	spiked Meter B Volume Vmb, liters	Stack Temp °F	Sample A Vacuum, (-) in Hg	Sample B Vacuum, (-) in Hg	Sorbent Ts, °F	Probe Tp, °F	Meter A Outlet Temp	Meter B Outlet Temp	Notes
(1122)	0.000	0.000								
5	2.4	3.2	See Method 4	2	3	251	251	76	76	
10	4.7	6.3		3	3	251	251	76	76	
15	6.8	9.3		3	3	249	250	76	76	
20	9.1	12.0		3	3	250	250	76	76	
25	11.3	14.0		4	3.5	250	250	77	77	
30	13.4	16.2		4	3.5	250	251	77	77	
35	15.7	18.6		4	3.5	250	251	78	78	
40	17.9	20.9		4	3.5	250	250	78	78	
45	20.1	23.0		4	3.5	250	250	78	78	
50	22.8	24.3		4	3.5	250	250	79	79	
55	25.4	24.7		4	7	250	258	79	79	
60	27.725	27.690		4	12	250	250	79	79	
(1222)										
Ø= 60	27.725	27.690	Ts= See M4					77	77	
	Vma	Vmb						Tma	Tmb	

Sample Train A Leak Rate (lpm)
Pretest 0.000 at 6 in Hg
Posttest 0.000 at 5 in Hg

Sample Train B Leak Rate (lpm)
Pretest 0.000 at 6 in Hg
Posttest 0.000 at 13 in Hg

Trap A ID 0LC035270
Spike Y/N No
Spike Level —

Trap B ID 0LC032010
Spike Y/N Yes
Spike Level 150ng

C T3/R2

BARR

EPA Method 30B
FIELD DATA SHEET

Project ArcelorMittal Minorca Mine
Sample Location Furnace Stack C
Date 12/14/16
Operators M. Petersen, M. Norstrom

Meter ID Dual Vost A
Meter A γ 0.9904 (1)unspiked
Meter B γ 0.9846 (2)spiked
Sample Rate 0.5 lpm
Bar. Press. 28.21 in. Hg

Test 3
Run 2

Sample Time ΔT	Meter A Volume Vma, liters unspiked	Meter B Volume Vmb, liters spiked	Stack Temp °F	Sample A Vacuum, (-) in Hg	Sample B Vacuum, (-) in Hg	Sorbent Ts, °F	Probe Tp, °F	Meter A Outlet Temp	Meter B Outlet Temp	Notes
(1422)	0.000	0.000								
5	1.7	2.4	See Method 4	5	2.5	252	252	79	79	
10	3.4	4.3		9	3	251	251	79	79	A freezing up
15	4.5	6.0		18	3.5	258	250	78	78	
20	4.6	9.2		23	4	250	250	78	78	
25	4.7	12.4		23	4	249	250	78	78	
30	6.3	15.6		23	4	250	250	78	78	
35	10.3	18.8		5.5	4	250	251	78	78	A, thawed out
40	14.3	22.0		5	4	250	250	78	78	
45	18.0	25.2		5	4	250	250	78	78	
50	21.7	28.2		5	4	251	250	78	78	
55	25.4	31.5		5	4	250	251	78	78	
60	28.917	34.442		5	4	250	250	79	79	
(1522)										
Ø= 60	28.917	34.442	Ts= See M4					78	78	
	$\overline{V}$ma	$\overline{V}$mb						$\overline{T}$ma	$\overline{T}$mb	

Sample Train A Leak Rate (lpm)
Pretest 0.000 at 10 in Hg
Posttest 0.000 at 23 in Hg

Sample Train B Leak Rate (lpm)
Pretest 0.000 at 5 in Hg
Posttest 0.000 at 6 in Hg

Trap A ID 0LC0353602
Spike Y/N No
Spike Level —

Trap B ID 0LC032055
Spike Y/N Yes
Spike Level 150ng

C T3/R3

BARR

EPA Method 30B
FIELD DATA SHEET

Project ArcelorMittal Minorca Mine
Sample Location Furnace Stack C
Date 12/14/16
Operators M. Peterson, M. Norstrom

Meter ID Dual Vost A
Meter A γ 0.9904 (1) unspiked
Meter B γ 0.9846 (2) spiked
Sample Rate 0.5 lpm
Bar. Press. 28.21 in. Hg

Test 3
Run 3

unspiked spiked

Sample Time ΔT	Meter A Volume Vma, liters	Meter B Volume Vmb, liters	Stack Temp °F	Sample A Vacuum, (-) in Hg	Sample B Vacuum, (-) in Hg	Sorbent Ts, °F	Probe Tp, °F	Meter A Outlet Temp	Meter B Outlet Temp	Notes
(1604)	0.000	0.000								
5	2.6	3.0	See Method 4	3.5	3.5	252	252	79	79	
10	5.3	6.0		3.5	3.5	250	250	79	79	
15	7.7	8.6		3.5	3.5	251	251	79	79	
20	10.1	11.3		3.5	3.5	250	250	79	79	
25	12.5	14.1		3.5	3.5	251	250	79	79	
30	14.8	16.5		3.5	3.5	250	251	79	80	
35	17.2	19.0		3.5	3	250	250	80	80	
40	19.5	21.3		3.5	3	250	250	80	80	
45	21.8	23.7		3.5	3	250	251	80	80	
50	24.1	26.2		3.5	3	250	250	80	80	
55	26.5	28.6		3.5	3	250	250	80	80	
60	28.854	31.047		3.5	3	250	249	80	80	
(1704)										
Ø= 60	28.854	31.047	Ts= See M4					80	80	
	Vma	Vmb						Tma	Tmb	

Sample Train A Leak Rate (lpm)
Pretest 0.000 at 8 in Hg
Posttest 0.000 at 6 in Hg

Sample Train B Leak Rate (lpm)
Pretest 0.000 at 6 in Hg
Posttest 0.000 at 5 in Hg

Trap A ID 0LC035381
Spike Y/N No
Spike Level —

Trap B ID 0L390556
Spike Y/N Yes
Spike Level 150ng

D T4/R1

BARR

EPA Method 30B
FIELD DATA SHEET

Project ArcelorMittal Minorca Mine
Sample Location Furnace Stack D
Date 12/14/16
Operators M. Peterson, M. Norstrom

Meter ID Dual Vost B
Meter A γ 1.0069 (1) unspiked
Meter B γ 1.0002 (2) spiked
Sample Rate 0.5 lpm
Bar. Press. 28.21 in. Hg

Test 4
Run 1

Sample Time ΔT	Meter A Volume Vma, liters (unspiked)	Meter B Volume Vmb, liters (spiked)	Stack Temp °F	Sample A Vacuum, (-) in Hg	Sample B Vacuum, (-) in Hg	Sorbent Ts, °F	Probe Tp, °F	Meter A Outlet Temp	Meter B Outlet Temp	Notes
(1122)	0.000	0.000								
5	4.8	2.8	See Method 4	3	3	250	250	76	76	
10	8.1	5.4		3	3	250	250	76	76	
15	11.0	7.0		2.5	3.5	250	249	76	76	
20	13.5	9.1		2	2	250	250	76	76	
25	16.1	12.4		2	3	250	249	77	77	
30	17.6	15.3		~~4~~ 2	~~3.5~~ 3	250	251	77	77	
35	19.8	16.5		2	3	250	250	77	78	
40	21.9	17.1		2	3	250	250	78	78	B starting to freeze up
45	23.9	18.2		2	3	250	250	78	78	
50	24.4	18.7		2	16	250	250	79	79	
55	26.9	19.6		3	20	250	250	79	79	
60	30.503	19.840		3	20	250	250	79	79	
(1222)										
Ø= 60	30.503	19.840	Ts= See M4					77	77	
	Vma	Vmb						Tma	Tmb	

Sample Train A Leak Rate (lpm)			Sample Train B Leak Rate (lpm)						
Pretest	0.000	at 8 in Hg	Pretest	0.000	at 5 in Hg	Trap A ID	OLC035311	Trap B ID	OLC032026
Posttest	0.000	at 10 in Hg	Posttest	0.000	at 21 in Hg	Spike Y/N	NO	Spike Y/N	Yes
						Spike Level	—	Spike Level	150ng

D J4/R2

EPA Method 30B
FIELD DATA SHEET

Project ArcelorMittal Minorca Mine
Sample Location Furnace Stack D
Date 12/14/16
Operators M. Petersen, M. Norstrem

Meter ID Dual Vost B
Meter A γ 1.0069 (1) unspiked
Meter B γ 1.0002 (2) spiked
Sample Rate 0.5 lpm
Bar. Press. 28.21 in. Hg

Test 4
Run 2

Sample Time ΔT	Meter A Volume Vma, liters unspiked	Meter B Volume Vmb, liters spiked	Stack Temp °F	Sample A Vacuum, (-) in Hg	Sample B Vacuum, (-) in Hg	Sorbent Ts, °F	Probe Tp, °F	Meter A Outlet Temp	Meter B Outlet Temp	Notes
(1422)	0.000	0.000								
5	2.9	2.3	See Method 4	2	2	252	252	77	77	
10	5.7	4.7		2	2	251	251	76	76	
15	8.5	7.4		2	2	250	250	76	76	
20	11.4	10.1		2	2.5	250	250	77	77	
25	14.2	12.6		2	2.5	250	251	77	77	
30	16.8	15.2		2	2.5	250	250	77	77	
35	19.3	17.8		2	2.5	250	249	77	77	
40	21.6	20.4		2	2.5	250	251	77	77	
45	23.7	22.7		2	2.5	250	250	77	77	
50	26.3	25.4		2	2.5	250	251	77	77	
55	28.7	28.2		2	2.5	250	249	78	78	
60	30.933	30.683		2	2.5	250	250	78	79	
(1522)										
Ø= 60	30.933	30.683	Ts= See M4					77	77	
	Vma	Vmb						Tma	Tmb	

Sample Train A Leak Rate (lpm)
Pretest 0.000 at 7 in Hg
Posttest 0.000 at 6 in Hg

Sample Train B Leak Rate (lpm)
Pretest 0.000 at 6 in Hg
Posttest 0.003 at 5 in Hg

Trap A ID 0LC0352816
Spike Y/N NO
Spike Level —

Trap B ID 0L3905509
Spike Y/N Yes
Spike Level 150ng

D T4/R3

BARR

EPA Method 30B
FIELD DATA SHEET

Project ArcelorMittal Minorca Mine
Sample Location Furnace Stack D
Date 12/14/16
Operators M. Petersen, M. Norstrom

Meter ID Dual Vost B
Meter A γ 1.0069 (1) unspiked
Meter B γ 1.0002 (2) spiked
Sample Rate 0.5 lpm
Bar. Press. 28.21 in. Hg

Test 4
Run 3

unspiked spiked

Sample Time ΔT	Meter A Volume Vma, liters	Meter B Volume Vmb, liters	Stack Temp °F	Sample A Vacuum, (-) in Hg	Sample B Vacuum, (-) in Hg	Sorbent Ts, °F	Probe Tp, °F	Meter A Outlet Temp	Meter B Outlet Temp	Notes
(1604)	0.000	0.000								
5	2.2	2.2	See Method 4	2	2	252	252	78	78	
10	4.9	4.8		2	2	250	250	78	78	
15	7.1	7.3		2	2	250	250	78	78	
20	9.7	9.8		2	2	250	250	78	78	
25	12.1	12.3		2	2	258	250	78	78	
30	14.7	14.9		2	2	250	249	78	78	
35	17.3	17.4		2	2	249	250	78	78	
40	19.8	19.9		2	2	250	251	79	79	
45	22.3	22.4		2	2	250	251	79	79	
50	24.8	24.9		2	2	250	250	79	79	
55	27.3	27.4		2	2	250	250	79	79	
60	29.779	29.820		2	2	250	250	79	79	
(1704)										
Ø= 60	29.779	29.820	Ts= See M4					78	78	
	Vma	Vmb						Tma	Tmb	

Sample Train A Leak Rate (lpm)
Pretest 0.000 at 5 in Hg
Posttest 0.000 at 4 in Hg

Sample Train B Leak Rate (lpm)
Pretest 0.000 at 5 in Hg
Posttest 0.000 at 4 in Hg

Trap A ID 0LC035259
Spike Y/N No
Spike Level

Trap B ID 0LC032050
Spike Y/N Yes
Spike Level 150ng

EPA METHOD 3A -- Instrument Analysis Data Sheet

Project: ArcelorMittal - Hg Screening
Sample Location: Furnace Stacks C and D / Tests 1, 2
Date: 1/17/2017
Operators: M. Petersen

Analyzer Make / Model / Serial No. Servomex 1440
Analyzer O_2 Range (span), %: 0-25%
Analyzer CO_2 Range (span), %: 0-25%

	Cylinder Serial No.	O2 Cert. Conc.	CO2 Cert. Conc.
Zero Gas	Nitrogen Lot#N70001633603	0.0	0.0
O2/CO2 Mid gas	CC116801	9.5	9.5
O2 High gas	CA06643	21.6	-
CO2 High gas	-	-	-

PRETEST ANALYZER CALIBRATION DATA

	O2		CO2	
	Cylinder Value, %	Analyzer Calibration Response, %	Cylinder Value, %	Analyzer Calibration Response, %
Zero Gas	0.0	0	0.0	0
Mid-range:	9.5	9.6	9.5	9.5
High-range:	21.6	21.6	-	-

Time of Calibration___ 1020

INTEGRATED BAG ANALYSIS

Location/Test No.	Furnace Stack C / Test 1			Furnace Stack D / Test 2		
Run No.	**1**	**2**	**3**	**1**	**2**	**3**
Time Sampled	1007 - 1041	1116 - 1147	1216 - 1249	1007 - 1041	1116 - 1147	1216 - 1249
Time Analyzed	1100	1155	1300	1104	1157	1303
O2, %	18.9	18.8	18.8	18.4	18.4	18.4
CO2,%	1.6	1.6	1.6	2	2	2

POSTTEST ANALYZER CALIBRATION DATA

	O2		CO2	
	Cylinder Value, %	Analyzer Calibration Response, %	Cylinder Value, %	Analyzer Calibration Response, %
Zero Gas	0.0	0	0.0	0
Mid-range:	9.5	9.6	9.5	9.5
High-range:	21.6	21.7	-	-

BARR

EPA METHOD 3A -- Instrument Analysis Data Sheet

Project ArcelorMittal - Hg Screening
Sample Location Furnace Stacks C and D / Tests 3, 4
Date 1/18/2017
Operators M. Petersen

Analyzer Make / Model / Serial No. _____ Servomex #1440
Analyzer O_2 Range (span), %: 0-25%
Analyzer CO_2 Range (span), %: 0-25%

	Cylinder Serial No.	O2 Cert. Conc.	CO2 Cert. Conc.
Zero Gas	Nitrogen Lot#N70001633603	0.0	0.0
O2/CO2 Mid gas	CC116801	9.5	9.5
O2 High gas	CA06643	21.6	-

PRETEST ANALYZER CALIBRATION DATA

	O2		CO2	
	Cylinder Value, %	Analyzer Calibration Response, %	Cylinder Value, %	Analyzer Calibration Response, %
Zero Gas	0.0	0	0.0	0
Mid-range:	9.5	9.5	9.5	9.5
High-range:	21.6	21.6	-	-

Time of Calibration___ 905

INTEGRATED BAG ANALYSIS

Location/Test No.	Furnace Stack C / Test 3			Furnace Stack D / Test 4		
Run No.	**1**	**2**	**3**	**1**	**2**	**3**
Time Sampled	901 - 934	1009 - 1041	1116 - 1148	901 - 934	1009 - 1041	1116 - 1148
Time Analyzed	950	1051	1200	953	1053	1203
O2, %	18.8	18.8	18.8	18.3	18.3	18.3
CO2,%	1.7	1.7	1.6	2	2	2

POSTTEST ANALYZER CALIBRATION DATA

	O2		CO2	
	Cylinder Value, %	Analyzer Calibration Response, %	Cylinder Value, %	Analyzer Calibration Response, %
Zero Gas	0.0	0	0.0	0
Mid-range:	9.5	9.6	9.5	9.5
High-range:	21.6	21.7	-	-

C

T1/R1

BARR

EPA METHOD 5
FIELD DATA SHEET

Project ArcelorMittal Minorca Mine
Smpl Loc Furnace Stack C SV016
Test No. 1 Run
Date 1-17-17 Operators MTP, DJK

Meter ID ~~DNB~~ AS-01
Meter Y 0.9852
Orifice H@

Probe ID 5-2
Pitot No. 5-2
Pitot Cp 0.84
Liner Type: Glass ☑ S.S. ☐

Bar. Pres 28.21 in Hg
Stat. Pres -0.80 in H_2O
Probe Lgth 5 ft
Other:______ Imp TC______

Sample Train Leak Rate (cfm)			
Pretest	0.000	at 9	in Hg
Posttest	0.000	at 15	in Hg
Pitot (3 in. Pos. ☑		Neg. ☑	

Sample Point	Sample Time Δθ	Meter Volume Vm, ft³	Velocity ΔP, in H_2O	Orifice ΔH, in H_2O	Sample Vacuum, in Hg	Stack Temp. Ts, °F	Sample Train Temperatures, °F Probe	Filter	Impinger Outlet	Meter Inlet	Meter Outlet	Oxygen Content, %	
	(1007)	0.000										(Optional)	
A-3	5	3.75	0.95	1.69	7	114	230	230	26	81	81	18.9	1.6
2	10	7.37	0.88	1.57	6.5	114	230	230	30	81	81		
1	15	11.09	0.95	1.69	7	114	230	230	34	82	82	19.0	1.6
B-3	20	14.65	1.00	1.78	7.5	114	242	232	38	82	82		
2	25	18.49	0.89	1.59	7	114	242	235	39	83	83	18.9	1.6
1	30	22.13	0.90	1.61	7	114	242	236	42	83	83		
	Δθ= 30	Vm 22.13		ΔH 1.65		Ts 114				Tm=	82.0		

	Initialization Values			Test Run Times		ORSAT System			Sample Train Components		
	Meter Temp	Oxygen Content	Moisture Content	Start Time	End Time	Bag No.	Bag Vol	cc/min * at 15 in Hg	Filter No.	Nozzle No.	Nozzle Dn
Run __	81	18.5	12.0	1007	1041	1-1	20	0.00	421676	2-7	0.213
											0.214

Nozzle Calibration	
☐ See Run 1	☐ See E-Copy
Tech.	Date
Nozzle No.	
1	
2	
3	
Avg. in.	

MOISTURE RECOVERY:	RUN __					
Impinger	1	2	3	4	Desiccant	Total
Final wt., g	108	~~180~~ 130	0		979	
Initial wt., g	100	100	0		975	
Difference	8	30	0		4	42

	Air Flows	
	ACFM	DSCFM
Run __	208,343	164,364

C
T1/R2

BARR

EPA METHOD 5
FIELD DATA SHEET

Project ArcelorMittal Minorca Mine
Smpl Loc Furnace Stack C SV016
Test No. 1 Run 2
Date 1-17-17 Operators MTP, DJK

Meter ID AS-01
Meter Y 0.9852
Orifice H@ 1.86
Liner Type: Glass ☑ S.S. ☐

Probe ID 5-2
Pitot No. 5-2
Pitot Cp 0.84
Other:______

Bar. Pres 28.24 in Hg
Stat. Pres -0.80 in H_2O
Probe Lgth 5 ft
Imp TC______

Sample Train Leak Rate (cfm)	
Pretest 0.003 at 10 in Hg	
Posttest 0.000 at 16 in Hg	
Pitot (3 in. Pos. ☑	Neg. ☑

Sample Point	Sample Time Δt	Meter Volume Vm, ft³	Velocity ΔP, in H_2O	Orifice ΔH, in H_2O	Sample Vacuum, in Hg	Stack Temp. Ts, °F	Sample Train Temperatures, °F Probe	Filter	Impinger Outlet	Meter Inlet	Meter Outlet	Oxygen Content, %	
		0.00										(Optional)	
B-3	5	2.64	0.91	1.72	7	115	247	233	42	83	83	18.9	1.6
2	10	6.35	0.89	1.68	7	115	248	235	43	83	83		
1	15	10.13	0.86	1.62	7.5	116	248	240	48	83	83	18.0	1.6
A-3	20	13.66	0.84	1.58	7	118	245	240	48	83	83		
2	25	17.38	0.89	1.68	7	118	233	236	48	84	84	18.0	1.6
1	30	21.05	0.86	1.62	7	116	235	235	49	85	85		
	θ= 30	Vm 21.05		$\overline{ΔH}$ 1.65		$\overline{Ts}$ 115.67				Tm=	83.50		

	Initialization Values			Test Run Times		ORSAT System			Sample Train Components		
	Meter Temp	Oxygen Content	Moisture Content	Start Time	End Time	Bag No.	Bag Vol	cc/min * at 15 in Hg	Filter No.	Nozzle No.	Nozzle Dn
Run __	83	19.0	8.9	1118	1147	1-2	20.0	0.00	421693	2-7	0.214

Nozzle Calibration	
☐ See Run 1	☐ See E-Copy
Tech.	Date
Nozzle No.	
1	
2	
3	
Avg. in.	

MOISTURE RECOVERY:	RUN __					
Impinger	1	2	3	4	Desiccant	Total
Final wt., g	96	134	0	X	984	
Initial wt., g	100	100	0		979	
Difference	-4	34	0		5	35

	Air Flows	
	ACFM	DSCFM
Run __	202,132	160,745

BARR

C
T1R3

EPA METHOD 5
FIELD DATA SHEET

Project ArcelorMittal Minorca Mine
Smpl Loc Furnace Stack C SV016
Test No. 1 Run 3
Date 1-17-17 Operators MTP, DJK

Meter ID AS-01
Meter Y 0.9852
Orifice H@ 1.86
Liner Type: Glass ☑ S.S. ☐

Probe ID 5-2
Pitot No. 5-2
Pitot Cp C 0.84
Other:

Bar. Pres 28.24 in Hg
Stat. Pres -0.80 in H_2O
Probe Lgth 5 ft
Imp TC

Sample Train Leak Rate (cfm)
Pretest 0.000 at 6 in Hg
Posttest 0.000 at 9 in Hg
Pitot (3 in. Pos. ☑ Neg. ☑

Sample Point	Sample Time Δt	Meter Volume vm, ft³	Velocity ΔP, in H_2O	Orifice ΔH, in H_2O	Sample Vacuum, in Hg	Stack Temp. Ts, °F	Sample Train Temperatures, °F Probe	Filter	Impinger Outlet	Meter Inlet	Meter Outlet	Oxygen Content, %	
		0.000										(Optional)	
A-3	5	3.75	0.96	1.85	8	115	238	234	43	84	84	18.8	1.6
2	10	7.50	0.87	1.67	7	116	238	234	43	85	85		
1	15	11.21	0.85	1.64	7	115	236	235	45	86	86	18.8	1.7
	20	15.02	0.94	1.81	7.5	115	236	234	45	86	86		
	25	18.97	0.92	1.77	8	116	246	240	50	87	87	18.9	1.6
	30	22.71	0.91	1.76	8	115	248	240	54	88	88		
	θ= 30	Vm 22.71		ΔH 1.75		Ts 115.33				Tm=	86.00		

	Initialization Values Meter Temp	Oxygen Content	Moisture Content	Test Run Times Start Time	End Time	ORSAT System Bag No.	Bag Vol	cc/min * at 15 in Hg	Sample Train Components Filter No.	Nozzle No.	Nozzle Dn
Run __	84	19.0	7.9	1216	1249	1-3	20.0	0.00	421695	2-7	0.214

Nozzle Calibration
☐ See Run 1 ☐ See E-Copy

Tech.	Date
Nozzle No.	
1	
2	
3	
Avg. in.	

MOISTURE RECOVERY:	RUN __					
Impinger	1	2	3	4	Desiccant	Total
Final wt., g	126	120	2	X	989	
Initial wt., g	100	100	0		984	
Difference	26	30	2		5	53

	Air Flows ACFM	DSCFM
Run __	206,982	159,792

D

T2/R1

BARR

EPA METHOD 5
FIELD DATA SHEET

Project ArcelorMittal Minorca Mine
Smpl Loc Furnace Stack D SV017
Test No. 2 Run 1
Date 1-17-17 Operators MTT-JSR

Meter ID C-10
Meter Y 09973
Orifice H@ 1.8828
Liner Type: Glass ☑ S.S. ☐

Probe ID ~~2-10~~ 5-3
Pitot No. 5-3
Pitot Cp 0.84
Other:____

Bar. Pres 28.24 in Hg
Stat. Pres -0.70 in H_2O
Probe Lgth 5 ft
Imp TC____

Sample Train Leak Rate (cfm)				
Pretest	0.000	at	7	in Hg
Posttest	0.000	at	10	in Hg
Pitot (3 in. Pos. ☑			Neg. ☑	

Sample Point	Sample Time Δt	Meter Volume vm, ft³	Velocity ΔP, in H_2O	Orifice ΔH, in H_2O	Sample Vacuum, in Hg	Stack Temp. Ts, °F	Sample Train Temperatures, °F Probe	Filter	Impinger Outlet	Meter Inlet	Meter Outlet	Oxygen Content, %
	(1007)	827.00										(Optional)
A-3	5	830.36	0.75	1.43	5.5	116	250	250	24	73	74	18.4
2	10	833.50	0.74	1.41	5.5	115	251	251	26	73	74	
1	15	836.77	0.69	1.32	5.5	116	250	251	26	72	74	18.5
B-3	20	840.01	0.72	1.37	5.5	115	252	253	27	73	74	
2	25	843.27	0.75	1.43	6	116	249	250	31	72	74	18.5
1	30	846.54	0.73	1.39	6	116	247	249	32	72	74	
	(1041)											
	θ= 30	Vm 19.59		ΔH 1.39		Ts 115.67					Tm= 73.26	

	Initialization Values			Test Run Times		ORSAT System			Sample Train Components		
	Meter Temp	Oxygen Content	Moisture Content	Start Time	End Time	Bag No.	Bag Vol	cc/min * at 15 in Hg	Filter No.	Nozzle No.	Nozzle Dn
Run __	74	18.0	11.0	1007	1041	2-1	20	0.00	421677	5-7	0.217

Nozzle Calibration	
☐ See Run 1	☐ See E-Copy
Tech.	Date
Nozzle No.	
1	
2	
3	
Avg. in.	

MOISTURE RECOVERY:	RUN __					
Impinger	1	2	3	4	Desiccant	Total
Final wt., g	138	106	0	X	1009	
Initial wt., g	100	100	0		1006	
Difference	38	6	0		3	47

	Air Flows	
	ACFM	DSCFM
Run __	185,521	143,035

BARR

D

P2/R2

EPA METHOD 5
FIELD DATA SHEET

Project ArcelorMittal Minorca Mine
Smpl Loc Furnace Stack D SV017
Test No. 2 Run 2
Date 1-17-17 Operators MTP, PJK

Meter ID C-10
Meter Y 0.9975
Orifice H@ 1.8829
Liner Type: Glass ☑ S.S. ☐

Probe ID 5-3
Pitot No. 5-3
Pitot Cp 0.84
Bar. Pres 28.24 in Hg
Stat. Pres -0.70 in H_2O
Probe Lgth 5 ft
Other:______ Imp TC______

Sample Train Leak Rate (cfm)			
Pretest 0.000	at 10	in Hg	
Posttest 0.000	at 8	in Hg	
Pitot (3 in. Pos. ☑		Neg. ☑	

Sample Point	Sample Time Δt	Meter Volume Vm, ft³	Velocity ΔP, in H_2O	Orifice ΔH, in H_2O	Sample Vacuum, in Hg	Stack Temp. Ts, °F	Sample Train Temperatures, °F Probe	Filter	Impinger Outlet	Meter Inlet	Meter Outlet	Oxygen Content, %	CO2
	(1116)	847.45								T		(Optional)	
B-3	5	850.81	0.83	1.59	6.5	116	252	250	37	73	74	18.4	2.0
2	10	854.38	0.80	1.53	7	116	252	252	37	73	74		
1	15	857.79	0.80	1.53	7	116	251	250	39	73	74	18.5	2.0
AB-3	20	861.14	0.68	1.30	6	117	250	252	41	73	74		
2	25	864.42	0.70	1.34	6	117	250	249	41	74	74	18.4	1.9
1	30	867.76	0.66	1.26	6	117	248	247	42	74	74		
	θ= 30	Vm 20.31		ΔH 1.43		Ts 116.67				Tm=	73.67		

	Initialization Values			Test Run Times		ORSAT System			Sample Train Components		
	Meter Temp	Oxygen Content	Moisture Content	Start Time	End Time	Bag No.	Bag Vol	cc/min * at 15 in Hg	Filter No.	Nozzle No.	Nozzle Dn
Run __	74	10.0	10.8	1116	1147	2-2	20 L	0.00	421694	5-7	2.17

Nozzle Calibration	
☐ See Run 1	☐ See E-Copy
Tech.	Date
Nozzle No.	
1	.
2	
3	
Avg. in.	

MOISTURE RECOVERY:	RUN __					
Impinger	1	2	3	4	Desiccant	Total
Final wt., g	140	108	0		1013	
Initial wt., g	100	100	0		1009	
Difference	40	8	0		4	52

	Air Flows	
	ACFM	DSCFM
Run __	187,529	143,819

BARR

D
T2/R3

EPA METHOD 5
FIELD DATA SHEET

Project ArcelorMittal Minorca Mine
Smpl Loc Furnace Stack D SV017
Test No. 2 Run 3
Date 1-17-17 Operators MTP, DJK

Meter ID C-10
Meter Y 0.9973
Orifice H@ 1.8829
Liner Type: Glass ☑ S.S. ☐

Probe ID 5-3
Pitot No. 5-3
Pitot Cp 0.84
Other:

Bar. Pres 28.21 in Hg
Stat. Pres -0.70 in H_2O
Probe Lgth 5 ft
Imp TC

Sample Train Leak Rate (cfm)			
Pretest 0.000	at 7	in Hg	
Posttest 0.000	at 9	in Hg	
Pitot (3 in. Pos. ☑		Neg. ☑	

Sample Point	Sample Time Δt	Meter Volume Vm, ft³	Velocity ΔP, in H_2O	Orifice ΔH, in H_2O	Sample Vacuum, in Hg	Stack Temp. Ts, °F	Sample Train Temperatures, °F Probe	Filter	Impinger Outlet	Meter Inlet	Meter Outlet	Oxygen Content, %	
	( )	867.98										(Optional)	
A-3	5	871.16	0.74	1.42	6	115	226	251	38	75	75	18.4	1.9
2	10	874.65	0.93	1.78	8	116	250	230	38	75	75		
1	15	878.33	0.95	1.81	8	116	250	233	39	75	75	18.4	2.0
B-3	20	882.03	0.83	1.59	7.5	116	252	251	39	75	78		
2	25	885.5	0.78	1.49	7.5	118	249	251	44	76	77	18.4	2.0
1	30	888.95	0.75	1.44	7.5	117	250	250	47	76	76		
	θ= 30	Vm 20.97		ΔH 1.57		Ts 116.33				Tm=	75.42		

	Initialization Values			Test Run Times		ORSAT System			Sample Train Components		
	Meter Temp	Oxygen Content	Moisture Content	Start Time	End Time	Bag No.	Bag Vol	cc/min * at 15 in Hg	Filter No.	Nozzle No.	Nozzle Dn
Run __	74	18.0	11.0	1216	1249	2-3	200	0.00	421696	5-7	0.217

Nozzle Calibration	
☐ See Run 1	☐ See E-Copy
Tech.	Date
Nozzle No.	
1	
2	
3	
Avg. in.	

MOISTURE RECOVERY:	RUN __					
Impinger	1	2	3	4	Desiccant	Total
Final wt., g	130	112	2	X	1018	
Initial wt., g	100	100	0		1013	
Difference	30	12	2		5	49

	Air Flows	
	ACFM	DSCFM
Run __	197,625	152,561

C
T3/R1

BA-2B
T10#2162

BARR

EPA METHOD 5
FIELD DATA SHEET

Project ArcelorMittal Minorca Mine
Smpl Loc Furnace Stack C SV016
Test No. 3 ~~1-18-17~~ Run 1
Date 1-18-17 Operators MTP, DJK

Meter ID AS-01
Meter Y 0.9852
Orifice H@ 1.86
Liner Type: Glass ☑ S.S. ☐

Probe ID 5-2
Pitot No. 5-2
Pitot Cp 0.84
Other:

Bar. Pres 28.07 in Hg
Stat. Pres -0.80 in H_2O
Probe Lgth 5 ft
Imp TC

Sample Train Leak Rate (cfm)			
Pretest 0.000	at	8	in Hg
Posttest 0.00	at	9	in Hg
Pitot (3 in. Pos. ☑		Neg. ☑	

Sample Point	Sample Time Δt	Meter Volume Vm, ft³	Velocity ΔP, in H_2O	Orifice ΔH, in H_2O	Sample Vacuum, in Hg	Stack Temp. Ts, °F	Sample Train Temperatures, °F Probe	Filter	Impinger Outlet	Meter Inlet	Meter Outlet	Oxygen Content, % (Optional)	CO2
		0.000											
B-3	5	3.64	0.96	1.71	7	114	254	234	34	62	62	18.8	1.7
2	10	7.36	0.93	1.65	7	116	253	234	36	64	64		
1	15	11.01	0.89	1.59	7	116	253	235	38	66	66	18.8	1.7
A-3	20	14.74	0.98	1.70	7	115	254	234	37	67	67		
2	25	18.51	0.96	1.72	7.5	116	233	230	40	70	70	18.8	1.7
1	30	21.99	0.89	1.61	8	114	233	228	39	72	72		
	θ= 30	Vm 21.99		ΔH 1.67		Ts 115.17					Tm= 66.83		

Run	Initialization Values Meter Temp	Oxygen Content	Moisture Content	Test Run Times Start Time	End Time	ORSAT System Bag No.	Bag Vol	cc/min * at 15 in Hg	Sample Train Components Filter No.	Nozzle No.	Nozzle Dn
Run __	~~57~~ 62	19.0	10.0	0901	0934	3-1	20.2	0.00	421707	2-7	0.214

Nozzle Calibration	
☐ See Run 1	☐ See E-Copy
Tech.	Date
Nozzle No.	
1	
2	
3	
Avg. in.	

MOISTURE RECOVERY:	RUN __					
Impinger	1	2	3	4	Desiccant	Total
Final wt., g	136	112	0	X	992	
Initial wt., g	100	100	0		989	
Difference	36	12	0		3	51

	Air Flows ACFM	DSCFM
Run __	~~197,109~~ ~~148~~ 210,970	~~142,325~~ 162,265

C

T3 R2

BARR

EPA METHOD 5
FIELD DATA SHEET

Project ArcelorMittal Minorca Mine
Smpl Loc Furnace Stack C SV016
Test No. 3 Run 2
Date 1-18-17 Operators MTP, DJK

Meter ID AS-01
Meter Y 0.9852
Orifice H@ 1.88
Liner Type: Glass ☑ S.S. ☐

Probe ID 5-2
Pitot No. 5-2
Pitot Cp 0.84
Bar. Pres 28.07 in Hg
Stat. Pres -0.80 in H_2O
Probe Lgth 5 ft
Other:______ Imp TC______

Sample Train Leak Rate (cfm)				
Pretest	0.000	at	6	in Hg
Posttest	0.000	at	8.5	in Hg
Pitot (3 in. Pos. ☑			Neg. ☑	

Sample Point	Sample Time ΔI	Meter Volume vm, ft³	Velocity ΔP, in H_2O	Orifice ΔH, in H_2O	Sample Vacuum, in Hg	Stack Temp. Ts, °F	Sample Train Temperatures, °F Probe	Filter	Impinger Outlet	Meter Inlet	Meter Outlet	Oxygen Content, %	CO_2
		0.000										(Optional)	
A-3	5	3.50	0.95	1.71	6	115	228	232	32	75	75	18.8	1.7
2	10	7.20	0.93	1.68	7	114	234	229	36	76	76		
1	15	10.91	0.92	1.67	6	114	237	220	37	77	77	18.9	1.7
B-3	20	14.54	0.98	1.78	7	114	233	233	37	78	78		
2	25	18.05	0.89	1.62	7	114	245	236	42	80	80	18.8	1.7
1	30	21.83	0.80	1.57	7	115	245	237	45	81	81		
	θ= 30	Vm 21.83		$\overline{\Delta H}$ 1.67		$\overline{Ts}$ 114.33					$\overline{Tm}$= 77.83		

	Initialization Values Meter Temp	Oxygen Content	Moisture Content	Test Run Times Start Time	End Time	ORSAT System Bag No.	Bag Vol	cc/min * at 15 in Hg	Sample Train Components Filter No.	Nozzle No.	Nozzle Dn
Run __	75	19.0	10.3	1009	1041	3-2	20.0	0.01	421709	2-7	0.214

Nozzle Calibration	
☐ See Run 1	☐ See E-Copy
Tech.	Date
Nozzle No.	
1	
2	
3	
Avg. in.	

MOISTURE RECOVERY:	RUN __					
Impinger	1	2	3	4	Desiccant	Total
Final wt., g	130	112	8	X	996	
Initial wt., g	100	100			992	
Difference	30	12	0		4	46

	Air Flows ACFM	DSCFM
Run __	209,015	162,279

BARR

C

T3/R3

EPA METHOD 5
FIELD DATA SHEET

Project ArcelorMittal Minorca Mine
Smpl Loc Furnace Stack C SV016
Test No. 3 Run 3
Date 1-18-17 Operators MTP, DJK

Meter ID AS-01
Meter Y 0.9852
Orifice H@ 1.86
Liner Type: Glass ☑ S.S. ☐

Probe ID 5-2
Pitot No. 5-2
Pitot Cp 0.84
Other:____

Bar. Pres 28.07 in Hg
Stat. Pres -0.80 in H_2O
Probe Lgth 5 ft
Imp TC____

Sample Train Leak Rate (cfm)			
Pretest	0.000 at	7	in Hg
Posttest	0.000 at	10	in Hg
Pitot (3 in. Pos. ☑		Neg. ☑	

Sample Point	Sample Time Δt	Meter Volume Vm, ft³	Velocity ΔP, in H_2O	Orifice ΔH, in H_2O	Sample Vacuum, in Hg	Stack Temp. Ts, °F	Sample Train Temperatures, °F Probe	Filter	Impinger Outlet	Meter Inlet	Meter Outlet	Oxygen Content, %	CO2
		0.000										(Optional)	
B-3	5	3.74	0.91	1.69	8	115	233	227	40	81	81	18.8	1.6
2	10	7.43	0.91	1.60	7.5	115	254	232	51	82	82		
1	15	11.07	0.85	1.58	7.5	114	253	239	54	83	83	18.8	1.6
A-3	20	14.74	0.95	1.76	7	115	253	240	54	84	84		
2	25	18.50	0.91	1.69	8	115	252	239	55	85	85	18.8	1.6
1	30	22.18	0.88	1.60	8	114	254	239	59	80	86		
	θ= 30	Vm 22.18		$\overline{\Delta H}$ 1.67		$\overline{Ts}$ 114.67					$\overline{Tm}$= 83.50 ~~74.00~~		

	Initialization Values			Test Run Times		ORSAT System			Sample Train Components			Nozzle Calibration	
	Meter Temp	Oxygen Content	Moisture Content	Start Time	End Time	Bag No.	Bag Vol	cc/min * at 15 in Hg	Filter No.	Nozzle No.	Nozzle Dn	☐ See Run 1 Tech. Nozzle No.	☐ See E-Copy Date
Run __	82	19.0	9.8	1116	1148	3-3	20 L	0.00	421711	2-7	0.214		
												1	
												2	
												3	
												Avg. in.	

MOISTURE RECOVERY:	RUN __					
Impinger	1	2	3	4	Desiccant	Total
Final wt., g	114	130	0	X	1001	
Initial wt., g	100	100	0		996	
Difference	14	30	0		5	49

	Air Flows	
	ACFM	DSCFM
Run __	206,635	159,358

D
T4/R1

BARR

EPA METHOD 5
FIELD DATA SHEET

Project ArcelorMittal Minorca Mine
Smpl Loc Furnace Stack D SV017
Test No. 4 Run 1
Date 1-18-17 Operators MTP, DJK

Meter ID C-10
Meter Y 0.9973
Orifice H@ 1.8829
Liner Type: Glass ☑ S.S. ☐

Probe ID 5-3
Pitot No. 5-3
Pitot Cp 0.84
Other:

Bar. Pres 28.07 in Hg
Stat. Pres -0.70 in H_2O
Probe Lgth 5 ft
Imp TC

Sample Train Leak Rate (cfm)			
Pretest 0.000	at 10	in Hg	
Posttest 0.000	at 5	in Hg	
Pitot (3 in. Pos. ☑	Neg. ☑		

B4-28
T10#6000

Sample Point	Sample Time Δt	Meter Volume Vm, ft³	Velocity ΔP, in H_2O	Orifice ΔH, in H_2O	Sample Vacuum, in Hg	Stack Temp. Ts, °F	Sample Train Temperatures, °F: Probe	Filter	Impinger Outlet	Meter Inlet	Meter Outlet	Oxygen Content, %
	(901)	889.20										(Optional)
B-3	5	892.51	0.74	1.37	3	117	251	249	26	56	56	~~18.0~~
2	10	895.76	0.76	1.41	3	118	250	251	32	60	58	
1	15	898.99	0.73	1.36	3	118	251	252	34	62	59	18.3
A-3	20	902.26	0.70	1.31	3	118	250	249	34	62	60	
2	25	905.62	0.75	1.41	3	117	248	249	33	64	61	18.4
1	30	908.83	0.72	1.36	3	116	251	249	33	65	62	
	θ= 30	Vm 19.63		ΔH 1.37		Ts 117.33					Tm= 60.42	

CO2
~~1.7~~ 18.3 2.0
1.9
2.0

	Initialization Values: Meter Temp	Oxygen Content	Moisture Content	Test Run Times: Start Time	End Time	ORSAT System: Bag No.	Bag Vol	cc/min * at 15 in Hg	Sample Train Components: Filter No.	Nozzle No.	Nozzle Dn
Run __	56	18.5	10.5	0901	0934	4-1	20.2	0.0	421708	5-7	0.217

Nozzle Calibration	
☐ See Run 1	☐ See E-Copy
Tech.	Date
Nozzle No.	
1	
2	
3	
Avg. in.	

MOISTURE RECOVERY:	RUN __					
Impinger	1	2	3	4	Desiccant	Total
Final wt., g	136	110	0	X	1114	
Initial wt., g	100	100	0		1110	
Difference	36	10	0		4	50

	Air Flows: ACFM	DSCFM
Run __	187,109	142,325

D
T4/R2

BARR

EPA METHOD 5
FIELD DATA SHEET

Project ArcelorMittal Minorca Mine
Smpl Loc Furnace Stack D SV017
Test No. 4 Run 2
Date 1-18-17 Operators MTP, DJK

Meter ID 6-10
Meter Y 0.9973
Orifice H@ 1.8829
Liner Type: Glass ☑ S.S. ☐

Probe ID S-3
Pitot No. S-3
Pitot Cp 0.84
Other:______

Bar. Pres 28.07 in Hg
Stat. Pres -0.70 in H_2O
Probe Lgth 5 ft
Imp TC______

Sample Train Leak Rate (cfm)				
Pretest	0.000	at	7	in Hg
Posttest	0.000	at	6	in Hg
Pitot (3 in. Pos. ☑		Neg. ☑)		

Sample Point	Sample Time Δt	Meter Volume Vm, ft³	Velocity ΔP, in H_2O	Orifice ΔH, in H_2O	Sample Vacuum, in Hg	Stack Temp. Ts, °F	Sample Train Temperatures, °F Probe	Filter	Impinger Outlet	Meter Inlet	Meter Outlet	Oxygen Content, %	CO_2
		901.02										(Optional)	
A-3	5	912.35	0.72	1.35	3	117	230	256	26	67	71	18.4	1.9
2	10	915.80	0.75	1.41	3	116	248	250	30	69	68		
1	15	918.90	0.67	1.26	3	116	251	251	31	70	68	18.3	2.0
B-3	20	922.18	0.78	1.47	3	117	249	248	31	70	69		
2	25	925.51	0.75	1.41	3	117	250	250	36	72	76	18.3	2.0
1	30	928.75	0.71	1.34	3	117	251	250	38	72	71		
	θ= 30	Vm 19.73		ΔH 1.37		Ts 116.67				Tm= 69.75			

	Initialization Values			Test Run Times		ORSAT System			Sample Train Components		
	Meter Temp	Oxygen Content	Moisture Content	Start Time	End Time	Bag No.	Bag Vol	cc/min * at 15 in Hg	Filter No.	Nozzle No.	Nozzle Dn
Run __	67	18.5	11.2	1009	1041	Y-2	20 l	0.0	~~421701~~ 421710	S-7	0.217

Nozzle Calibration	
☐ See Run 1	☐ See E-Copy
Tech.	Date
Nozzle No.	
1	
2	
3	
Avg. in.	

MOISTURE RECOVERY:	RUN __					
Impinger	1	2	3	4	Desiccant	Total
Final wt., g	130	110	0		1117	
Initial wt., g	100	100	0		1114	
Difference	30	10	0		3	43

	Air Flows	
	ACFM	DSCFM
Run __	186,050	143,762

D
T4/R3

BARR

EPA METHOD 5
FIELD DATA SHEET

Project ArcelorMittal Minorca Mine
Smpl Loc Furnace Stack D SV017
Test No. 4 Run 3
Date 1-18-17 Operators MTP, DJK

Meter ID C-10
Meter Y 0.9973
Orifice H@ 1.8829
Liner Type: Glass ☑ S.S. ☐

Probe ID 5-3
Pitot No. 5-3
Pitot Cp 0.84
Other:

Bar. Pres 28.07 in Hg
Stat. Pres -0.70 in H_2O
Probe Lgth 5 ft
Imp TC

Sample Train Leak Rate (cfm)			
Pretest 0.000	at	7	in Hg
Posttest 0.000	at	6	in Hg
Pitot (3 in. Pos. ☑		Neg. ☑	

Sample Point	Sample Time Δ t	Meter Volume Vm, ft³	Velocity ΔP, in H_2O	Orifice ΔH, in H_2O	Sample Vacuum, in Hg	Stack Temp. Ts, °F	Sample Train Temperatures, °F Probe	Filter	Impinger Outlet	Meter Inlet	Meter Outlet	Oxygen Content, %	CO_2
		928.95										(Optional)	
B-3	5	932.37	0.76	1.48	3	116	229	254	42	73	73	18.4	1.9
2	10	935.79	0.74	1.44	3	116	250	251	47	73	73		
1	15	939.18	0.76	1.48	3	116	248	250	49	71	73	18.3	2.0
A-3	20	942.55	0.74	1.44	3	116	250	250	52	74	74		
2	25	945.88	0.71	1.38	3	116	251	250	53	75	75	18.3	2.0
1	30	949.25	0.70	1.37	3	116	246	249	56	76	75		
	θ= 30	Vm 20.30		ΔH 1.43		Ts 116.00				Tm=	74.00		

	Initialization Values Meter Temp	Oxygen Content	Moisture Content	Test Run Times Start Time	End Time	ORSAT System Bag No.	Bag Vol	cc/min * at 15 in Hg	Sample Train Components Filter No	Nozzle No.	Nozzle Dn
Run __	73	18.5	9.9	1116	1148	4-3	20 L	0.0	421712	5-7	0.217

Nozzle Calibration	
☐ See Run 1	☐ See E-Copy
Tech.	Date
Nozzle No.	
1	
2	
3	
Avg. in.	

MOISTURE RECOVERY:	RUN __ 1	2	3	4	Desiccant	Total
Impinger	1	2	3	4	Desiccant	Total
Final wt., g	132	112	0	X	1123	
Initial wt., g	100	100	0		1117	
Difference	32	12	0		6	50

	Air Flows ACFM	DSCFM
Run __	167,014	142,949

✓ T1/R1

BARR

EPA Method 30B
FIELD DATA SHEET

Project ArcelorMittal Minorca Mine
Sample Location Furnace Stack C SV016
Date 1-17-17
Operators MTP / MJN

Meter ID PVB-
Meter A γ 1.00 ~~7~~369
Meter B γ 1.0002
Sample Rate 1.0 l/min lpm
Bar. Press. 28.24 in. Hg

Test 1
Run 1

Sample Time ΔT	Meter A Volume Vma, liters	Meter B Volume Vmb, liters	Stack Temp °F	Sample A Vacuum, in Hg	Sample B Vacuum, in Hg	Sorbent Ts, °F	Probe Tp, °F	Meter A Outlet Temp	Meter B Outlet Temp	Notes
(1007)	0.000	0.000								
5	6.000	5.516	SEE	-2	-4	260	260	73	73	
10	11.510	11.210	M-5	-2	-3.5	252	250	73	73	
15	16.400	16.405		-2	-3	251	250	74	74	
20	21.140	21.300		-2	-3	251	251	75	74	
25	26.205	26.413		-2	-3	250	250	75	75	
30	30.376	31.895		-2	-3	251	252	76	75	
30 min	30.376	31.895								
Θ= 1037	$\overline{Vma}$=	$\overline{Vmb}$=	$\overline{Ts}$= —					$\overline{Tma}$= 74.3	$\overline{Tmb}$= 74.0	

Sample Train A Leak Rate (lpm)
Pretest 0.000 at 7 in Hg
Posttest 0.010 at 5 in Hg

Sample Train B Leak Rate (lpm)
Pretest 0.000 at 7 in Hg
Posttest 0.008 at 5 in Hg

Trap A ID 349746
Spike Y/N No
Spike Level —

Trap B ID 391640
Spike [✓ Y]/N Yes
Spike Level 50 ng

C
T1/R2

BARR

EPA Method 30B
FIELD DATA SHEET

Project ArcelorMittal Minorca Mine
Sample Location Furnace Stack C SV016
Date 1-17-17
Operators MTP, MJR

Meter ID D✓B
Meter A γ 1.0069
Meter B γ 1.0002
Sample Rate 1.0 l/min lpm
Bar. Press. 28.24 in. Hg

Test 1
Run 2

spike

Sample Time ΔT	Meter A Volume Vma, liters	Meter B Volume Vmb, liters	Stack Temp °F	Sample A Vacuum, in Hg	Sample B Vacuum, in Hg	Sorbent Ts, °F	Probe Tp, °F	Meter A Outlet Temp	Meter B Outlet Temp	Notes
(1116)	0.000	0.000								
5	5.791	5.788	SEE	-3	-4	251	250	78	77	
10	9.900	10.105	NS	-2	-3	251	250	77	76	
15	14.080	14.020		-2	-4	251	250	78	77	
20	20.180	20.610		-3	-4	250	250	78	77	
25	25.310	25.820		-2	-3	250	251	78	77	
30	29.556	29.355		-2	-3	250	251	78	77	
(1146)										
Ø= 30	Vma= 29.556	Vmb= 29.355	Ts=					Tma= 77.8	Tmb= 76.8	

Sample Train A Leak Rate (lpm)
Pretest 0.000 at 6 in Hg
Posttest 0.002 at 4 in Hg

Sample Train B Leak Rate (lpm)
Pretest 0.000 at 7 in Hg
Posttest 0.000 at 4 in Hg

Trap A ID 394752
Spike Y/N NO
Spike Level —

Trap B ID 391663
Spike Y/N Yes
Spike Level 50ng

C
T1/R3

BARR

EPA Method 30B
FIELD DATA SHEET

Project ArcelorMittal Minorca Mine
Sample Location Furnace Stack C SV016
Date 1-17-17
Operators MJN, DJK

Meter ID DVB
Meter A γ 1.0069
Meter B γ 1.0002
Sample Rate 1.0 lpm
Bar. Press. 28.24 in. Hg

Test 1
Run 3

Spike

Sample Time ΔT	Meter A Volume Vma, liters	Meter B Volume Vmb, liters	Stack Temp °F	Sample A Vacuum, in Hg	Sample B Vacuum, in Hg	Sorbent Ts, °F	Probe Tp, °F	Meter A Outlet Temp	Meter B Outlet Temp	Notes
(1216)	0.000	0.000								
5	4.670	5.050	SEE MS	-2	-3	250	251	77	77	
10	9.150	9.890		-2	-3	250	251	78	77	
15	15.540	15.320		-2	-3	251	250	78	77	
20	19.420	19.740		-2	-3	251	250	79	78	
25	24.280	25.210		-2	-3	251	250	80	79	
30	30.769	30.898		-3	-4	251	251	81	80	
(1246)										
	30.769	30.898								
Ø= 30	Vma=	Vmb=	Ts= —					Tma= 78.8	Tmb= 78.0	

(1249)

Sample Train A Leak Rate (lpm)
Pretest 0.009 at 9 in Hg
Posttest 0.004 at 5 in Hg

Sample Train B Leak Rate (lpm)
Pretest 0.000 at 4 in Hg
Posttest 0.000 at 4 in Hg

Trap A ID 391536
Spike Y/N NO
Spike Level —

Trap B ID 391890
Spike Y/N Yes
Spike Level 50 ng

D
T2R1

BARR

EPA Method 30B
FIELD DATA SHEET

Project ArcelorMittal Minorca Mine
Sample Location Furnace Stack D SV017
Date 01/17/17
Operators MTP/MJN

Meter ID DN 4
Meter A γ 0.9904
Meter B γ ~~1.0065~~ 0.9846
Sample Rate 1.0 lpm
Bar. Press. 28.24 in. Hg

Test 2
Run 1

Sample Time ΔT	Meter A Volume Vma, liters	Meter B Volume Vmb, liters	Stack Temp °F	Sample A Vacuum, in Hg	Sample B Vacuum, in Hg	Sorbent Ts, °F	Probe Tp, °F	Meter A Outlet Temp	Meter B Outlet Temp	Notes
(1007)	0.000	0.000								
5	6.175	6.000	SEE	-5	-5	250	250	75	75	
10	12.865	12.213	MS	-5	-5	251	250	74	75	
15	19.370	18.300		-5	-5	251	250	75	76	
20	25.775	24.250		-5	-5	252	251	75	75	
25	30.465	29.550		-4	-4	250	251	75	76	
30	33.888	33.582		-4	-4	250	250	75	76	
(1037)										
	33.888	33.582								
Ø= 30	Vma=	Vmb=	Ts= —					Tma= 75.2	Tmb= 75.3	

Sample Train A Leak Rate (lpm)
Pretest 0.00 at 5 in Hg
Posttest 0.007 at 5 in Hg

Sample Train B Leak Rate (lpm)
Pretest 0.00 at 5 in Hg
Posttest 0.008 at 5 in Hg

Trap A ID 394925
Spike Y/N [✓ N] NO
Spike Level —

Trap B ID 391876
Spike [✓ Y]/N Yes
Spike Level 50ng

D
T2|R2

BARR

EPA Method 30B
FIELD DATA SHEET

Project ArcelorMittal Minorca Mine
Sample Location Furnace Stack D SV017
Date 1-17-17
Operators MJP, MJN

Meter ID DV A
Meter A γ 0.9909
Meter B γ 0.9846
Sample Rate 1.0 l/min lpm
Bar. Press. 28.24 in. Hg

Test 2
Run 2

Sample Time ΔT	Meter A Volume Vma, liters	Meter B Volume Vmb, liters	Stack Temp °F	Sample A Vacuum, in Hg	Spike Sample B Vacuum, in Hg	Sorbent Ts, °F	Probe Tp, °F	Meter A Outlet Temp	Meter B Outlet Temp	Notes
(1116)	0.000	0.000								
5	4.940	5.100	see	-5	-5	250	251	78	78	
10	10.120	10.090	M5	-3	-4	251	250	78	78	
15	15.160	15.050		-3	-4	278	265	77	78	
20	19.440	19.530		-3	-4	280	274	78	78	
25	25.390	24.980		-5	-5	295	290	78	79	
30	30.260	30.110		-5	-5	300	303	78	79	
	30.260	30.110								
Ø= 30	Vma=	Vmb=	Ts=					Tma= 78	Tmb= 78.8	

Sample Train A Leak Rate (lpm)
Pretest 0.000 at 6 in Hg
Posttest 0.008 at 5 in Hg

Sample Train B Leak Rate (lpm)
Pretest 0.000 at 6 in Hg
Posttest 0.010 at 7 in Hg

Trap A ID 399693
Spike Y/N NO
Spike Level —

Trap B ID 391866
Spike [✓ Y]/N Yes
Spike Level 50 ug

BARR

EPA Method 30B
FIELD DATA SHEET

D
T2/R3

Project ArcelorMittal Minorca Mine
Sample Location Furnace Stack D SV017
Date 1-17-17
Operators MJN, DJR

Meter ID DV A
Meter A γ 0.9904
Meter B γ 0.9846
Sample Rate 1.0 lpm
Bar. Press. 28.24 in. Hg

Test 2
Run 3

Sample Time ΔT	Meter A Volume Vma, liters	Meter B Volume Vmb, liters	Stack Temp °F	Sample A Vacuum, in Hg	Spike Sample B Vacuum, in Hg	Sorbent Ts, °F	Probe Tp, °F	Meter A Outlet Temp	Meter B Outlet Temp	Notes
(1216)	0.000	0.000								
5	4.940	5.100	SEE	-5	-5	301	298	79	79	
10	10.190	9.920	M-5	-5	-4	299	300	79	79	
15	14.9265	15.420		-5	-5	300	300	79	79	
20	19.970	20.060		-5	-5	299	300	79	80	
25	25.160	24.750		-5	-5	300	301	80	80	
30	30.047	29.912	↓	-5	-5	301	300	80	80	
Ø= 30	Vma=	Vmb=	Ts=					Tma=	Tmb= 79.5	

(1249)

Sample Train A Leak Rate (lpm)			Sample Train B Leak Rate (lpm)						
Pretest	0.000	at 5 in Hg	Pretest	0.006	at 9 in Hg	Trap A ID	394 777	Trap B ID	391 891
Posttest	0.000	at 6.5 in Hg	Posttest	0.006	at 6 in Hg	Spike Y/N	No	Spike [✓ Y]/N	Yes
						Spike Level	—	Spike Level	50 ng

C
T3 / R1

BARR

EPA Method 30B
FIELD DATA SHEET

Project ArcelorMittal Minorca Mine
Sample Location Furnace Stack C SV016
Date 1-18-17
Operators MJN, DJK

Meter ID DV-13
Meter A γ 1.0069
Meter B γ 1.0062
Sample Rate 1.0 lpm
Bar. Press. 28.07 in. Hg

Test 3
Run 1

Sample Time ΔT	Meter A Volume Vma, liters	Meter B Volume Vmb, liters	Stack Temp °F	Sample A Vacuum, in Hg	spike Sample B Vacuum, in Hg	Sorbent Ts, °F	Probe Tp, °F	Meter A Outlet Temp	Meter B Outlet Temp	Notes
(901)	0.000	0.000								
5	5.250	4.920	SEE	-3	-3	252	250	56	56	
10	9.350	10.050	M5	-2	-4	250	252	58	58	
15	14.010	14.915		-2	-4	250	249	60	60	
20	19.810	20.100		-2	-4	251	250	61	61	
25	25.490	25.105		-2	-4	250	250	62	61	
30	30.602	30.393		-2	-4	251	250	63	62	
(093[illegible])										
	30.602	30.393								
Ø= 30	Vma=	Vmb=	Ts= –					Tma=	Tmb=	

Sample Train A Leak Rate (lpm)
Pretest 0.000 at 7 in Hg
Posttest 0.010 at 5 in Hg

Sample Train B Leak Rate (lpm)
Pretest 0.000 at 6 in Hg
Posttest 0.000 at 5 in Hg

Trap A ID 349654
Spike Y/N NO
Spike Level —

Trap B ID 391879
Spike Y/N Yes
Spike Level 50 ng

C
T3/R2

BARR

EPA Method 30B
FIELD DATA SHEET

Project ArcelorMittal Minorca Mine
Sample Location Furnace Stack C SV016
Date 1-18-17
Operators MJN, DJK

Meter ID DU-B
Meter A γ 1.0069
Meter B γ 1.0002
Sample Rate 1.0 lpm
Bar. Press. 28.07 in. Hg

Test 3
Run R

Sample Time ΔT	Meter A Volume Vma, liters	Meter B Volume Vmb, liters	Stack Temp °F	Sample A Vacuum, in Hg	Spike Sample B Vacuum, in Hg	Sorbent Ts, °F	Probe Tp, °F	Meter A Outlet Temp	Meter B Outlet Temp	Notes
(1009)	0.000	0.000								
5	5.210	5.010	SEE	-3	-4	299	300	69	68	
10	9.720	9.850	M5	-2	-4	299	300	69	69	
15	14.780	15.050		-2	-4	299	301	70	69	
20	20.030	20.110		-2	-4	300	300	71	70	
25	25.180	24.930		-2	-4	300	300	72	71	
30	29.945	30.026		-2	-4	299	300	73	72	
(1059)										
	29.845	30.026								
Ø= 30	Vma=	Vmb=	Ts=					Tma=	Tmb=	

Sample Train A Leak Rate (lpm)
Pretest 0.000 at 4 in Hg
Posttest 0.000 at 4 in Hg

Sample Train B Leak Rate (lpm)
Pretest 0.000 at 5 in Hg
Posttest 0.003 at 5.5 in Hg

Trap A ID 399571
Spike Y/N NO
Spike Level —

Trap B ID 401329
Spike Y/N Yes
Spike Level 50 ng

C
T3|R3

BARR

EPA Method 30B
FIELD DATA SHEET

Project ArcelorMittal Minorca Mine
Sample Location Furnace Stack C SV016
Date 1-18-17
Operators MJN, DJK

Meter ID DVB
Meter A γ 1.0069
Meter B γ 1.0002
Sample Rate 1.0 lpm
Bar. Press. 28.07 in. Hg

Test 3
Run 3

Sample Time ΔT	Meter A Volume Vma, liters	Meter B Volume Vmb, liters	Stack Temp °F	Sample A Vacuum, in Hg	Spike Sample B Vacuum, in Hg	Sorbent Ts, °F	Probe Tp, °F	Meter A Outlet Temp	Meter B Outlet Temp	Notes
(1116)	0.000	0.000	SEE							
5	4.090	5.610	M5	2	4	300	300	75	74	
10	9.865	10.350		-2	-4	300	300	75	75	
15	14.888	14.950		-3	-3	300	300	76	75	
20	20.750	19.600		-3	-3	300	300	77	76	
25	24.860	24.700		-3	-3	301	299	78	77	
30	29.978	30.268		-3	-4	300	300	79	78	
(1148)										
	29.978	30.268								
Ø= 30	Vma=	Vmb=	Ts=					Tma=	Tmb=	

Sample Train A Leak Rate (lpm)
Pretest 0.000 at 4 in Hg
Posttest 0.000 at 9 in Hg

Sample Train B Leak Rate (lpm)
Pretest 0.000 at 5.5 in Hg
Posttest 0.000 at 4 in Hg

Trap A ID 401323
Spike Y/N No
Spike Level —

Trap B ID 401282
Spike Y/N Yes
Spike Level 50 ng

D
T4/R1

BARR

EPA Method 30B
FIELD DATA SHEET

Project ArcelorMittal Minorca Mine
Sample Location Furnace Stack D SV017
Date 1-18-17
Operators MJN, DJK

Meter ID DV-A
Meter A γ 0.9909
Meter B γ 0.9846
Sample Rate 1.0 lpm
Bar. Press. 28.07 in. Hg

Test 4
Run 1

Sample Time ΔT	Meter A Volume Vma, liters	Meter B Volume Vmb, liters	Stack Temp °F	Sample A Vacuum, in Hg	spike Sample B Vacuum, in Hg	Sorbent Ts, °F	Probe Tp, °F	Meter A Outlet Temp	Meter B Outlet Temp	Notes
(901)	0.000	0.000								
5	5.930	5.310	SEE	-5	-5	278	272	54	55	
10	10.610	10.230	NS	-4	-4	270	272	55	56	
15	14.805	14.910		-4	-4	270	271	56	56	
20	19.890	19.770		-4	-4	272	269	56	57	
25	25.110	24.830		-4	-5	270	272	57	58	
30	30.301	29.832		-4	-5	269	270	57	58	
(0934)										
	30.301	29.832								
Ø= 30	Vma= —	Vmb= —	Ts= —					Tma=	Tmb=	

Sample Train A Leak Rate (lpm)			Sample Train B Leak Rate (lpm)						
Pretest	0.000	at 6 in Hg	Pretest	0.002	at 6.5 in Hg	Trap A ID	399568	Trap B ID	401293
Posttest	0.018	at 5 in Hg	Posttest	0.012	at 5 in Hg	Spike Y/N	NO	Spike Y/N	Yes
						Spike Level	—	Spike Level	50 ng

D
T4/R2

BARR

EPA Method 30B
FIELD DATA SHEET

Project ArcelorMittal Minorca Mine
Sample Location Furnace Stack D SV017
Date 1-18-17
Operators MJN, DJK

Meter ID DVA
Meter A γ 0.9904
Meter B γ 0.9846
Sample Rate 1.0 lpm
Bar. Press. 28.07 in. Hg

Test 4
Run 2

Sample Time ΔT	Meter A Volume Vma, liters	Meter B Volume Vmb, liters	Stack Temp °F	Sample A Vacuum, in Hg	Spike Sample B Vacuum, in Hg	Sorbent Ts, °F	Probe Tp, °F	Meter A Outlet Temp	Meter B Outlet Temp	Notes
(1009)	0.000	0.000								
5	5.290	4.900	See	-4	-4	301	300	65	65	
10	10.420	9.860	M5	-5	-5	299	300	65	65	
15	14.775	14.940	↓	-5	-5	300	300	65	66	
20	19.875	20.010		-4	-5	300	300	66	66	
25	25.130	25.965		-5	-5	300	301	67	67	
30	29.949	29.953		-5	-5	298	301	67	68	
(1099)										
Ø= 30	Vma= 29.949	Vmb= 29.953	Ts=					Tma=	Tmb=	

Sample Train A Leak Rate (lpm)
Pretest 0.000 at 5.5 in Hg
Posttest 0.000 at 5.5 in Hg

Sample Train B Leak Rate (lpm)
Pretest 0.002 at 6.5 in Hg
Posttest 0.000 at 6 in Hg

Trap A ID 394870
Spike Y/N NO
Spike Level —

Trap B ID 401281
Spike Y/N Yes
Spike Level 50 ng

D
T4/R3

BARR

EPA Method 30B
FIELD DATA SHEET

Project ArcelorMittal Minorca Mine
Sample Location Furnace Stack D SV017
Date 1-18-17
Operators MJN, DJK

Meter ID DVA
Meter A γ 0.9904
Meter B γ 0.9846
Sample Rate 1.0 lpm
Bar. Press. 28.07 in. Hg

Test 4
Run 3

Sample Time ΔT	Meter A Volume Vma, liters	Meter B Volume Vmb, liters	Stack Temp °F	Sample A Vacuum, in Hg	Spike Sample B Vacuum, in Hg	Sorbent Ts, °F	Probe Tp, °F	Meter A Outlet Temp	Meter B Outlet Temp	Notes
(1116)	0.000	0.000								
5	5.150	5.230	SEE	4	4.5	300	300	72	72	
10	10.160	10.250	MS	-4	-5	300	300	73	73	
15	15.004	15.100		-4	-4	301	300	73	73	
20	19.850	19.860		-4	-4	299	300	73	74	
25	25.050	24.940		-4	-4	300	300	74	74	
30	30.079	30.067		-4	-4	300	300	74	75	
(1146)										
	30.079	30.067								
Ø= 30	Vma=	Vmb=	Ts=					Tma=	Tmb=	

Sample Train A Leak Rate (lpm)			Sample Train B Leak Rate (lpm)						
Pretest	0.000	at 5.5 in Hg	Pretest	0.004	at 6.5 in Hg	Trap A ID	401324	Trap B ID	401291
Posttest	0.000	at 5 in Hg	Posttest	0.000	at 6 in Hg	Spike Y/N	NO	Spike Y/N	Yes
						Spike Level	—	Spike Level	50 ng

ONTARIO HYRDO D-6784-16 MERCURY TESTING
IMPINGER RECOVERY

Project Arcelor Mittal
Date 2/8/17

Project No. 23691873.00 LONG
Operators BAW

Source Stack A SV014
Sample Location

TEST 1 RUN 1	IMPINGER VOLUMES							DRY COLUMN
	1	2	3	4	5	6	7	
	g	g	g	g	g	g	g	g
START.	754.3	762.5	764.4	748.9	~~755.1~~ 756.6	~~743.2~~ 748.5	~~748.3~~ 748.9	959.0
END	772.7	811.8	801.1	772.3	760.8	751.8	744.5	976.4
CHANGE								
							MASS OF MOISTURE COLLECTED, g	

TEST 1 RUN 2	IMPINGER VOLUMES							DRY COLUMN
	1	2	3	4	5	6	7	
	g	g	g	g	g	g	g	g
START.	754.5	752.3	758.7	756.8	754.4	760.2	758.4	964.1
END	765.0	799.0	788.5	777.1	761.0	765.8	758.8	984.8
CHANGE								
							MASS OF MOISTURE COLLECTED, g	

TEST 1 RUN [illegible]	IMPINGER VOLUMES							DRY COLUMN
	1	2	3	4	5	6	7	
	g	g	g	g	g	g	g	g
START.	~~755.8~~	~~742.3~~	~~742.0~~	~~765.7~~	~~755.2~~	~~758.1~~	~~796.9~~	~~1005.9~~
END								
CHANGE								
							MASS OF MOISTURE COLLECTED, g	

TEST 1 RUN 3	IMPINGER VOLUMES							DRY COLUMN
	1	2	3	4	5	6	7	
	g	g	g	g	g	g	g	g
START.	764.4	755.5	774.6	751.9	763.3	766.3	766.8	942.0
END	792.2	802.8	803.5	768.6	771.5	768.1	765.2	960.3
CHANGE								

COMMENTS

BARR

Method 5/Ontario Hydro
FIELD DATA SHEET

Project ArcelorMittal Minorca Mine
Smpl Loc Furnace Stack A SV014
Test No. 1 Run 1
Date 2/8/17 Operators MJN/EMP/JAR2

Meter ID C-10
Meter Y 1.0038
Orifice H@ 1.8032
Liner Type: ☒Glass ☐S.S. ☐Other

Probe ID 5-2
Pitot No. 5-2
Pitot Cp 0.84
Bar. Pres 28.33 in Hg
Stat. Pres -1.0 in H_2O
Probe Lgth 5 ft
Imp TC 2162

Sample Train Leak Rate (cfm)			
Pretest 0.00	at 15	in Hg	
Posttest 0.000	at 8	in Hg	
Pitot (3 in.) Pos. ☒	Neg. ☒		

Sample Point	Sample Time Δt	Meter Volume Vm, ft³	Velocity ΔP, in H_2O	Orifice ΔH, in H_2O	Ideal Meter Volume	Sample Vacuum, in Hg	Stack Temp. Ts, °F	Sample Train Temperatures, °F Probe	Filter	Impinger Outlet	Meter Inlet	Meter Outlet	Oxygen Content, %
	0807	135.10											
1-1	5	138.49	0.85	1.55	NA	-5.0	104	230	249	34	68	68	
2	10	142.06	0.87	1.58		-5.0	105	250	250	34	67	68	
3	15	145.60	0.85	1.55		-5	104	250	249	34	67	68	
4	20	149.02	0.85	1.55		-5	104	251	252	44	66	68	
5	25	152.38	0.80	1.45		-5	104	250	252	45	67	68	
6	30	155.69	0.80	1.46		-5	104	250	248	49	67	68	
2-1	35	159.22	0.88	1.60		-5	104	252	239	50	68	68	
2	40	162.78	0.90	1.64		-6	103	250	253	52	67	68	
3	45	166.39	0.89	1.62		-6	104	249	250	52	67	69	
4	50	169.98	0.90	1.64		-6	104	249	247	52	67	69	
5	55	173.56	0.89	1.62		-6	104	250	251	53	67	69	
6	60	177.11	0.88	1.60		-6	104	250	249	52	67	69	
3-1	65	180.52	0.95	1.73		-6	105	249	249	39	69	69	
2	70	184.35	0.96	1.75		-6	104	250	249	39	68	69	
3	75	187.93	0.95	1.73		-6	104	250	249	37	69	70	
4	80	191.68	0.96	1.75		-6	104	251	250	35	68	70	
5	85	195.24	0.88	1.60		-6	105	251	249	34	69	70	
6	90	198.78	0.86	1.57		-6	105	250	249	40	69	70	
4-1	95	202.62	1.10	2.01		-7	104	250	252	46	71	71	
2	100	206.43	1.00	1.83		-7	104	250	253	48	71	72	
3	105	210.24	0.99	1.81		-7	104	250	251	50	70	71	
4	110	213.80	0.89	1.63		-6	105	250	250	52	70	72	
5	115	217.39	0.93	1.71		-6	103	251	250	54	70	72	
6	120	221.03	0.89	1.63		-6	103	251	250	56	70	72	
	Ø=1020	Vm=85.93		ΔH=1.65			Ts=104.0					Tm=68.90	

	Initialization Values Meter Temp	Oxygen Content	Moisture Content	Test Run Times Start Time	End Time	ORSAT System Bag No.	Bag Vol	cc/min * at 15 in Hg	Sample Train Components Filter No.	Nozzle No.	Nozzle Dn
Run 1	67	19.6%	12.0%	0807	1020	A-1	60	0.0	4Q0588	A-1	0.215
Run 2											

Nozzle Calibration	
Tech.	Date
Nozzle No.	
1	See E-6a1
2	
3	
Avg. in.	

Moisture Recovery Data and impinger content information: Run 1

Impinger	1	2	3	4	5	6	7	Desiccant	Total
Final wt., g	772.7	811.8	801.1	772.3	760.8	751.8	744.5	976.4	
Initial wt., g	754.3	762.5	764.4	748.9	~~755.1~~	~~743.2~~	~~748.3~~	959.0	
Difference :	18.4	49.3	36.7	23.4	~~4.7~~	~~8.3~~	~~-3.4~~	17.4	148.3
	1 N KCl			HNO3/H2O2	756.6	H2SO4/KMnO4 748.5	748.9		

MJN

Run 1

Air Flows	
ACFM	DSCFM
194,834	159,026

BARR

Method 5/Ontario Hydro
FIELD DATA SHEET

Project ArcelorMittal Minorca Mine
Smpl Loc Furnace Stack A SV014
Test No. 1 Run 2
Date 2/8/17 Operators MJW/RMA/JARZ

Meter ID C-10
Meter Y 1.0033
Orifice H@ 1.8832
Liner Type: ☑Glass ☐S.S. ☐Other

Probe ID 5-2
Pitot No. 5-2
Pitot Cp 0.84

Bar. Pres 28.33 in Hg
Stat. Pres -1.0 in H₂O
Probe Lgth 5 ft
Imp TC 2162

Sample Train Leak Rate (cfm)			
Pretest 0.000	at 10	in Hg	
Posttest 0.00	at 5	in Hg	
Pitot (3 in.) Pos. ☒ Neg. ☒			

Sample Point	Sample Time ΔI	Meter Volume Vm, ft³	Velocity ΔP, in H_2O	Orifice ΔH, in H_2O	Ideal Meter Volume	Sample Vacuum, in Hg	Stack Temp. Ts, °F	Sample Train Temperatures, °F Probe	Filter	Impinger Outlet	Meter Inlet	Meter Outlet	Oxygen Content, %
	1104	222.70											
1-1	5	226.51	1.00	1.85	NA	-3	104	253	246	34	73	74	
2	10	230.35	1.10	2.02		-3	104	251	254	34	73	74	
3	15	234.25	1.00	1.84		-3	104	250	250	34	71	74	
4	20	238.36	1.10	2.15		-3	104	250	250	39	72	75	
5	25	242.43	1.05	2.06		-3	105	250	251	40	71	75	
6	30	246.27	0.95	1.86		-3	105	250	250	41	72	75	
2-1	35	250.13	0.98	1.92		-3	104	250	250	43	73	75	
2	40	254.11	1.00	1.96		-3	104	251	250	45	73	75	
3	45	258.02	0.98	1.92		-3	105	250	252	49	72	75	
4	50	261.85	0.96	1.88		-3	104	250	250	50	72	75	
5	55	265.53	0.87	1.71		-3	104	250	251	51	72	75	
6	60	269.14	0.83	1.63		-3	104	251	250	54	73	75	
3-1	65	272.88	0.88	1.73		-3	104	250	250	54	75	75	
2	70	276.65	0.89	1.75		-3	105	249	251	56	74	75	
3	75	280.40	0.89	1.75		-3	105	251	250	56	74	75	
4	80	284.20	0.91	1.79		-3	104	250	249	59	74	76	
5	85	287.81	0.83	1.63		-3	104	251	250	59	74	76	
6	90	291.37	0.80	1.57		-3	104	250	249	60	75	76	
4-1	95	295.10	0.92	1.81		-3	104	248	249	60	77	76	
2	100	298.91	0.93	1.83		-3	105	250	250	60	76	76	
3	105	302.75	0.92	1.81		-3	104	250	250	63	75	76	
4	110	306.66	0.95	1.87		-3	105	249	249	63	75	76	
5	115	310.88	0.86	1.69		-3	105	250	250	64	74	76	
6	120	313.91	0.80	1.57		-3	104	250	248	60	74	76	
	Ø=1313	Vm=91.21		ΔH=1.82			Ts=104.3					Tm=74.38	

	Initialization Values Meter Temp	Oxygen Content	Moisture Content	Test Run Times Start Time	End Time	ORSAT System Bag No.	Bag Vol	cc/min * at 15 in Hg	Sample Train Components Filter No. MOS	Nozzle No.	Nozzle Dn
Run 2	75	19.6%	12.0%	1104	1313	A-1	60L	0.0	420599	A-1	0.215
Run 2											

Nozzle Calibration	
Tech.	Date
Nozzle No.	
1	
2	see E-Copy
3	
Avg. in.	

Moisture Recovery Data and impinger content information: Run 2

Impinger	1	2	3	4	5	6	7	Desiccant	Total
Final wt., g									
Initial wt., g	791.5	752.3	758.7	756.8	791.4	760.2	758.4	964.1	
Difference									
	1 N KCl			HNO3/H2O2	H2SO4/KMNO4				

Run 2

Air Flows	
ACFM	DSCFM

Method 5/Ontario Hydro
FIELD DATA SHEET

Project ArcelorMittal Minorca Mine
Smpl Loc Furnace Stack A SV014
Test No. 1 Run 3
Date 2/8/17 Operators MJN/RMP/DAEZ

Meter ID C-10
Meter Y 1.0038
Orifice H@ 1.8832
Liner Type: ☒Glass ☐S.S. ☐Other

Probe ID 5-2
Pitot No. 5-2
Pitot Cp 0.84

Bar. Pres 28.33 in Hg
Stat. Pres -1.0 in H_2O
Probe Lgth 5 ft
Imp TC 2162

Sample Train Leak Rate (cfm)			
Pretest 0.00	at	10	in Hg
Posttest 0.00	at	6	in Hg
Pitot (3 in.) Pos. ☒Neg. ☒			

Sample Point	Sample Time ΔI	Meter Volume Vm, ft³	Velocity ΔP, in H_2O	Orifice ΔH, in H_2O	Ideal Meter Volume	Sample Vacuum, in Hg	Stack Temp. Ts, °F	Sample Train Temperatures, °F Probe	Filter	Impinger Outlet	Meter Inlet	Meter Outlet	Oxygen Content, %
	1548	346.90											
1-1	5	350.38	0.90	1.79	NA	-4	104	245	245	41	74	73	
2	10	354.03	0.88	1.75		-4	104	251	252	42	73	73	
3	15	357.80	0.90	1.79		-4	104	250	256	42	71	73	
4	20	361.49	0.86	1.70		-4	105	250	248	45	70	73	
5	25	364.98	0.75	1.48		-4	105	251	250	47	70	72	
6	30	368.37	0.75	1.48		-4	105	250	251	49	69	72	
2-1	35	372.05	0.89	1.76		-5	105	250	250	42	70	71	
2	40	375.89	0.94	1.86		-5	105	251	253	49	69	71	
3	45	379.59	0.89	1.76		-5	105	250	249	50	69	71	
4	50	383.23	0.85	1.68		-5	104	251	250	51	68	70	
5	55	386.85	0.75	1.48		-5	104	250	250	52	69	70	
6	60	390.16	0.74	1.46	MJN	-5	105	250	249	53	68	70	
3-1	65	393.54	~~0.85~~ 0.76	~~1.67~~ 1.50		-5	105	250	246	52	69	69	
2	70	397.14	0.85	1.67		-5	105	250	250	52	66	69	
3	75	401.01	0.97	1.91		-5	105	250	251	52	65	68	
4	80	404.89	1.00	1.96		-5	105	251	248	53	64	68	
5	85	408.39	0.74	1.45		-5	105	250	252	52	64	67	
6	90	411.69	0.76	1.48		-4	106	252	253	52	64	67	
4-1	95	415.52	0.98	1.92		-5	105	249	250	44	64	66	
2	100	419.40	1.00	1.96		-5	104	249	249	47	63	66	
3	105	423.26	1.00	1.95		-5	105	250	252	46	62	65	
4	110	427.14	1.00	1.95		-5	105	250	251	46	61	65	
5	115	430.84	0.92	1.79		-5	105	251	250	45	60	64	
6	120	434.51	0.91	1.77		-5	104	250	250	44	60	64	
	Ø= 1754	Vm= 87.61		ΔH= 1.72			Ts= 104.8					Tm= 67.85	

	Initialization Values Meter Temp	Oxygen Content	Moisture Content	Test Run Times Start Time	End Time	ORSAT System Bag No.	Bag Vol	cc/min * at 15 in Hg	Sample Train Components Filter No.	Nozzle No.	Nozzle Dn
Run 3	74	19.6%	7.7%	1548 ~~1436~~	1754	A-3	60L	0.0	4Q0592	A-1	0.215
Run 2											

Nozzle Calibration	
Tech.	Date
Nozzle No.	
1	See E-Copy
2	
3	
Avg. in.	

Moisture Recovery Data and impinger content information: Run 3

Impinger	1	2	3	4	5	6	7	Desiccant	Total
Final wt., g	792.2	802.8	803.5	768.6	771.5	768.1	765.2	960.3	
Initial wt., g	764.4	755.5	774.6	751.9	763.3	766.3	766.8	942	
Difference	27.8	47.3	28.9	16.7	8.2	1.8	-1.6	18.3	147.4
	1 N KCl			HNO3/H2O2	H2SO4/KMNO4				

Run 3

Air Flows	
ACFM	DSCFM
191,504	156,132

BARR

ONTARIO HYRDO D-6784-16 MERCURY TESTING
IMPINGER RECOVERY

Project ArcelorMittal
Date
Project No. ~~&~~ 23691843.00
Operators BAW
Source Stack B SV015
Sample Location

TEST 2 RUN ~~1~~	IMPINGER VOLUMES 1	2	3	4	5	6	7	DRY COLUMN
	g	g	g	g	g	g	g	g
START.	~~758.8~~	~~770.3~~	~~768.9~~	~~754.0~~				~~918.8~~
END								
CHANGE								
							MASS OF MOISTURE COLLECTED, g	

TEST 2 RUN ~~2~~ 1	IMPINGER VOLUMES 1	2	3	4	5	6	7	DRY COLUMN
	g	g	g	g	g	g	g	g
START.	759.8	757.7	763.7	754.8	753.8	766.2	761.6	960.8
END 790.6	~~777.6~~	~~781.8~~	772.0	762.0	757.5	769.7	761.2	992.3
CHANGE		795.2						
							MASS OF MOISTURE COLLECTED, g	

TEST 2 RUN ~~3~~ 2	IMPINGER VOLUMES 1	2	3	4	5	6	7	DRY COLUMN
	g	g	g	g	g	g	g	g
START.	764.1	747.7	772.6	752.5	739.8	741.6	745.2	968.4
END	769.1	792.3	806.0	775.2	756.8	753.2	750.4	996.3
CHANGE								
							MASS OF MOISTURE COLLECTED, g	

TEST 2 RUN ~~4~~ 3	IMPINGER VOLUMES 1	2	3	4	5	6	7	DRY COLUMN
	g	g	g	g	g	g	g	g
START.	761.4	748.1	775.8	760.5	755.1	768.1	760.4	955.3
END	800.0	804.1	806.6	776.5	761.1	769.4	758.8	973.7
CHANGE								

COMMENTS

BARR

Method 5/Ontario Hydro
FIELD DATA SHEET

Project ArcelorMittal Minorca Mine
Smpl Loc Furnace Stack B SV015
Test No. 2 Run 1
Date 2/9/17 Operators MJW/PMP/JARZ

Meter ID C-10
Meter Y 1.0038
Orifice H@ 1.8832
Liner Type: ☒Glass ☐S.S. ☐Other

Probe ID 5-2
Pitot No. 5-2
Pitot Cp 0.84
Probe Lgth 5 ft

Bar. Pres 28.40 in Hg
Stat. Pres -0.90 in H_2O
Imp TC 2162

Sample Train Leak Rate (cfm)				
Pretest	0.00	at	10	in Hg
Posttest	0.00	at	5	in Hg
Pitot (3 in.)	Pos. ☒	Neg. ☒		

Sample Point	Sample Time ΔT	Meter Volume Vm, ft³	Velocity ΔP, in H_2O	Orifice ΔH, in H_2O	Ideal Meter Volume	Sample Vacuum, in Hg	Stack Temp. Ts, °F	Sample Train Temperatures, °F Probe	Filter	Impinger Outlet	Meter Inlet	Meter Outlet	Oxygen Content, %
	754	437.80											
1-1	5	441.40	0.96	1.81	NA	-3	107	251	253	51	46	45	
2	10	445.14	0.95	1.79		-3	107	260	260	52	48	46	
3	15	448.76	0.93	1.75		-3	108	260	260	51	49	47	
4	20	452.36	0.90	1.70		-3	107	260	261	50	50	48	
5	25	455.85	0.87	1.65		-3	107	261	260	56	51	49	
6	30	459.37	0.88	1.67		-3	107	260	259	59	53	50	
2-1	35	463.36	1.10	2.10		-3	107	260	261	60	54	53	
2	40	467.34	1.10	2.10		-3	108	261	262	61	55	53	
3	45	471.37	1.10	2.10		-3	108	260	260	62	56	54	
4	50	475.22	1.10	2.11		-3	108	261	260	61	56	54	
5	55	479.10	1.00	1.92		-3	108	260	261	62	57	55	
6	60	483.01	0.99	1.90		-3	108	260	259	63	58	56	
3-1	65	486.56	0.83	1.60		-3	108	259	260	34	63	61	
2	70	490.25	0.93	1.81		-3	107	260	260	34	62	61	
3	75	493.85	0.88	1.71		-3	108	262	259	33	61	61	
4	80	497.53	0.99	1.92		-3	108	260	261	34	60	61	
5	85	501.10	0.89	1.72		-3	108	261	263	33	60	61	
6	90	504.78	0.76	1.47		-3	108	259	261	33	59	60	
4-1	95	508.24	0.82	1.59		-3	107	261	261	34	60	60	
2	100	511.55	0.73	1.42		-3	106	259	263	34	61	61	
3	105	515.02	0.81	1.57		-3	106	259	260	34	61	61	
4	110	518.64	0.89	1.73		-3	107	260	261	34	62	62	
5	115	522.30	0.89	1.73		-3	106	260	259	34	63	63	
6	120	525.90	0.85	1.66		-3	106	260	259	35	63	63	
	Ø= 1030	Vm= 88.00		$\overline{\Delta H}$= 1.77			$\overline{Ts}$= 107.3					$\overline{Tm}$= 56.52	

pause @ 0903 to work on "D" stack

	Initialization Values Meter Temp	Oxygen Content	Moisture Content	Test Run Times Start Time	End Time	ORSAT System Bag No.	Bag Vol	cc/min * at 15 in Hg	Sample Train Components Filter No.	Nozzle No.	Nozzle Dn
Run 1	46	19.3%	7.5%	754	1030	B-1	60L	0.0	~~4e~~21100427	B-1	0.215
Run 2											

Nozzle Calibration	
Tech.	Date
Nozzle No.	
1	
2	See E-Copy
3	
Avg. in.	

Moisture Recovery Data and impinger content information: Run 1

Impinger	1	2	3	4	5	6	7	Desiccant	Total
Final wt., g	790.6	795.2	772	762	757.5	769.7	761.2	992.3	
Initial wt., g	759.8	757.7	763.7	754.8	753.8	766.2	761.6	960.8	
Difference	30.8	37.5	8.3	7.2	3.7	3.5	-0.4	31.5	122.1
	1 N KCl			HNO3/H2O2	H2SO4/KMNO4				

Run 1

Air Flows	
ACFM	DSCFM
196,218	162,116

BARR

Method 5/Ontario Hydro
FIELD DATA SHEET

Project ArcelorMittal Minorca Mine
Smpl Loc Furnace Stack B SV015
Test No. 2 Run 2
Date 2/9/17 Operators MJW/RMP/JARZ

Meter ID C-10
Meter Y 1.0038
Orifice H@ 1.8032
Liner Type: ☒Glass ☐S.S. ☐Other

Probe ID 5-2
Pitot No. 5-2
Pitot Cp 0.84

Bar. Pres 28.40 in Hg
Stat. Pres -0.90 in H2O
Probe Lgth 5 ft
Imp TC 2162

Sample Train Leak Rate (cfm)			
Pretest	0.00	at 10	in Hg
Posttest	0.000	at 12	in Hg
Pitot (3 in.)	Pos. ☒	Neg. ☒	

Sample Point	Sample Time Δt	Meter Volume vm, ft³	Velocity ΔP, in H2O	Orifice ΔH, in H2O	Ideal Meter Volume	Sample Vacuum, in Hg	Stack Temp. Ts, °F	Sample Train Temperatures, °F Probe	Filter	Impinger Outlet	Meter Inlet	Meter Outlet	Oxygen Content, %
	1115	527.91											
1-1	5	531.80	0.92	1.80	NA	-4	107	300	278	60	65	64	
2	10	535.20	0.88	1.72		-4	106	300	280	59	64	64	
3	15	539.21	0.88	1.72		-4	107	300	296	60	63	64	
4	20	542.91	0.88	1.72		-4	107	301	297	63	64	65	
5	25	546.64	0.88	1.72		-4	106	275	278	64	64	65	
6	30	550.30	0.88	1.75		-4	106	274	273	65	64	65	
2-1	35	552.26	1.10	2.20		-4	105	275	274	63	66	65	
2	40	555.35	1.10	2.20		-10	106	277	272	65	66	65	
3	45	559.52	1.10	2.20		-12	105	276	275	64	66	66	
4	50	563.60	0.99	1.98		-9	105	251	251	65	67	67	
5	55	568.00	1.00	2.00		-7	106	250	249	65	67	67	
6	60	571.61	0.97	1.94		-6	107	250	250	64	69	69	
3-1	65	575.62	1.00	2.01		-6	105	250	250	66	70	69	
2	70	579.50	1.00	2.01		-6	106	250	252	65	72	71	
3	75	583.72	1.05	2.12		-6	105	251	251	64	72	71	
4	80	587.88	1.05	2.12		-6	106	251	249	65	73	72	
5	85	592.16	1.10	2.22		-6	107	251	249	64	74	73	
6	90	596.52	1.10	2.23		-7	106	252	251	63	75	74	
4-1	95	600.99	1.05	2.14		-7	105	250	250	62	74	73	
2	100	604.99	1.00	2.03		-7	106	250	249	62	74	73	
3	105	609.[illegible]	0.92	1.86		-6	107	251	252	56	76	76	
MJP 4	613.53 110	~~609.59~~	0.97	1.97		-5	106	250	247	53	75	75	
5	115	617.53	0.96	1.95		-5	105	250	249	52	76	75	
6	120	621.57	0.99	2.02		-5	104	250	250	51	77	75	
	Ø=1330	Vm 93.66		ΔH= 1.98			Ts= 105.9					Tm= 69.56	

-Vacuum trouble

	Initialization Values Meter Temp	Oxygen Content	Moisture Content	Test Run Times Start Time	End Time	ORSAT System Bag No.	Bag Vol	cc/min * at 15 in Hg	Sample Train Components Filter No.	Nozzle No.	Nozzle Dn
Run 2	65	19.3%	7.5%	1115	1330	B-2	60 L	0.0	4Q0574	B-1	0.245
Run 2											

Nozzle Calibration	
Tech.	Date
Nozzle No.	
1	See E-
2	copy
3	
Avg. in.	

Moisture Recovery Data and impinger content information: Run 2

Impinger	1	2	3	4	5	6	7	Desiccant	Total
Final wt., g	769.1	792.3	806	775.2	756.8	753.2	750.4	996.3	
Initial wt., g	764.1	747.7	772.6	752.5	739.8	741.6	745.2	968.4	
Difference	5	44.6	33.4	22.7	17	11.6	5.2	27.9	167.4
	1 N KCl			HNO3/H2O2		H2SO4/KMNO4			

Run 2

Air Flows	
ACFM	DSCFM
203,898	165,581

BARR

Method 5/Ontario Hydro
FIELD DATA SHEET

Project ArcelorMittal Minorca Mine
Smpl Loc Furnace Stack B SV015
Test No. 2 Run 3
Date 2/9/17 Operators MJW/RMP/ARZ

Meter ID C-10
Meter Y 1.0038
Orifice H@ 1.8832
Liner Type: ☐Glass ☐S.S. ☐Other________

Probe ID 5-2
Pitot No. 5-2
Pitot Cp 0.84

Bar. Pres 28.40 in Hg
Stat. Pres -0.90 in H_2O
Probe Lgth 5 ft
Imp TC 2162

Sample Train Leak Rate (cfm)				
Pretest	0.00	at	10	in Hg
Posttest	0.00	at	9	in Hg
Pitot (3 in.) Pos. ☒Neg. ☒				

Sample Point	Sample Time ΔI	Meter Volume vm, ft³	Velocity ΔP, in H_2O	Orifice ΔH, in H_2O	Ideal Meter Volume	Sample Vacuum, in Hg	Stack Temp. Ts, °F	Sample Train Temperatures, °F: Probe	Filter	Impinger Outlet	Meter Inlet	Meter Outlet	Oxygen Content, %
	1356	622.00											
1-1	5	626.20	1.10	2.25	NA	-6	106	250	248	38	78	77	
2	10	630.41	1.05	2.14		-6	107	249	249	59	77	78	
3	15	634.63	1.10	2.24		-6	108	250	250	60	75	77	
4	20	638.71	1.05	2.13		-6	108	253	252	62	73	~~78~~ 75	
5	25	642.58	0.90	1.82		-5	107	251	250	64	73	74	
6	30	646.52	1.05	2.06		-5	107	250	250	63	72	73	
2-1	35	650.39	0.96	1.88		-5	108	249	249	62	72	73	
2	40	654.30	0.98	1.92		-5	107	252	248	62	72	73	
3	45	658.00	0.87	1.71		-4	106	252	253	61	72	72	
4	50	661.87	0.98	1.92		-4	107	251	253	54	72	72	
5	55	665.80	1.00	1.96		-5	107	250	252	59	72	72	
6	60	669.65	0.97	1.90		-5	107	248	247	54	72	71	
3-1	65	673.65	1.10	2.16		-5	106	250	251	51	73	72	
2	70	677.92	1.15	2.26		-5	106	250	249	49	74	72	
3	75	682.06	1.10	2.16		-5	106	249	249	43	75	73	
4	80	685.96	1.00	1.97		-5	106	251	250	40	73	74	
5	85	689.86	1.10	2.17		-5	106	250	250	38	75	75	
6	90	693.73	0.94	1.86		-4	106	249	251	35	76	75	
4-1	95	697.64	0.99	1.96		-4	106	248	251	36	76	76	
2	100	701.88	1.15	2.28		-4	106	251	250	35	75	76	
3	105	706.10	1.15	2.27		-4	106	250	247	36	76	76	
4	110	710.01	1.00	2.18		-4	106	252	247	37	76	76	
5	115	713.82	0.93	1.84		-4	106	249	251	37	76	76	
6	120	717.52	0.97	1.92		-4	106	250	250	37	77	77	
	Ø=1610	Vm=95.52		ΔH=2.03			Ts=106.5					Tm=74.35	

	Initialization Values: Meter Temp	Oxygen Content	Moisture Content	Test Run Times: Start Time	End Time	ORSAT System: Bag No.	Bag Vol	cc/min * at 15 in Hg	Sample Train Components: Filter No.	Nozzle No.	Nozzle Dn
Run 3	78	19.3%	~~6.5%~~	1356	1610	B-3	60L	0.0	4Q0593	B-1	0.215
Run 2											

8.10% e
8.6

Nozzle Calibration	
Tech.	Date
Nozzle No.	
1	See E- Copy
2	
3	
Avg. in.	

Moisture Recovery Data and impinger content information: Run 3

Impinger	1	2	3	4	5	6	7	Desiccant	Total
Final wt., g	800	804.1	806.6	776.5	761.1	769.4	758.8	973.7	
Initial wt., g	761.4	748.1	775.8	760.5	755.1	768.1	760.4	955.3	
Difference	38.6	56	30.8	16	6	1.3	-1.6	18.4	165.5
	1 N KCl			HNO3/H2O2	H2SO4/KMNO4				

Run 3

Air Flows	
ACFM	DSCFM
207,448	168,553

BARR

ONTARIO HYRDO D-6784-16 MERCURY TESTING
IMPINGER RECOVERY

Project Arcelor Mittal Date 2/8/17

Project No. Z3691843.00 LONG Operators B4W

Source Stack C SV016 Sample Location

TEST 3 RUN 1	IMPINGER VOLUMES							DRY COLUMN
	1	2	3	4	750.1 5	750.0 6	759.7 7	
	g	g	g	g	g	g	g	g
START.	768.6	763.9	758.8	754.6	~~749.5~~	~~757.0~~	~~758.7~~	976.5
END	797.2	815.3	791.9	775.2	756.0	755.7	760.1	997.1
CHANGE								
							MASS OF MOISTURE COLLECTED, g	

TEST 3 RUN 2	IMPINGER VOLUMES							DRY COLUMN
	1	2	3	4	5	6	7	
	g	g	g	g	g	g	g	g
START.	758.6	749.9	768.8	750.0	757.8	760.1	764.2	969.4
END	792.0	814.9	808.8	776.3	772.0	762.4	765.6	981.8
CHANGE								
							MASS OF MOISTURE COLLECTED, g	

TEST 3 RUN 3	IMPINGER VOLUMES							DRY COLUMN
	1	2	3	4	5	6	7	
	g	g	g	g	g	g	g	g
START.	775.2	769.2	764.9	760.6	751.2	762.9	762.6	915.6
END	825.8	838.2	800.7	777.0	755.1	765.4	761.9	927.7
CHANGE								
							MASS OF MOISTURE COLLECTED, g	

TEST ____ RUN 4	IMPINGER VOLUMES							DRY COLUMN
	1	2	3	4	5	6	7	
	g	g	g	g	g	g	g	g
START.								
END								
CHANGE								

COMMENTS

BARR

Method 5/Ontario Hydro
FIELD DATA SHEET

Project ArcelorMittal Minorca Mine
Smpl Loc Furnace Stack C SV016
Test No. 3 Run 1
Date 2/8/17 Operators MJN/RMP/JARZ

Meter ID C-12 MJN
Meter Y ~~1.0065~~ 0.9950
Orifice H@ ~~1.7056~~ 1.9878
Liner Type: ☒Glass ☐S.S. ☐Other

Probe ID 5-3
Pitot No. 5-3
Pitot Cp 0.84

Bar. Pres 28.33 in Hg
Stat. Pres -0.85 in H2O
Probe Lgth 5 ft
Imp TC TPO-1

Sample Train Leak Rate (cfm)			
Pretest 0.00	at	15	in Hg
Posttest 0.00	at	6	in Hg
Pitot (3 in.) Pos. ☒Neg. ☒			

Sample Point	Sample Time Δt	Meter Volume vm, ft³	Velocity ΔP, in H_2O	Orifice ΔH, in H_2O	Ideal Meter Volume	Sample Vacuum, in Hg	Stack Temp. ts, °F	Sample Train Temperatures, °F					Oxygen Content, %
								Probe	Filter	Impinger Outlet	Meter Inlet	Meter Outlet	
	0807	330.70											
1-1	5	334.25	0.95	1.74	NA	-5	113	249	251	34	67	66	
2	10	337.99	0.97	1.78		-5	114	250	250	36	66	66	
3	15	341.63	0.90	1.65		-4	114	247	250	36	66	67	
4	20	345.19	0.93	1.71		-4	113	248	251	34	66	67	
5	25	348.56	0.84	1.54		-4	113	249	249	34	66	67	
6	30	351.91	0.83	1.52		-4	114	251	251	34	66	67	
2-1	35	355.40	0.91	1.67		-4	113	250	251	34	67	67	
2	40	358.90	0.92	1.69		-4	113	250	250	35	67	67	
3	45	362.38	0.89	1.64		-4	113	251	250	36	67	67	
4	50	366.03	0.96	1.76		-5	113	250	250	37	67	68	
5	55	369.65	0.96	1.77		-5	113	250	250	38	67	68	
6	60	373.23	0.94	1.73		-5	113	251	250	40	67	68	
3-1	65	376.74	0.91	1.67		-5	113	249	250	42	68	69	
2	70	380.20	0.89	1.64		-5	113	247	250	43	68	69	
3	75	383.85	0.96	1.77		-5	113	243	251	44	69	69	
4	80	387.38	0.92	1.70		-5	113	244	250	46	69	70	
5	85	390.85	0.86	1.59		-5	113	249	250	50	70	70	
6	90	394.30	0.85	1.57		-5	114	252	250	51	70	70	
4-1	95	397.83	0.90	1.66		-5	113	253	250	52	71	71	
2	100	401.45	0.95	1.76		-5	113	255	249	56	71	71	
3	105	405.04	0.97	1.79		-5	114	253	250	58	71	71	
4	110	408.75	0.97	1.79		-5	114	254	250	58	71	72	
5	115	412.15	0.83	1.54		-5	113	252	250	59	71	72	
6	120	415.74	0.85	1.58		-5	113	251	250	60	72	72	
	Ø=1020	Vm=85.04		ΔH=1.68			Ts=113.3					Tm=68.56	

	Initialization Values			Test Run Times		ORSAT System			Sample Train Components		
	Meter Temp	Oxygen Content	Moisture Content	Start Time	End Time	Bag No.	Bag Vol	cc/min * at 15 in Hg	Filter No.	Nozzle No.	Nozzle Dn
Run 1	66	18.5%	12.5%	0807	1020	C-1	60	0.0	4Q0594	C-1	0.214
Run 2											

Nozzle Calibration	
Tech.	Date
Nozzle No.	
1	
2	See
3	E-Cal
Avg. in.	

MJN
Moisture Recovery Data and impinger content information:

Impinger	797.2	2	3	4	5	6	7	Desiccant	Total
Final wt., g	~~780.6~~	815.3	791.9	775.2	756.0	755.7	760.1	997.1	
Initial wt., g	768.6	763.9	758.8	754.6	~~749.5~~	750.0	~~750.7~~	976.5	
Difference	28.6	51.4	33.1	20.6	5.9	5.7	0.4	20.6	166.3
	1 N KCl			HNO3/H2O2	750.1	H2SO4/KMNO4	754.7		

MJN

Air Flows	
ACFM	DSCFM
205,993	163,326

BARR

Method 5/Ontario Hydro
FIELD DATA SHEET

Project ArcelorMittal Minorca Mine
Smpl Loc Furnace Stack C SV016
Test No. 3 Run 2
Date 2/8/17 Operators MJN/RMP/JARZ

Meter ID C-12
Meter Y ~~1.0003~~ 0.9950
Orifice H@ ~~1.7056~~ 1.9878
Liner Type: ☒ Glass ☐ S.S. ☐ Other

Probe ID 5-3
Pitot No. 5-3
Pitot Cp 0.84

Bar. Pres 28.33 in Hg
Stat. Pres -0.85 in H_2O
Probe Lgth 5 ft
Imp TC TIO-1

Sample Train Leak Rate (cfm)				
Pretest	0.00	at	10	in Hg
Posttest	0.00	at	10	in Hg
Pitot (3 in.)	Pos. ☒	Neg. ☒		

Sample Point	Sample Time Δt	Meter Volume vm, ft³	Velocity ΔP, in H_2O	Orifice ΔH, in H_2O	Ideal Meter Volume	Sample Vacuum, in Hg	Stack Temp. ts, °F	Sample Train Temperatures, °F Probe	Filter	Impinger Outlet	Meter Inlet	Meter Outlet	Oxygen Content, %
	1104	416.14											
1-1	5	419.85	0.98	1.82	NA	-6	113	230	251	34	74	74	
2	10	423.48	0.98	1.82		-6	113	231	251	34	74	74	
3	15	427.25	0.98	1.82		-6	113	233	251	35	74	74	
4	20	430.98	0.94	1.75		-6	113	244	250	35	74	74	
5	25	434.50	0.83	1.62		-6	114	244	250	35	74	74	
6	30	437.93	0.80	1.56		-5	113	245	251	34	74	75	
2-1	35	441.87	1.05	2.05		-7	113	247	250	36	75	75	
2	40	445.84	1.05	2.05		-7	113	248	250	36	75	75	
3	45	449.70	0.98	1.91		-7	114	250	250	36	76	75	
4	50	453.55	0.99	1.93		-7	114	247	250	38	76	76	
5	55	457.12	0.88	1.72		-7	113	249	250	40	76	76	
6	60	460.75	0.89	1.74		-6	113	253	250	41	76	76	
3-1	65	464.38	0.94	1.84		-7	114	260	250	42	77	76	
2	70	468.11	0.93	1.82		-7	114	255	250	45	77	76	
3	75	471.95	0.95	1.91		-7	114	251	250	46	77	77	
4	80	475.84	0.97	1.95		-7	113	251	250	48	77	77	
5	85	479.68	0.94	1.89		-7	113	250	249	50	77	77	
6	90	483.58	0.93	1.87		-7	113	249	249	50	78	77	
4-1	95	487.20	0.85	1.71		-7	114	253	250	52	78	78	
2	100	490.95	0.90	1.82		-7	113	251	250	52	78	78	
3	105	494.60	0.94	1.90		-7	113	250	250	52	78	78	
4	110	498.25	0.84	1.69		-7	114	250	250	52	78	78	
5	115	501.94	0.78	1.57		-7	113	250	250	53	78	78	
6	120	505.49	0.81	1.64		-6	113	248	250	53	78	79	
	Ø= 1313	Vm=89.35		ΔH=1.81			Ts=113.3					Tm=76.17	

	Initialization Values Meter Temp	Oxygen Content	Moisture Content	Test Run Times Start Time	End Time	ORSAT System Bag No.	Bag Vol	cc/min * at 15 in Hg	Sample Train Components Filter No.	Nozzle No.	Nozzle Dn
Run 2	74	18.5%	12.5%	1104	1313	C-2	60	0.0	400595	C-1	0.244
Run 2											

Nozzle Calibration	
Tech.	Date
Nozzle No.	
1	See
2	
3	E-Copy
Avg. in.	

Moisture Recovery Data and impinger content information: Run 2

Impinger	1	2	3	4	5	6	7	Desiccant	Total
Final wt., g	792	814.9	808.8	776.3	772	762.4	765.6	981.8	
Initial wt., g	758.6	749.9	768.8	750.0	757.8	760.1	764.2	969.4	
Difference	33.4	65	40	26.3	14.2	2.3	1.4	12.4	195
	1 N KCl			HNO3/H2O2	H2SO4/KMNO4				

Run 2

Air Flows	
ACFM	DSCFM
207,605	162,692

BARR

Method 5/Ontario Hydro
FIELD DATA SHEET

Project ArcelorMittal Minorca Mine
Smpl Loc Furnace Stack C SV016
Test No. 3 Run 3
Date 2/8/17 Operators MJW/RMD/JARZ

Meter ID C-12
Meter Y ~~1.0063~~ 0.9950
Orifice H@ ~~1.7056~~ 1.9878
Liner Type: ☒Glass ☐S.S. ☐Other

Probe ID 5-3
Pitot No. 5-3
Pitot Cp 0.84

Bar. Pres 28.33 in Hg
Stat. Pres -0.85 in H₂O
Probe Lgth 5 ft
Imp TC TRO-1

Sample Train Leak Rate (cfm)			
Pretest 0.00	at 10	in Hg	
Posttest 0.00	at 6	in Hg	
Pitot (3 in.)	Pos. ☒	Neg. ☒	

Sample Point	Sample Time Δt	Meter Volume Vm, ft³	Velocity ΔP, in H₂O	Orifice ΔH, in H₂O	Ideal Meter Volume	Sample Vacuum, in Hg	Stack Temp. Ts, °F	Sample Train Temperatures, °F Probe	Filter	Impinger Outlet	Meter Inlet	Meter Outlet	Oxygen Content, %
	1436	505.90											
1-1	5	509.10	0.95	1.86	NA	-5	113	230	240	36	79	79	
2	10	512.90	0.90	1.81		-5	112	245	250	34	81	80	
3	15	516.65	0.86	1.73		-4	113	243	250	36	80	81	
4	20	520.24	0.77	1.55		-5	113	250	260	36	80	81	
5	25	523.89	0.86	1.73		-4	113	252	260	34	80	81	
6	30	527.39	0.75	1.51		-4	113	257	260	34	79	81	
2-1	35	531.10	0.93	1.87		-5	113	255	260	34	81	81	
2	40	534.96	0.92	1.85		-5	113	255	260	35	80	81	
3	45	538.72	0.91	1.83		-5	113	256	261	35	80	81	
4	50	542.42	0.88	1.77		-5	114	255	260	34	80	81	
5	55	546.00	0.80	1.61		-5	114	260	260	35	80	81	
6	60	549.57	0.84	1.69		-5	114	260	260	35	80	81	
3-1	65	553.22	0.87	1.75		-5	113	263	260	34	79	81	
2	70	556.88	0.87	1.75		-5	113	263	260	34	79	81	
3	75	560.54	0.91	1.83		-5	113	263	261	34	78	81	
4	80	564.30	0.91	1.82		-5	114	261	260	34	77	80	
5	85	567.81	0.80	1.60		-5	114	261	260	35	77	80	
6	90	571.39	0.85	1.68		-5	113	262	259	35	77	80	
4-1	95	575.10	0.93	1.86		-5	113	263	261	34	76	79	
2	100	578.95	0.94	1.88		-5	113	259	261	37	75	79	
3	105	582.70	0.88	1.75		-5	114	261	260	39	75	78	
4	110	586.38	0.90	1.80		-5	113	261	260	41	74	78	
5	115	590.05	0.77	1.54		-5	113	261	261	43	74	77	
6	120	593.38	0.75	1.49		-5	114	255	260	44	74	77	
	Ø=1651	Vm=87.48		ΔH= 1.73			Ts=113.3					Tm=79.04	

Pause @ 1401 for equip malf.

pause @ 1516 problem w/ stack A. Restart 1523

	Initialization Values Meter Temp	Oxygen Content	Moisture Content	Test Run Times Start Time	End Time	ORSAT System Bag No.	Bag Vol	cc/min * at 15 in Hg	Sample Train Components Filter No.	Nozzle No.	Nozzle Dn
Run 3	79	18.5%	9.0%	1436	1651	C-3	60 L	0.0	400596	C-1	0.214
Run 2											

Nozzle Calibration	
Tech.	Date
Nozzle No.	
1	See E-Copy
2	
3	
Avg. in.	

Moisture Recovery Data and impinger content information: Run 3

Impinger	1	2	3	4	5	6	7	Desiccant	Total
Final wt., g	825.8	838.2	800.7	777	755.1	765.4	761.9	927.7	
Initial wt., g	775.2	769.2	764.9	760.6	751.2	762.9	762.6	915.6	
Difference	50.6	69	35.8	16.4	3.9	2.5	-0.7	12.1	189.6
	1 N KCl			HNO3/H2O2	H2SO4/KMNO4				

Run 3

Air Flows	
ACFM	DSCFM
200,993	157,354

BARR

ONTARIO HYRDO D-6784-16 MERCURY TESTING
IMPINGER RECOVERY

Project ArcelorMittal
Date 2/9/17
Project No. 23691843.00
Operators BAW
Source Stack D SV017
Sample Location

TEST 4 RUN	IMPINGER VOLUMES							~~DRY~~ COLUMN
	1	2	3	4	5	6	7	
	g	g	g	g	g	g	g	g
START.	~~760.5~~	~~768.5~~	~~767.9~~	~~753.3~~	~~758.2~~	~~749.4~~	~~753.7~~	~~921.3~~
END								
CHANGE								
MASS OF MOISTURE COLLECTED, g								

TEST 4 RUN 1	IMPINGER VOLUMES							DRY COLUMN
	1	2	3	4	5	6	7	
	g	g	g	g	g	g	g	g
START.	774.1	769.7	766.6	759.9	731.3	740.1	740.6	926.2
END	796.7	809.5	790.6	774.9	742.4	741.6	737.7	942.0
CHANGE								
MASS OF MOISTURE COLLECTED, g								

913.2
[illegible]
~~911.9~~
930.4

TEST 4 RUN 2	IMPINGER VOLUMES							DRY COLUMN
	1	2	3	4	5	6	7	
	g	g	g	g	g	g	g	g
START.	759.6	767.4	770.9	758.7	756.1	749.2	753.3	943.9
END	834.9	832.3	791.8	766.8	761.4	747.3	754.2	959.5
CHANGE								
MASS OF MOISTURE COLLECTED, g								

TEST 4 RUN 3	IMPINGER VOLUMES							DRY COLUMN
	1	2	3	4	5	6	7	
	g	g	g	g	g	g	g	g
START.	775.8	769.9	765.4	737.0	757.4	761.4	761.5	939.9
END	848.2	840.5	790.0	744.4	759.5	761.2	760.0	951.6
CHANGE								

COMMENTS

BARR

Method 5/Ontario Hydro
FIELD DATA SHEET

Project ArcelorMittal Minorca Mine
Smpl Loc Furnace Stack D SV017
Test No. 4 Run 1
Date 2/9/17 Operators MJW/RMP/JARZ
Meter ID C-12
Meter Y 0.9950
Orifice H@ 1.9878
Liner Type: ☒Glass ☐S.S. ☐Other
Probe ID 5-3
Pitot No. 5-3
Pitot Cp 0.84
Bar. Pres 28.40 in Hg
Stat. Pres -0.95 in H_2O
Probe Lgth 5 ft
Imp TC TI-01

Sample Train Leak Rate (cfm)				
Pretest	0.00	at	10	in Hg
Posttest	0.00	at	15	in Hg
Pitot (3 in.) Pos. ☒Neg. ☒				

Sample Point	Sample Time Δt	Meter Volume Vm, ft³	Velocity ΔP, in H_2O	Orifice ΔH, in H_2O	Ideal Meter Volume	Sample Vacuum, in Hg	Stack Temp. Ts, °F	Sample Train Temperatures, °F Probe	Filter	Impinger Outlet	Meter Inlet	Meter Outlet	Oxygen Content, %
	1001	630.10											
1-1	5	633.20	0.72	1.31	NA	-8	117	257	300	50	62	62	
2	10	636.26	0.72	1.32		-8	115	269	301	52	61	62	
3	15	639.46	0.69	1.26		-8	116	277	301	53	61	62	
4	20	642.62	0.69	1.26		-7	117	279	301	54	61	63	
5	25	645.74	0.73	1.33		-7	117	287	300	56	61	63	
6	30	648.61	0.72	1.32		-8	115	289	300	58	61	63	
2-1	35	651.71	0.71	1.30		-8	115	301	299	60	64	64	
2	40	654.98	0.73	1.34		-8	116	301	300	62	62	64	
3	45	658.21	0.72	1.32		-8	116	300	300	62	61	64	
4	50	661.30	0.72	1.31		-8	117	296	300	62	60	64	
5	55	662.75	0.73	1.34		-10	115	301	299	64	60	64	
6	60	664.80	0.69	1.26		-9	116	307	300	64	61	64	
3-1	65	667.50	0.70	1.28		-10	116	295	300	65	64	64	
2	70	669.94	0.67	1.23		-10	116	294	300	64	63	64	
3	75	672.96	0.67	1.23		-10	117	294	300	64	63	65	
4	80	676.15	0.68	1.25		-12	117	283	278	64	63	65	
5	85	679.45	0.69	1.26		-12	117	278	275	64	63	65	
6	90	682.51	0.71	1.30		-12	116	277	270	65	63	65	
4-1	95	686.88	0.65	1.19		-11	117	269	250	65	64	66	
2	100	689.89	0.70	1.29		-12	116	267	250	65	64	66	
3	105	693.22	0.67	1.23		-11	116	270	250	65	64	66	
4	110	696.44	0.70	1.28		-10	119	253	251	61	64	66	
5	115	699.65	0.70	1.28		-10	117	253	249	56	65	66	
6	120	702.74	0.70	1.29		-10	117	250	249	52	65	67	
	Ø=1221	Vm=72.64		ΔH=1.28			Ts=116.3					Tm=63.42	

vacuum trouble possible D.C. freeze

switch dry column Restart 1115

	Initialization Values Meter Temp	Oxygen Content	Moisture Content	Test Run Times Start Time	End Time	ORSAT System Bag No.	Bag Vol	cc/min * at 15 in Hg	Sample Train Components Filter No.	Nozzle No.	Nozzle Dn
Run 1	62	18.0%	12.0%	1001	1221	5-1	60L	0.0	400648	D-1	0.214
Run 2											

Nozzle Calibration	
Tech.	Date
Nozzle No.	
1	See E copy
2	
3	
Avg. in.	

Moisture Recovery Data and impinger content information Run 1

Impinger	1	2	3	4	5	6	7	Desiccant	Total
Final wt., g	796.7	801.5	790.6	774.9	742.4	741.6	737.7	942	
Initial wt., g	774.1	761.7	766.6	759.9	731.3	740.1	740.6	926.2	
Difference	22.6	39.8	24	15	11.1	1.5	-2.9	33	144.1
	1 N KCl			HNO3/H2O2	H2SO4/KMNO4				

Run 1

Air Flows	
ACFM	DSCFM
190,783	142,866

BARR

Method 5/Ontario Hydro
FIELD DATA SHEET

Project ArcelorMittal Minorca Mine
Smpl Loc Furnace Stack D SV017
Test No. 4 Run 2
Date 2/9/17 Operators MJN/RMP/JAR2

Meter ID C-12
Meter Y 0.9950
Orifice H@ 1.9878
Liner Type: ☒Glass ☐S.S. ☐Other

Probe ID 5-3
Pitot No. 5-3
Pitot Cp 0.84

Bar. Pres 28.40 in Hg
Stat. Pres -0.95 in H_2O
Probe Lgth 5 ft
Imp TC TTO-1253

Sample Train Leak Rate (cfm)				
Pretest	0.00	at	10	in Hg
Posttest	0.00	at	5	in Hg
Pitot (3 in.)	Pos. ~~☒~~	Neg. ☒		

Switch UM. prior to start

Sample Point	Sample Time Δt	Meter Volume Vm, ft³	Velocity ΔP, in H_2O	Orifice ΔH, in H_2O	Ideal Meter Volume	Sample Vacuum, in Hg	Stack Temp. Ts, °F	Sample Train Temperatures, °F Probe	Filter	Impinger Outlet	Meter Inlet	Meter Outlet	Oxygen Content, %
	1325	707.00											
1-1	5	710.35	0.72	1.50	NA	-3	118	229	249	40	76	76	
2	10	713.51	0.72	1.35		-3	118	230	250	42	75	76	
3	15	716.72	0.72	1.35		-3	118	235	250	47	75	76	
4	20	720.01	0.71	1.40		-3	118	237	249	50	75	77	
5	25	723.31	0.72	1.42		-3	118	245	251	53	75	77	
6	30	726.60	0.71	1.41		-3	117	246	251	56	75	77	
2-1	35	729.75	0.74	1.46		-3	117	245	252	53	75	77	
2	40	733.12	0.70	1.39		-3	117	250	250	60	76	78	
3	45	736.29	0.71	1.41		-3	118	244	249	57	76	78	
4	50	739.47	0.69	1.37		-3	118	252	250	61	76	78	
5	55	742.62	0.68	1.35		-3	117	253	254	61	76	78	
6	60	745.75	0.68	1.35		-3	118	252	250	63	76	78	
3-1	65	748.96	0.70	1.39		-3	118	251	248	61	76	78	
2	70	752.18	0.70	1.39		-3	118	250	249	61	76	78	
3	75	755.44	0.72	1.43		-3	118	250	250	60	76	78	
4	80	758.70	0.71	1.40		-3	119	259	251	59	76	78	
5	85	761.95	0.70	1.39		-3	118	252	253	59	76	78	
6	90	765.20	0.73	1.45		-3	118	248	250	57	76	78	
4-1	95	768.46	0.71	1.41		-3	118	249	249	53	76	78	
2	100	771.65	0.70	1.39		-3	118	245	248	49	76	78	
3	105	774.89	0.72	1.43		-3	117	251	250	48	77	78	
4	110	778.24	0.74	1.47		-4	118	249	250	43	77	79	
5	115	781.54	0.74	1.47		-4	117	249	250	40	78	79	
6	120	784.74	0.73	1.45		-3	117	249	251	37	78	79	
	Ø=1545	Vm=77.74		ΔH=1.41			Ts=117.8					Tm=76.85	

	Initialization Values Meter Temp	Oxygen Content	Moisture Content	Test Run Times Start Time	End Time	ORSAT System Bag No.	Bag Vol	cc/min * at 15 in Hg	Sample Train Components Filter No.	Nozzle No.	Nozzle Dn
Run 2	75	18.0%	~~12.0%~~ 9.0% @ Pt.4	1325	1545	D-2	60L	0.0	~~[illegible]~~ 4Q0544	D-1	0.214
Run 2											

Nozzle Calibration	
Tech.	Date
Nozzle No.	
1	See E-Copy
2	
3	
Avg. in.	

Moisture Recovery Data and impinger content information: Run 2

Impinger	1	2	3	4	5	6	7	Desiccant	Total
Final wt., g									
Initial wt., g	759.6	761.4	770.9	758.7	756.1	749.2	753.3	943.9	
Difference									
	1 N KCl			HNO3/H2O2	H2SO4/KMNO4				

Run 2

Air Flows	
ACFM	DSCFM

BARR

Method 5/Ontario Hydro
FIELD DATA SHEET

Project ArcelorMittal Minorca Mine
Smpl Loc Furnace Stack D SV017
Test No. 4 Run 3
Date 2/9/17 Operators MJW/RMP/JAEZ

Meter ID C-12
Meter Y 0.9950
Orifice H@ 1.9878
Liner Type: ☒Glass ☐S.S. ☐Other

Probe ID 5-3
Pitot No. 5-3
Pitot Cp 0.84

Bar. Pres 28.40 in Hg
Stat. Pres -0.95 in H_2O
Probe Lgth 5 ft
Imp TC 1253

Sample Train Leak Rate (cfm)			
Pretest 0.00	at	10	in Hg
Posttest 0.00	at	6	in Hg
Pitot (3 in.) Pos. ☒Neg. ☒			

Sample Point	Sample Time ΔI	Meter Volume Vm, ft³	Velocity ΔP, in H_2O	Orifice ΔH, in H_2O	Ideal Meter Volume	Sample Vacuum, in Hg	Stack Temp. Ts, °F	Sample Train Temperatures, °F Probe	Filter	Impinger Outlet	Meter Inlet	Meter Outlet	Oxygen Content, %
	1600	785.10											
1-1	5	788.03	0.69	1.46	NA	-5	119	235	250	56	85	83	
2	10	791.26	0.65	1.26		-5	118	230	250	57	84	83	
3	15	794.51	0.67	1.29		-5	120	235	250	58	82	83	
4	20	797.80	0.69	1.33		-5	119	235	249	60	81	83	
5	25	801.10	0.70	1.35		-5	119	248	251	63	79	83	
6	30	804.42	0.74	1.42		-6	118	244	249	59	78	83	
2-1	35	807.61	0.71	1.37		-6	117	249	250	54	77	82	
2	40	810.78	0.70	1.34		-6	118	252	250	51	77	81	
3	45	813.96	0.70	1.34		-6	118	253	250	47	77	81	
4	50	817.10	0.69	1.32		-5	119	246	250	43	76	80	
5	55	820.29	0.72	1.37		-6	119	246	250	39	75	80	
6	60	823.50	0.73	1.39		-6	118	245	249	36	74	79	
3-1	65	826.66	0.70	1.33		-5	118	246	250	34	74	79	
2	70	829.82	0.70	1.33		-5	118	253	251	33	73	78	
3	75	832.95	0.72	1.37		-6	118	248	250	33	73	77	
4	80	836.08	0.72	1.37		-6	119	250	250	33	72	77	
5	85	839.20	0.71	1.35		-6	118	249	250	34	72	76	
6	90	842.32	0.72	1.37		-6	117	250	249	34	71	76	
4-1	95	845.43	0.71	1.35		-6	118	250	250	34	71	76	
2	100	848.53	0.70	1.33		-6	118	249	250	34	71	75	
3	105	851.69	0.69	1.31		-6	118	250	248	34	71	75	
4	110	854.88	0.72	1.36		-6	118	249	251	33	70	74	
5	115	858.07	0.72	1.36		-6	117	250	250	33	70	74	
6	120	861.21	0.71	1.34		-6	119	250	250	33	70	74	
	Ø=1810	Vm= 76.11		ΔH= 1.35			Ts= 118.3					Tm= 76.98	

	Initialization Values Meter Temp	Oxygen Content	Moisture Content	Test Run Times Start Time	End Time	ORSAT System Bag No.	Bag Vol	cc/min * at 15 in Hg	Sample Train Components Filter No.	Nozzle No.	Nozzle Dn
Run 3	84	18.0%	11.0%	1400	1810	D-3	60L	0.0	400649	D-1	0.214
Run 2											

Nozzle Calibration Tech.	Date
Nozzle No.	
1	See E-copy
2	
3	
Avg. in.	

Moisture Recovery Data and impinger content information: Run 3

Impinger	848.2	2	3	4	5	6	7	Desiccant	Total
Final wt., g	~~800~~	840.5	790	744.4	759.5	761.2	760	951.6	
Initial wt., g	775.8	769.9	765.4	737	757.4	761.4	761.5	939.9	
Difference	72.4	70.6	24.6	7.4	2.1	-0.2	-1.5	11.7	187.1
	1 N KCl			HNO3/H2O2	H2SO4/KMNO4				

Run 3

Air Flows ACFM	DSCFM
182,408	140,280

BARR

ONTARIO HYRDO D-6784-16 MERCURY TESTING
IMPINGER RECOVERY

Project Arcelor Mittal
Date 3/28/17
Project No.
Operators BAW
Source Stack A SV014
Sample Location

TEST 1 RUN 1	IMPINGER VOLUMES							DRY COLUMN
	1	2	3	4	5	6	7	
	g	g	g	g	g	g	g	g
START.	781.5	764.5	752.8	763.2	741.7	757.9	764.8	926.2
END	888.8	810.8	761.6	766.3	742.7	757.6	765.0	944.2
CHANGE								
							MASS OF MOISTURE COLLECTED, g	

TEST 1 RUN 2	IMPINGER VOLUMES							DRY COLUMN
	1	2	3	4	5	6	7	
	g	g	g	g	g	g	g	g
START.	757.2	764.9	749.0	732.0	765.8	748.4	800.5	935.9
END	856.0	812.4	763.4	738.4	766.4	748.3	799.3	952.7
CHANGE								
							MASS OF MOISTURE COLLECTED, g	

TEST 1 RUN 3	IMPINGER VOLUMES							DRY COLUMN
	1	2	3	4	5	6	7	
	g	g	g	g	g	g	g	g
START.	753.0	755.0	761.5	760.2	754.0	758.5	758.6	938.6
END	828.9	815.4	776.4	768.8	755.3	759.5	757.3	952 6
CHANGE								
							MASS OF MOISTURE COLLECTED, g	

TEST RUN 4	IMPINGER VOLUMES							DRY COLUMN
	1	2	3	4	5	6	7	
	g	g	g	g	g	g	g	g
START.								
END								
CHANGE								

COMMENTS

BARR

Method 5/Ontario Hydro
FIELD DATA SHEET

Project ArcelorMittal Minorca Mine
Smpl Loc Furnace Stack A SV014
Test No. 1 Run 1
Date 3/28/17 Operators MJN/RMP/JARZ

Meter ID C-9
Meter Y 1.0113
Orifice H@ 1.9583
Liner Type: ☒Glass ☐S.S. ☐Other

Probe ID 5-2
Pitot No. 5-2
Pitot Cp 0.84

Bar. Pres 28.47 in Hg
Stat. Pres -1.0 in H2O
Probe Lgth 5 ft
Imp TC 5843

Sample Train Leak Rate (cfm)			
Pretest 0.00	at	10	in Hg
Posttest 0.00	at	5	in Hg
Pitot (3 in.) Pos. ☒	Neg. ☒		

Sample Point	Sample Time ΔT	Meter Volume Vm, ft³	Velocity ΔP, in H2O	Orifice ΔH, in H2O	Ideal Meter Volume	Sample Vacuum, in Hg	Stack Temp. Ts, °F	Sample Train Temperatures, °F Probe	Filter	Impinger Outlet	Meter Inlet	Meter Outlet	Oxygen Content, %
	0804	840.30											
1-1	5	843.84	0.97	1.79	NA	-3	113	245	242	46	46	47	
2	10	847.45	0.97	1.79		-3	113	244	246	45	46	46	
3	15	850.95	0.95	1.75		-3	112	245	245	43	47	45	
4	20	854.38	0.93	1.72		-3	111	245	245	44	49	44	
5	25	857.60	0.76	1.40		-2.5	112	245	245	46	50	45	
6	30	860.67	0.76	1.40		-2	112	245	245	47	50	45	
2-1	35	864.07	0.88	1.63		-3	112	246	247	47	47	45	
2	40	867.53	0.91	1.68		-3	112	244	243	47	51	45	
3	45	870.85	0.86	1.59		-3	113	246	246	45	53	46	
4	50	874.21	0.86	1.60		-3	112	245	245	45	54	46	
5	55	877.38	0.74	1.37		-3	112	245	246	45	56	47	
6	60	880.49	0.74	1.38		-2	112	245	245	45	57	48	
3-1	65	884.15	0.98	1.83		-3	112	245	248	45	55	48	
2	70	887.75	1.00	1.86		-3	112	245	243	46	58	49	
3	75	891.38	0.99	1.85		-3	112	248	247	46	60	50	
4	80	895.10	1.00	1.80		-3	112	246	245	46	60	51	
5	85 MN	898.48	0.84	1.58		-3	112	245	245	47	61	52	
6	90	901.78	0.84	1.58		-3	111	245	245	47	61	52	
4-1	95	905.41	1.00	1.88		-3	111	245	248	46	56	53	
2	100	909.16	1.05	1.97		-3	112	245	243	49	61	54	
3	105	912.90	1.05	1.98		-3	113	247	246	50	62	54	
4	110	916.65	1.05	1.98		-3	112	245	245	53	63	55	
5	115	920.18	0.92	1.74		-3	113	245	245	54	63	55	
6	120	923.71	0.92	1.74		-3	113	245	245	56	64	56	
	Ø= 1011	Vm= 83.41		ΔH̄= 1.71			T̄s= 112.13					T̄m= 52.25	

	Initialization Values Meter Temp	Oxygen Content	Moisture Content	Test Run Times Start Time	End Time	ORSAT System Bag No.	Bag Vol	cc/min * at 15 in Hg	Sample Train Components Filter No.	Nozzle No.	Nozzle Dn
Run 1	~~50~~ 47	19.6	8.0%	0804	1011	A-1	60 L	0.0	4Q0650	A-1	0.213
Run 2											

Nozzle Calibration	
Tech.	Date
Nozzle No.	
1	See E-Cal
2	
3	
Avg. in.	

Moisture Recovery Data and impinger content information:

Impinger	1	2	3	4	5	6	7	Desiccant	Total
Final wt., g	888.8	910.8	761.6	766.3	742.7	757.6	765	944.2	
Initial wt., g	781.5	764.5	752.8	763.2	741.7	757.9	764.8	926.2	
Difference	107.3	146.3	8.8	3.1	1	-.3	.02	18	184.4
	1 N KCl			HNO3/H2O2	H2SO4/KMNO4				

Air Flows	
ACFM	DSCFM
197,403	156,542

BARR

Method 5/Ontario Hydro
FIELD DATA SHEET

Project ArcelorMittal Minorca Mine
Smpl Loc Furnace Stack A SV014
Test No. 1 Run 2
Date 3/28/17 Operators MJN/RMP/JARZ

Meter ID C-9
Meter Y 1.0113
Orifice H@ 1.9583
Liner Type: ☒Glass ☐S.S. ☐Other

Probe ID 5-2
Pitot No. 5-2
Pitot Cp 0.84

Bar. Pres 28.41 in Hg
Stat. Pres -1.0 in H_2O
Probe Lgth 5 ft
Imp TC 5843

Sample Train Leak Rate (cfm)			
Pretest 0.00	at	10	in Hg
Posttest 0.00	at	6	in Hg
Pitot (3 in.) Pos. ☒	Neg. ☒		

Sample Point	Sample Time ΔT	Meter Volume Vm, ft³	Velocity ΔP, in H_2O	Orifice ΔH, in H_2O	Ideal Meter Volume	Sample Vacuum, in Hg	Stack Temp. Ts, °F	Sample Train Temperatures, °F Probe	Filter	Impinger Outlet	Meter Inlet	Meter Outlet	Oxygen Content, %
	1043	924.05											
1-1	5	927.85	1.10	2.03	NA	-4	112	252	246	60	57	57	
2	10	931.72	1.10	2.03		-4	112	251	246	60	60	57	
3	15	935.54	1.10	2.04		-4	113	245	245	60	62	57	
4	20	939.32	1.10	2.04		-4	113	245	245	62	64	58	
5	25	942.94	0.93	1.73		-4	113	245	246	63	66	58	
6	30	946.56	0.93	1.74		-4	112	246	246	60	66	59	
2-1	35	950.18	1.00	1.87		-4	113	245	246	60	64	59	
2	40	953.87	1.00	1.86		-4	114	245	245	58	66	60	
3	45	957.51	0.98	1.82		-4	115	245	247	57	68	60	
4	50	961.13	0.97	1.81		-4	115	245	245	54	69	61	
5	55	964.50	0.84	1.58		-4	113	246	244	56	69	61	
6	60	967.88	0.82	1.53		-4	112	245	247	57	69	62	
3-1	65	971.31	0.88	1.64		-4	112	246	246	55	66	62	
2	70	974.78	0.87	1.61		-4	116	244	244	55	70	63	
3	75	978.18	0.87	1.61		-4	116	245	246	54	71	63	
4	80	981.55	0.87	1.62		-4	115	245	243	53	71	64	
5	85	984.85	0.78	1.45		-4	115	245	245	53	72	64	
6	90	988.00	0.77	1.43		-4	115	246	247	53	72	65	
4-1	95	991.60	0.91	1.70		-4	115	245	245	52	70	66	
2	100	995.12	0.93	1.73		-4	115	245	243	53	72	66	
3	105	998.63	0.92	1.71		-4	116	244	242	53	71	66	
4	110	1002.14	0.93	1.73		-4	115	245	246	53	71	66	
5	115	1005.52	0.84	1.56		-4	116	245	248	54	70	66	
6	120	1008.90	0.82	1.53		-4	115	246	245	54	70	66	
	Ø=1250	Vm=84.85		ΔH=1.72			Ts=114.1					Tm=64.83	

	Initialization Values Meter Temp	Oxygen Content	Moisture Content	Test Run Times Start Time	End Time	ORSAT System Bag No.	Bag Vol	cc/min * at 15 in Hg	Sample Train Components Filter No.	Nozzle No.	Nozzle Dn
Run 1	57	19.6%	9.0%	1043	1250	A-2	60L	0.0	420654	A-1	0.243
Run 2											

Nozzle Calibration	
Tech.	Date
Nozzle No.	
1	E-Copy
2	
3	
Avg. in.	

Moisture Recovery Data and impinger content information:

Impinger	1	2	3	4	5	6	7	Desiccant	Total
Final wt., g	856.0	812.4	763.4	738.4	766.4	748.3	799.3	952.7	
Initial wt., g	757.2	764.9	749.0	732.0	765.8	748.4	800.5	935.9	
Difference	98.8	47.5	14.4	6.4	0.6	-0.1	-1.2	16.8	183.2
	1 N KCl			HNO3/H2O2	H2SO4/KMNO4				

Air Flows	
ACFM	DSCFM
199051	157302

BARR

Method 5/Ontario Hydro
FIELD DATA SHEET

Project ArcelorMittal Minorca Mine
Smpl Loc Furnace Stack A SV014
Test No. 1 Run 3
Date 3/28/17 Operators MJN/RMD/JARZ

Meter ID C-9
Meter Y 1.0113
Orifice H@ 1.9583
Liner Type: ☒Glass ☐S.S. ☐Other

Probe ID 5-2
Pitot No. 5-2
Pitot Cp 0.84
Bar. Pres 28.47 in Hg
Stat. Pres -1.0 in H_2O
Probe Lgth 5 ft
Imp TC 5843

Sample Train Leak Rate (cfm)				
Pretest	0.00	at	10	in Hg
Posttest	0.00	at	5	in Hg

Pitot (3 in.) Pos. ☒ Neg. ☒

Sample Point	Sample Time Δt	Meter Volume vm, ft³	Velocity ΔP, in H_2O	Orifice ΔH, in H_2O	Ideal Meter Volume	Sample Vacuum, in Hg	Stack Temp. Ts, °F	Sample Train Temperatures, °F Probe	Filter	Impinger Outlet	Meter Inlet	Meter Outlet	Oxygen Content, %
	1319	9.45											
1-1	5	13.09	0.97	1.79	NA	-3	115	248	248	51	64	64	
2	10	16.78	0.98	1.80		-3	118	246	247	50	67	64	
3	15	20.32	0.93	1.72		-3	117	245	245	46	70	64	
4	20	23.83	0.93	1.73		-3	116	245	245	48	71	65	
5	25	27.18	0.82	1.52		-3	116	245	244	47	71	65	
6	30	30.40	0.77	1.43		-2	117	246	246	47	71	65	
2-1	35	33.94	0.89	1.65		-3	116	248	246	49	68	65	
2	40	37.41	0.92	1.70		-3	118	245	245	47	70	65	
3	45	40.90	0.90	1.67		-3	117	245	245	49	71	66	
4	50	44.32	0.83	1.54		-3	116	245	245	50	72	66	
5	55	47.33	0.67	1.25		-2	116	246	247	51	72	66	
6	60	50.29	0.67	1.25		-2	117	245	245	51	72	66	
3-1	65	53.87	0.95	1.77		-3	117	246	246	53	70	67	
2	70	57.49	0.97	1.80		-3	117	243	244	51	72	67	
3	75	61.15	0.96	1.79		-3	115	246	246	50	73	67	
4	80	64.80	0.96	1.79		-3	116	246	246	52	74	68	
5	85	68.08	0.76	1.42		-2	116	243	245	52	75	68	
6	90	71.35	0.79	1.48		-2	~~118~~ 115	245	243	52	75	68	
4-1	95	74.70	0.95	1.78		-3	116	247	248	55	72	68	
2	100	78.50	0.96	1.79		-3	116	245	245	55	76	68	
3	105	82.30	1.10	2.07		-3	114	245	245	55	77	68	
4	110	86.20	1.10	2.07		-3	114	245	245	56	78	68	
5	115	89.95	0.97	1.83		-3	113	245	245	57	79	69	
6	120	93.54	0.94	1.78		-3	112	246	247	58	80	70	
	Θ=1526	Vm=94.09		ΔH̄= 1.68			T̄s= 115.8					T̄m=69.50	

	Initialization Values Meter Temp	Oxygen Content	Moisture Content	Test Run Times Start Time	End Time	ORSAT System Bag No.	Bag Vol	cc/min * at 15 in Hg	Sample Train Components Filter No.	Nozzle No.	Nozzle Dn
Run 1	64	19.6%	9.5%	1319	1526	A-3	60L	0.0	400690	A-1	0.213
Run 2											

Nozzle Calibration	
Tech.	Date
Nozzle No.	
1	E-Cert
2	
3	
Avg. in.	

Moisture Recovery Data and impinger content information:

Impinger	1	2	3	4	5	6	7	Desiccant	Total
Final wt., g	828.9	815.4	776.4	768.8	755.3	759.5	757.3	952.6	
Initial wt., g	753.0	755.0	761.5	760.2	754.0	758.5	758.6	938.6	
Difference	75.9	60.4	14.9	8.6	1.3	1	-1.3	14	174.8
	1 N KCl			HNO3/H2O2	H2SO4/KMNO4				

Air Flows	
ACFM	DSCFM
196587	155302

BARR

ONTARIO HYRDO D-6784-16 MERCURY TESTING
IMPINGER RECOVERY

Project ArcelorMittal
Date 3/29/17
Project No.
Operators BAW
Source Stack B SV015
Sample Location

TEST 2 RUN 1	IMPINGER VOLUMES							DRY COLUMN
	1	2	3	4	5	6	7	
	g	g	g	g	g	g	g	g
START.	800.5	770.7	755.5	765.8	743.0	760.4	765.5	941.6
END	932.4	806.5	761.4	766.9	742.7	760.0	765.5	~~98~~ 958.4 BW
CHANGE								
							MASS OF MOISTURE COLLECTED, g	

TEST 2 RUN 2	IMPINGER VOLUMES							DRY COLUMN
	1	2	3	4	5	6	7	
	g	g	g	g	g	g	g	g
START.	760.5	762.8	760.5	734.5	768.0	749.4	802.7	948.3
END	887.0	802.3	767.0	739.2	768.9	748.9	801.1	964.4
CHANGE								
							MASS OF MOISTURE COLLECTED, g	

TEST 2 RUN 3	IMPINGER VOLUMES							DRY COLUMN
	1	2	3	4	5	6	7	
	g	g	g	g	g	g	g	g
START.	760.8	750.9	766.0	764.1	756.1	761.6	762.9	958.4
END	870.7	805.6	776.8	768.5	757.3	762.5	762.8	974.0
CHANGE								
							MASS OF MOISTURE COLLECTED, g	

TEST ____ RUN 4	IMPINGER VOLUMES							DRY COLUMN
	1	2	3	4	5	6	7	
	g	g	g	g	g	g	g	g
START.								
END								
CHANGE								

COMMENTS

BARR

Method 5/Ontario Hydro
FIELD DATA SHEET

Project ArcelorMittal Minorca Mine
Smpl Loc Furnace Stack B SV015
Test No. 2 Run 1
Date 3/29/17 Operators TAK /~~AMM~~/JAZZ RMP

Meter ID C-9
Meter Y 1.0113
Orifice H@ 1.9583
Liner Type: ☒Glass ☐S.S. ☐Other

Probe ID 5-2
Pitot No. 5-2
Pitot Cp 0.84

Bar. Pres 28.63 in Hg
Stat. Pres -0.90 in H_2O
Probe Lgth 5 ft
Imp TC 5843

Sample Train Leak Rate (cfm)				
Pretest	0.00	at	10	in Hg
Posttest	0.00	at	6	in Hg
Pitot (3 in.)	Pos. ☒Neg.	☒		

Sample Point	Sample Time ΔI	Meter Volume Vm, ft³	Velocity ΔP, in H_2O	Orifice ΔH, in H_2O	Ideal Meter Volume	Sample Vacuum, in Hg	Stack Temp. Ts, °F	Sample Train Temperatures, °F Probe	Filter	Impinger Outlet	Meter Inlet	Meter Outlet	Oxygen Content, %
	0745	94.00											
1-1	5	~~10~~ 97.45	0.89	1.61	NA	3.0	114	244	247	35	48	48	
2	10	100.80	0.89	1.61		3.0	113	246	242	35	50	48	
3	15	104.15	0.84	1.52		3.0	113	246	250	35	53	49	
4	20	107.35	0.84	1.52		3.0	113	244	242	37	55	49	
5	25	110.36	0.71	1.29		3.0	113	247	245	33	55	49	
6	30	113.30	0.66	1.26		3.0	113	246	243	33	56	50	
2-1	35	116.96	1.05	1.91		3.0	113	247	235	38	55	50	
2	40	120.65	1.05	1.91		3.0	113	243	245	33	56	51	
3	45	124.22	1.05	1.92		3.0	113	240	246	39	56	51	
4	50	127.94	1.10	2.01		3.0	113	244	247	39	57	51	
5	55	131.36	0.88	1.61		3.0	113	243	245	40	57	51	
6	60	134.80	0.88	1.61		3.0	113	243	245	40	57	51	
3-1	65	138.65	1.10	2.01		3.5	113	241	243	39	55	51	
2	70	142.34	1.10	2.00		3.5	113	243	238	41	57	51	
3	75	146.05	1.15	2.10		4.0	113	246	241	41	58	51	
4	80	149.95	1.15	2.10		4.0	113	244	245	42	58	52	
5	85	153.59	1.05	1.92		3.5	113	246	246	43	58	52	
6	90	157.35	1.03	1.92		3.5	113	242	243	44	59	52	
4-1	95	160.90	0.95	1.74		3.0	113	245	246	44	57	52	
2	100	165.52	0.98	1.79		3.0	114	245	244	45	59	53	
3	105	168.10	0.95	1.74		3.0	113	246	249	45	59	53	
4	110	171.53	0.92	1.69		3.0	113	246	243	46	59	53	
5	115	174.01	0.80	1.47		3.0	113	245	247	46	60	53	
6	120	177.94	0.80	1.47		3.0	113	245	248	46	60	53	
	Ø= 120	Vm= 83.94	0.95	ΔH= 1.74			Ts= 113.08					Tm= 53.71	

	Initialization Values Meter Temp	Oxygen Content	Moisture Content	Test Run Times Start Time	End Time	ORSAT System Bag No.	Bag Vol	cc/min * at 15 in Hg	Sample Train Components Filter No.	Nozzle No.	Nozzle Dn
Run 1	50	19.3%	9.0%	0745	0952	B-1	60L	0.0	400641	B-1	0.213
Run 2											

Nozzle Calibration	
Tech.	Date
Nozzle No.	
1	
2	E-COPY
3	
Avg. in.	

Moisture Recovery Data and impinger content information:

Impinger	1	2	3	4	5	6	7	Desiccant	Total
Final wt., g	932.4	806.5	761.4	766.9	742.7	760.0	765.5	958.4	
Initial wt., g	800.5	770.7	755.5	765.8	743.0	760.4	765.5	941.6	
Difference	131.9	35.8	5.9	1.1	-0.3	-0.4	0	16.8	190.8
	1 N KCl			HNO3/H2O2	H2SO4/KMNO4				

Air Flows	
ACFM	DSCFM
200747	159489

BARR

Method 5/Ontario Hydro
FIELD DATA SHEET

Project	ArcelorMittal Minorca Mine	Meter ID	C-9	Probe ID	5-2	Bar. Pres	28.63 in Hg
Smpl Loc	Furnace Stack B SV015	Meter Y	1.0113	Pitot No.	5-2	Stat. Pres	-0.90 in H2O
Test No.	2 Run 2	Orifice H@	1.9523	Pitot Cp	0.84	Probe Lgth	5 ft
Date	3/29/17	Operators	TAK / RMP / JAR2	Liner Type:	☒Glass ☐S.S. ☐Other	Imp TC	5843

Sample Train Leak Rate (cfm)				
Pretest	0.00	at	15	in Hg
Posttest	0.00	at	5	in Hg
Pitot (3 in.)	Pos. ☒	Neg. ☒		

Sample Point	Sample Time Δt	Meter Volume vm, ft³	Velocity ΔP, in H₂O	Orifice ΔH, in H₂O	Ideal Meter Volume	Sample Vacuum, in Hg	Stack Temp. ts, °F	Probe	Filter	Impinger Outlet	Meter Inlet	Meter Outlet	Oxygen Content, %
	1025	178.40											
1-1	5	181.95	0.97	1.78	NA	3.0	113	250	244	40	59	56	
2	10	185.62	0.98	1.80		3.0	112	244	245	40	61	57	
3	15	189.15	0.91	1.68		3.0	113	245	245	40	64	58	
4	20	192.55	0.91	1.68		3.0	113	247	248	42	66	59	
5	25	195.80	0.84	1.56		3.0	113	246	246	42	67	60	
6	30	199.15	0.86	1.60		3.0	114	244	243	42	67	61	
2-1	35	202.87	1.05	1.96		3.0	112	245	245	43	68	63	
2	40	206.75	1.10	2.05		3	113	244	242	43	70	63	
3	45	210.73	1.10	2.06		3	112	247	246	43	71	64	
4	50	214.63	1.10	2.06		3	112	245	244	43	73	65	
5	55	218.29	0.96	1.81		3	112	245	245	43	75	67	
6	60	221.94	0.97	1.83		3	113	247	246	44	72	68	
3-1	65	225.80	1.10	2.07		3	112	248	248	41	70	68	
2	70	229.61	1.05	1.98		3	111	244	244	42	72	67	
3	75	233.29	0.99	1.97		3	112	246	245	42	73	68	
4	80	237.14	1.10	2.08		3	112	245	247	43	74	68	
5	85	240.63	0.87	1.65		3	111	245	245	43	74	69	
6	90 MW	244.09	0.83	1.57		3	111	245	246	43	74	69	
4-1	249.60	~~250.85~~	0.87 MW	1.65		3	111	245	242	42	71	69	
2	100	250.85	~~0.87~~ 0.74	1.40		3	112	246	242	43	73	69	
3	105	254.36	0.87	1.64		3	112	246	243	43	73	70	
4	110	257.79	0.88	1.67		3	111	245	241	42	74	70	
5	115	261.03	0.74	1.40		3	111	242	245	43	74	70	
6	120	264.21	0.72	1.37		3	111	243	245	43	74	70	
	Ø=1234	Vm=85.81		ΔH=1.76			Ts=112.0					Tm=67.85	

	Initialization Values			Test Run Times		ORSAT System			Sample Train Components		
	Meter Temp	Oxygen Content	Moisture Content	Start Time	End Time	Bag No.	Bag Vol	cc/min * at 15 in Hg	Filter No.	Nozzle No.	Nozzle Dn
Run 1	57	19.3	10.0	1025	1234	B-2	60L	0.0	4Q01694	D-1	0.213
Run 2											

Nozzle Calibration	
Tech.	Date
Nozzle No.	
1	
2	E-COPY
3	
Avg. in.	

Moisture Recovery Data and impinger content information:

Impinger	1	2	3	4	5	6	7	Desiccant	Total
Final wt., g	887.0	802.3	767.0	739.2	766.9	748.9	801.1	964.4	
Initial wt., g	760.5	762.8	760.5	734.5	766.0	749.4	802.7	948.3	
Difference	126.5	39.5	6.5	4.7	0.9	-0.5	-1.6	16.1	192.1
	1 N KCl			HNO3/H2O2	H2SO4/KMNO4				

Air Flows	
ACFM	DSCFM
199009	158586

BARR

Method 5/Ontario Hydro
FIELD DATA SHEET

Project ArcelorMittal Minorca Mine
Smpl Loc Furnace Stack B SV015
Test No. 2 Run 3
Date 3/29/17 Operators MSN /RMP/JAR

Meter ID C-9
Meter Y 1.0113
Orifice H@ 1.9583
Liner Type: ☒Glass ☐S.S. ☐Other

Probe ID S-2
Pitot No. S-2
Pitot Cp 0.84

Bar. Pres 28.63 in Hg
Stat. Pres -0.90 in H_2O
Probe Lgth 5 ft
Imp TC 5843

Sample Train Leak Rate (cfm)			
Pretest 0.00	at 10	in Hg	
Posttest 0.00	at 5	in Hg	
Pitot (3 in.) Pos. ☒	Neg. ☒		

Sample Point	Sample Time ΔT	Meter Volume Vm, ft³	Velocity ΔP, in H_2O	Orifice ΔH, in H_2O	Ideal Meter Volume	Sample Vacuum, in Hg	Stack Temp. Ts, °F	Sample Train Temperatures, °F Probe	Filter	Impinger Outlet	Meter Inlet	Meter Outlet	Oxygen Content, %
	1304	264.60											
1-1	5	268.21	0.96	1.83	NA	3.0	111	245	242	42	72	72	
2	10	271.85	0.93	1.78		3	111	245	241	41	72	72	
3	15	275.39	0.88	1.68		3	111	246	251	39	73	72	
4	20	277.88	0.90	1.72		3	112	245	246	41	72	71	
5	25	282.12	0.70	1.34		3	111	246	247	41	73	71	
6	30	285.29	0.70	1.34		3	112	241	240	42	74	71	
2-1	35	289.24	1.10	2.10		3	112	245	243	41	72	71	
2	40	293.12	1.05	2.00		3	112	242	243	41	75	71	
3	45	297.05	1.10	2.11		3	111	241	245	41	75	71	
4	50	300.93	1.05	2.01		3	112	245	245	42	73	71	
5	55	304.62	0.95	1.62		3	112	246	244	42	69	70	
6	60	308.17	0.89	1.69		3	112	245	245	42	68	68	
3-1	65	311.80	1.10	2.09		3	111	245	245	41	66	66	
2	70	315.55	0.94	1.78		3	112	247	245	41	68	65	
3	75	319.10	0.94	1.78		3	112	247	243	41	69	65	
4	80	322.65	0.94	1.78		3	112	244	242	45	70	65	
5	85	326.30	0.99	1.88		3	112	242	245	45	69	65	
6	90	329.88	0.95	1.80		3	111	241	245	46	68	65	
4-1	95	333.30	0.84	1.59		3	112	245	243	45	64	64	
2	100	336.60	0.79	1.49		3	112	242	243	46	68	64	
3	105	339.86	0.86	1.62		3	113	241	245	46	69	64	
4	110	343.35	0.89	1.68		3	113	245	246	47	69	64	
5	115	346.76	0.80	1.51		3	112	245	245	47	69	65	
6	120	350.05	0.80	1.51		3	113	245	246	47	70	65	
	Θ=1512	Vm=85.45		ΔH= 1.74			Ts=111.8					Tm=69.08	

	Initialization Values Meter Temp	Oxygen Content	Moisture Content	Test Run Times Start Time	End Time	ORSAT System Bag No.	Bag Vol	cc/min * at 15 in Hg	Sample Train Components Filter No.	Nozzle No.	Nozzle Dn
Run 1	71	19.3	9.5	1304	1512	B-3	60L	0.0	HQ0695	B-1	0.213
Run 2											

Nozzle Calibration	
Tech.	Date
Nozzle No.	
1	E-Copy
2	
3	
Avg. in.	

Moisture Recovery Data and impinger content information:

Impinger	1	2	3	4	5	6	7	Desiccant	Total
Final wt., g	870.7	805.6	776.8	768.5	757.3	762.5	762.8	974.0	
Initial wt., g	760.8	750.9	766	764.1	756.1	761.6	762.9	958.4	
Difference	109.9	54.7	10.8	4.4	1.2	0.9	-0.1	15.6	197.4
	1 N KCl			HNO3/H2O2	H2SO4/KMNO4				

Air Flows	
ACFM	DSCFM
196508	156697

BARR

ONTARIO HYRDO D-6784-16 MERCURY TESTING
IMPINGER RECOVERY

Project ArcelorMittal
Date 3/28/17
Project No.
Operators BAW
Source Stack C SV016
Sample Location

TEST 3 RUN 1	IMPINGER VOLUMES							DRY COLUMN
	1	2	3	4	5	6	7	
	g	g	g	g	g	g	g	g
START.	751.0	752.8	753.5	759.3	761.9	755.0	751.0	949.2
END	869.3	809.6	768.3	764.8	763.0	752.3	747.6	970.4
CHANGE								
MASS OF MOISTURE COLLECTED, g								

TEST 3 RUN 2	IMPINGER VOLUMES							DRY COLUMN
	1	2	3	4	5	6	7	
	g	g	g	g	g	g	g	g
START.	760.0	758.5	755.3	732.5	725.0	762.1	755.4	964.8
END	889.7	800.1	764.5	739.1	726.7	764.1	753.5	983.4
CHANGE								
MASS OF MOISTURE COLLECTED, g								

TEST 3 RUN 3	IMPINGER VOLUMES							DRY COLUMN
	1	2	3	4	5	6	7	
	g	g	g	g	g	g	g	g
START.	755.6	749.9	761.2	761.0	758.6	761.8	755.1	922.2
END	887.8	789.1	770.0	765.6	760.6	762.3	752.3	943.3
CHANGE								
MASS OF MOISTURE COLLECTED, g								

TEST ______ RUN 4	IMPINGER VOLUMES							DRY COLUMN
	1	2	3	4	5	6	7	
	g	g	g	g	g	g	g	g
START.								
END								
CHANGE								

COMMENTS

BARR

Method 5/Ontario Hydro
FIELD DATA SHEET

Project ArcelorMittal Minorca Mine
Smpl Loc Furnace Stack C SV016
Test No. 3 Run 1
Date 3/28/17 Operators MJN/RMP/JARZ

Meter ID C-8
Meter Y 1.0244
Orifice H@ 1.9371
Liner Type: ☒Glass ☐S.S. ☐Other________

Probe ID 5-5
Pitot No. 5-5
Pitot Cp 0.84

Bar. Pres 28.47 in Hg
Stat. Pres -0.85 in H$_2$O
Probe Lgth 5 ft
Imp TC TI0-1

Sample Train Leak Rate (cfm)				
Pretest	0.00	at	10	in Hg
Posttest	0.00	at	6	in Hg
Pitot (3 in.) Pos. ☒	Neg. ☒			

Sample Point	Sample Time Δt	Meter Volume Vm, ft³	Velocity ΔP, in H$_2$O	Orifice ΔH, in H$_2$O	Ideal Meter Volume	Sample Vacuum, in Hg	Stack Temp. Ts, °F	Sample Train Temperatures, °F Probe	Filter	Impinger Outlet	Meter Inlet	Meter Outlet	Oxygen Content, %
	0804	689.30											
1-1	5	692.67	0.96	1.62	N/A	-4	118	244	245	53	49	50	
2	10	696.17	0.97	1.63		-4	118	245	244	54	47	49	
3	15	699.64	0.96	1.61		-4	118	245	245	53	48	48	
4	20	702.98	0.94	1.58		-4	118	248	245	54	49	48	
5	25	706.11	0.83	1.39		-4	119	246	247	55	50	47	
6	30	709.18	0.82	1.38		-4	118	246	245	57	49	47	
2-1	35	712.52	0.95	1.59		-4	118	244	245	58	47	46	
2	40	715.89	0.97	1.62		-4	118	244	245	59	49	46	
3	45	719.20	0.90	1.51		-4	118	246	245	57	51	46	
4	50	722.54	0.90	1.51		-4	118	245	245	56	52	47	
5	55	725.65	0.76	1.28		-4	117	246	246	56	54	47	
6	60	728.74	0.77	1.30		-4	118	244	245	56	54	47	
3-1	65	732.02	0.90	1.52		-4	117	246	244	54	54	48	
2	70	735.36	0.91	1.54		-4	117	245	245	55	55	48	
3	75	738.64	0.84	1.42		-4	118	244	245	52	57	49	
4	80	741.90	0.86	1.46		-4	117	247	245	53	57	50	
5	85	744.97	0.76	1.29		-4	118	245	246	53	58	50	
6	90	747.99	0.77	1.31		-4	117	246	244	53	58	51	
4-1	95	751.32	0.91	1.55		-4	117	246	245	51	56	52	
2	100	754.72	0.92	1.56		-4	117	246	247	56	59	52	
3	105	758.07	0.87	1.48		-4	117	246	245	56	60	53	
4	110	761.40	0.87	1.49		-4	117	245	243	58	60	53	
5	115	764.55	0.80	1.37		-5	117	245	246	60	61	54	
6	120	767.69	0.79	1.35	✓	-5	117	245	245	61	61	54	
	Ø= 1011	Vm= 78.39		$\overline{\Delta H}$= 1.47			$\overline{Ts}$= 117.6					$\overline{Tm}$= 51.60	

	Initialization Values Meter Temp	Oxygen Content	Moisture Content	Test Run Times Start Time	End Time	ORSAT System Bag No.	Bag Vol	cc/min * at 15 in Hg	Sample Train Components Filter No.	Nozzle No.	Nozzle Dn
Run 1	~~60~~ 50 MN	18.5%	9.5%	0804	1011	C-1	60 L	0	4Q0651	C-1	0.210
Run 2											

Nozzle Calibration	
Tech.	Date
Nozzle No.	
1	See E-
2	
3	Copy
Avg. in.	

Moisture Recovery Data and impinger content information:

Impinger	1	2	3	4	5	6	7	Desiccant	Total
Final wt., g	869.3	809.6	768.3	764.8	763	752.3	747.4	970.4	
Initial wt., g	751.0	752.8	753.5	759.3	761.9	755.0	751.0	949.2	
Difference	118.3	56.8	14.8	5.5	1.1	-2.7	+3.4	21.2	211.6
	1 N KCl			HNO3/H2O2	H2SO4/KMNO4				

Air Flows	
ACFM	DSCFM
202,690	156,050

BARR

Method 5/Ontario Hydro
FIELD DATA SHEET

Project ArcelorMittal Minorca Mine
Smpl Loc Furnace Stack C SV016
Test No. 3 Run 2
Date 3/28/17 Operators MJN/RMP/JARZ

Meter ID C-8
Meter Y 1.0044
Orifice H@ 1.9371
Liner Type: ☒Glass ☐S.S. ☐Other

Probe ID 5-5
Pitot No. 5-5
Pitot Cp 0.84

Bar. Pres 28.47 in Hg
Stat. Pres -0.35 in H2O
Probe Lgth 5 ft
Imp TC TT01

Sample Train Leak Rate (cfm)
Pretest 0.000 at 10 in Hg
Posttest 0.000 at 6 in Hg
Pitot (3 in.) Pos. ☒ Neg. ☒

Sample Point	Sample Time ΔI	Meter Volume Vm, ft³	Velocity ΔP, in H_2O	Orifice ΔH, in H_2O	Ideal Meter Volume	Sample Vacuum, in Hg	Stack Temp. Ts, °F	Sample Train Temperatures, °F Probe	Filter	Impinger Outlet	Meter Inlet	Meter Outlet	Oxygen Content, %
	1043	768.05											
1-1	5	771.51	0.96	1.62	NA	~~-5~~ ~~-6~~2 MN	116	245	237	64	55	55	
2	10	774.90	0.95	1.60		~~-5~~ ~~-6~~0 MN	117	245	241	64	58	55	
3	15	778.27	0.97	1.64		-5	117	245	246	62	60	56	
4	20	781.66	0.93	1.54		-5	116	245	246	61	62	56	
5	25	785.15	0.78	1.30		-5	116	245	246	61	63	57	
6	30	788.10	0.77	1.28		-5	118	246	247	61	64	58	
2-1	35	791.75	0.93	1.55		-5	117	247	245	62	60	58	
2	40	795.01	0.93	1.54		-5	117	245	245	60	64	59	
3	45	798.22	0.85	1.42		-5	118	245	245	57	65	59	
4	50	801.29	0.83	1.39		-5	117	244	245	55	66	59	
5	55	804.17	0.70	1.17		-4	117	246	244	56	67	60	
6	60	807.04	0.70	1.17		-4	117	245	247	57	67	61	
3-1	65	810.38	0.92	1.54		-5	117	244	241	57	64	61	
2	70	813.80	0.96	1.61		-5	117	247	245	57	68	62	
3	75	817.18	0.93	1.56		-5	117	243	246	55	69	62	
4	80	820.54	0.94	1.58		-5	117	246	244	56	70	63	
5	85	823.75	0.80	1.35		-5	117	245	245	56	70	64	
6	90	826.90	0.78	1.32		-5	117	244	246	57	71	64	
4-1	95	830.30	0.94	1.59		-5	117	245	245	58	70	65	
2	100	833.71	0.95	1.60		-5	117	245	245	58	70	65	
3	105	837.14	0.94	1.58		-5	118	244	245	59	69	65	
4	110	840.58	0.96	1.62		-5	118	245	245	61	69	65	
5	115	843.90	0.84	1.41		-5	118	243	246	62	68	65	
6	120	847.15	0.81	1.37		-5	116	245	245	63	68	65	
	Ø=1250	Vm=79.10		$\overline{\Delta H}$=1.47			$\overline{Ts}$=117.0					$\overline{Tm}$= 63.25	

	Initialization Values Meter Temp	Oxygen Content	Moisture Content	Test Run Times Start Time	End Time	ORSAT System Bag No.	Bag Vol	cc/min * at 15 in Hg	Sample Train Components Filter No.	Nozzle No.	Nozzle Dn
Run 1	55	18.5%	10.0%	1043	1250	C-2	60L	0.0	4Q0653	C-1	0.210
Run 2											

Nozzle Calibration	
Tech.	Date
Nozzle No.	
1	
2	E-COPY
3	
Avg. in.	

Moisture Recovery Data and impinger content information:

Impinger	1	2	3	4	5	6	7	Desiccant	Total
Final wt., g	889.7	800.1	764.5	739.1	726.7	764.1	753.5	983.4	
Initial wt., g	760.0	758.5	755.3	732.5	725.0	762.1	755.4	964.8	
Difference	129.7	41.3	9.2	6.6	1.7	2	-1.9	18.6	207.2
	1 N KCl			HNO3/H2O2	H2SO4/KMNO4				

Air Flows	
ACFM	DSCFM
203119	156828

BARR

Method 5/Ontario Hydro
FIELD DATA SHEET

Project ArcelorMittal Minorca Mine
Smpl Loc Furnace Stack C SV016
Test No. 3 Run 3
Date 3/28/17 Operators MJN/RMP/JARZ

Meter ID C-8
Meter Y 1.0044
Orifice H@ 1.9371
Liner Type: ☒Glass ☐S.S. ☐Other

Probe ID 5-5
Pitot No. 5-5
Pitot Cp 0.84

Bar. Pres 28.47 in Hg
Stat. Pres -0.85 in H2O
Probe Lgth 5 ft
Imp TC TID-1

Sample Train Leak Rate (cfm)				
Pretest	0.00	at	10	in Hg
Posttest	0.00	at	5	in Hg
Pitot (3 in.)	Pos. ☒	Neg. ☑		

Sample Point	Sample Time ΔT	Meter Volume Vm, ft³	Velocity ΔP, in H₂O	Orifice ΔH, in H₂O	Ideal Meter Volume	Sample Vacuum, in Hg	Stack Temp. Ts, °F	Sample Train Temperatures, °F Probe	Filter	Impinger Outlet	Meter Inlet	Meter Outlet	Oxygen Content, %
	1319	847.75											
1-1	5	851.15	0.92	1.55	NA	-4	117	245	245	61	63	63	
2	10	854.55	0.95	1.60		-4	118	245	245	60	65	63	
3	15	857.89	0.94	1.58		-4	118	245	246	57	67	63	
4	20	861.35	0.95	1.61		-4	116	245	245	59	68	64	
5	25	864.60	0.80	1.36		-4	116	245	245	60	68	64	
6	30	867.80	0.79	1.34		-4	117	247	246	61	68	64	
2-1	35	871.04	0.82	1.39		-4	118	247	249	62	68	64	
2	40	874.45	0.94	1.59		-4	118	245	249	60	68	64	
3	45	877.89	0.88	1.49		-4	118	246	245	61	69	64	
4	50	881.17	0.84	1.42		-4	118	246	246	62	70	65	
5	55	884.25	0.73	1.24		-4	118	243	247	62	70	65	
6	60	887.17	0.74	1.25		-4	118	245	246	62	70	65	
3-1	65	890.39	0.84	1.42		-4	119	247	248	62	68	65	
2	70	893.61	0.84	1.42		-4	119	243	242	62	70	66	
3	75	896.70	0.77	1.30		-4	119	245	245	62	70	66	
4	80	899.79	0.77	1.31		-4	118	245	245	60	71	66	
5	85	902.77	0.64	1.08		-3	119	243	246	60	71	66	
6	90	905.68	0.65	1.10		-3	119	242	245	63	70	66	
4-1	95	908.90	0.81	1.37		-4	119	247	246	63	68	66	
2	100	912.10	0.85	1.43		-4	122	246	244	64	70	66	
3	105	915.30	0.82	1.38		-4	123	245	246	63	71	67	
4	110	918.57	0.84	1.42		-4	121	246	245	64	72	67	
5	115	921.64	0.75	1.27		-4	119	248	245	65	72	67	
6	120	924.75	0.75	1.27		-4	121	245	247	65	72	67	
	Ø 1526	Vm= 77.00		ΔH= 1.38 MN			Ts= 118.8					Tm ~~69.50~~	67.08 MN

	Initialization Values			Test Run Times		ORSAT System			Sample Train Components		
	Meter Temp	Oxygen Content	Moisture Content	Start Time	End Time	Bag No.	Bag Vol	cc/min * at 15 in Hg	Filter No.	Nozzle No.	Nozzle Dn
Run 1	63	18.5%	11.0%	1319	1526	C-3	60L	0.0	400652	C-1	0.210
Run 2											

Nozzle Calibration	
Tech.	Date
Nozzle No.	
1	See E-Copy
2	
3	
Avg. in.	

Moisture Recovery Data and impinger content information:

Impinger	1	2	3	4	5	6	7	Desiccant	Total
Final wt., g	887.8	789.1	770.0	765.6	760.6	762.3	752.3	943.3	
Initial wt., g	755.6	749.9	761.2	761.0	758.6	761.8	755.1	922.2	
Difference	132.2	39.2	8.8	4.6	2	0.5	-2.8	21.1	205.6
	1 N KCl			HNO3/H2O2	H2SO4/KMNO4				

Air Flows	
ACFM	DSCFM
196,479	152574

BARR

ONTARIO HYRDO D-6784-16 MERCURY TESTING
IMPINGER RECOVERY

Project Arcelor Mittal Date 3/29/17

Project No. Operators BAW

Source Stack D S VD17 Sample Location

TEST 4 RUN 1	IMPINGER VOLUMES							DRY COLUMN
	1	2	3	4	5	6	7	
	g	g	g	g	g	g	g	g
START.	759.3	761.3	762.8	750.7	725.1	765.8	758.5	971.7
END	925.3	781.1	765.0	752.3	725.0	765.7	758.0	981.0
CHANGE								
MASS OF MOISTURE COLLECTED, g								

TEST 4 RUN 2	IMPINGER VOLUMES							DRY COLUMN
	1	2	3	4	5	6	7	
	g	g	g	g	g	g	g	g
START.	753.3	757.4	759.7	764.8	763.6	767.0	754.3	944.2
END	907.3	780.7	762.6	767.5	764.4	767.6	754.2	958.8
CHANGE								
MASS OF MOISTURE COLLECTED, g								

TEST 4 RUN 3	IMPINGER VOLUMES							DRY COLUMN
	1	2	3	4	5	6	7	
	g	g	g	g	g	g	g	g
START.	759.0	755.1	761.0	734.3	725.0	764.8	758.7	949.0
END	912.6	777.7	764.5	736.9	725.1	765.2	758.4	963.7
CHANGE								
MASS OF MOISTURE COLLECTED, g								

TEST RUN 4	IMPINGER VOLUMES							DRY COLUMN
	1	2	3	4	5	6	7	
	g	g	g	g	g	g	g	g
START.								
END								
CHANGE								

COMMENTS

BARR

Method 5/Ontario Hydro
FIELD DATA SHEET

Project ArcelorMittal Minorca Mine
Smpl Loc Furnace Stack D SV017
Test No. 4 Run 1
Date 3/29/17 Operators TAK/RMP/SARZ

Meter ID C-8
Meter Y 1.0044
Orifice H@ 1.9371
Liner Type: ☐ Glass ☐ S.S. ☐ Other

Probe ID 5-5
Pitot No. 5-5
Pitot Cp 0.84

Bar. Pres ~~28.47~~ 23.43 in Hg
Stat. Pres -0.95 in H_2O
Probe Lgth 5 ft
Imp TC TIO-1

Sample Train Leak Rate (cfm)			
Pretest 0.00	at	10	in Hg
Posttest 0.00	at	7	in Hg
Pitot (3 in.) Pos. ☒ Neg. ☒			

Sample Point	Sample Time ΔT	Meter Volume vm, ft³	Velocity ΔP, in H_2O	Orifice ΔH, in H_2O	Ideal Meter Volume	Sample Vacuum, in Hg	Stack Temp. Ts, °F	Sample Train Temperatures, °F Probe	Filter	Impinger Outlet	Meter Inlet	Meter Outlet	Oxygen Content, %
	0745	925.15											
1-1	5	927.80	0.57	0.90	N/A	3.0	127	247	232	32	48	49	
2	10	930.40	0.58	0.91		3.0	128	245	236	32	50	49	
3	15	933	0.62	0.98		3.0	128	247	249	31	51	49	
4	20	935.72	0.62	0.98		3.0	128	244	245	31	52	49	
5	25	938.20	0.57	0.90		3.0	123	245	247	32	52	49	
6	30	940.73	0.57	0.90		3.0	123	245	244	32	54	50	
2-1	35	943.52	0.71	1.18		3.5	126	244	243	32	53	50	
2	40	946.70	0.75	1.19		3.5	126	247	250	32	54	50	
3	45	949.38	0.75	1.20		3.5	125	245	244	33	54	50	
4	50	952.21	0.73	1.16		3.5	125	244	245	33	54	50	
5	55	955.10	0.65	1.04		3.5	122	246	245	33	55	51	
6	60	957.75	0.64	1.03		3.5	120	245	246	34	54	51	
3-1	65	960.65	0.78	1.26		3.5	120	243	244	34	54	52	
2	70	963.77	0.79	1.27		3.5	120	245	245	34	55	51	
3	75	966.70	0.74	1.19		3.5	120	245	246	35	56	51	
4	80	969.75	0.75	1.21		3.5	121	246	245	35	56	51	
5	85	972.53	0.67	1.08		3.5	120	245	246	35	56	52	
6	90	975.27	0.66	1.07		3.5	120	245	244	36	56	52	
4-1	95	978.13	0.73	1.18		3.8	120	242	241	36	55	52	
2	100	981.12	0.76	1.22		3.8	124	247	245	35	56	52	
3	105	984.14	0.79	1.27		3.8	124	244	246	36	57	52	
4	110	987.17	0.80	1.29		3.8	121	244	245	34	57	52	
5	115	990.10	0.72	1.16		3.8	120	247	246	36	57	53	
6	120	992.95	0.73	1.18		3.8	120	247	245	37	58	53	
	Θ= 120	Vm= 67.80	0.70	ΔH= 1.11			Ts= 123.33					Tm= 52.54	

	Initialization Values Meter Temp	Oxygen Content	Moisture Content	Test Run Times Start Time	End Time	ORSAT System Bag No.	Bag Vol	cc/min * at 15 in Hg	Sample Train Components Filter No.	Nozzle No.	Nozzle Dn
Run 1	50	18.0%	12%	0745	0952	D-1	60L	0.0	4Q 0692	D-1	0.210
Run 2											

Nozzle Calibration	
Tech.	Date
Nozzle No.	
1	E-copy
2	
3	
Avg. in.	

Moisture Recovery Data and impinger content information:

Impinger	1	2	3	4	5	6	7	Desiccant	Total
Final wt., g	925.3	781.1	765	752.3	725	765.7	758	981	
Initial wt., g	759.3	761.3	762.8	750.7	725.1	765.8	758.5	971.7	
Difference	166	19.8	2.2	1.6	-0.1	-0.1	-0.5	9.3	198.2
	1 N KCl			HNO3/H2O2	H2SO4/KMNO4				

Air Flows	
ACFM	DSCFM
181379	137630

BARR

Method 5/Ontario Hydro
FIELD DATA SHEET

Project ArcelorMittal Minorca Mine
Smpl Loc Furnace Stack D SV017
Test No. 4 Run 2
Date 3/29/17 Operators TAK/RMP/JARZ

Meter ID C-8
Meter Y 1.0044
Orifice H@ 1.9371
Liner Type: ☒Glass ☐S.S. ☐Other

Probe ID 5-5
Pitot No. 5-5
Pitot Cp 0.84

Bar. Pres 28.63 in Hg
Stat. Pres -0.95 in H_2O
Probe Lgth 5 ft
Imp TC TC-1

Sample Train Leak Rate (cfm)
Pretest 0.00 at 12 in Hg
Posttest 0.00 at 5 in Hg
Pitot (3 in.) Pos. ☒ Neg. ☒

Sample Point	Sample Time ΔI	Meter Volume Vm, ft³	Velocity ΔP, in H_2O	Orifice ΔH, in H_2O	Ideal Meter Volume	Sample Vacuum, in Hg	Stack Temp. Ts, °F	Sample Train Temperatures, °F Probe	Filter	Impinger Outlet	Meter Inlet	Meter Outlet	Oxygen Content, %
	1025	993.50											
1-1	5	996.52	0.74	1.21	√A	3.0	120	235	236	35	60	57	
2	10	999.50	0.74	1.20		3.0	123	245	242	37	61	59	
3	15	1002.45	0.76	1.24		3.0	122	247	246	37	64	60	
4	20	1005.45	0.75	1.23		3.0	121	248	245	36	65	62	
5	25	1008.21	0.68	1.12		3.0	121	248	246	37	67	63	
6	30	1011.14	0.69	1.14		3.0	120	244	245	38	68	64	
2-1	35	1014.10	0.72	1.24		3.0	120	249	255	39	70	66	
2	40	1017.11	0.75	1.24		3	120	245	255	41	71	67	
3	45	1020.16	0.74	1.23		3	120	246	253	39	73	68	
4	50	1023.28	0.74	1.23		3	120	245	253	40	75	70	
5	55	1026.18	0.63	1.05		3	120	246	256	40	76	71	
6	60	1029.06	0.64	1.07		3	120	247	255	41	75	72	
3-1	65	1032.13	0.74	1.24		3	122	247	251	43	74	73	
2	70	1035.17	0.75	1.25		3	125	244	252	43	75	73	
3	75	1038.22	0.73	1.21		3	125	247	255	42	76	74	
4	80	1041.23	0.73	1.22		3	125	245	254	42	76	74	
5	85	1044.19	0.64	1.07		3	124	245	252	44	76	75	
6	90	1047.05	0.64	1.08		3	120	246	257	44	76	75	
4-1	95	1049.85	0.62	1.03		3	127	245	254	44	76	75	
2	100	1052.76	0.60	1.00		3	128	246	254	44	76	75	
3	105	1055.40	0.62	1.03		3	127	248	254	43	76	76	
4	110	1058.41	0.61	1.02		3	127	245	254	43	76	76	
5	115	1061.17	0.59	0.98		3	127	246	253	43	77	76	
6	120	1063.95	0.58	0.97		3	126	245	250	43	77	76	
	Ø=1234	Vm=70.45		ΔH=1.14			Ts=122.9					Tm=71.10	

	Initialization Values Meter Temp	Oxygen Content	Moisture Content	Test Run Times Start Time	End Time	ORSAT System Bag No.	Bag Vol	cc/min * at 15 in Hg	Sample Train Components Filter No.	Nozzle No.	Nozzle Dn
Run 1	59	19%	12.0	1025	1234	D-2	60L	0.0	400693	D-1	0.210
Run 2											

Nozzle Calibration	
Tech.	Date
Nozzle No.	
1	
2	E-COPY
3	
Avg. in.	

Moisture Recovery Data and impinger content information:

Impinger	1	2	3	4	5	6	7	Desiccant	Total
Final wt., g	907.3	780.7	762.6	767.5	764.4	767.6	754.2	958.8	
Initial wt., g	753.3	757.4	759.7	764.8	763.6	767.0	754.3	944.2	
Difference	154	23.3	2.9	2.7	0.8	0.6	-0.1	14.6	198.8
	1 N KCl			HNO3/H2O2	H2SO4/KMNO4				

Air Flows	
ACFM	DSCFM
190197	136827

BARR

Method 5/Ontario Hydro
FIELD DATA SHEET

Project ArcelorMittal Minorca Mine
Smpl Loc Furnace Stack D SV017
Test No. 4 Run 3
Date 3/29/17 Operators MJN / RMP/JAR

Meter ID C-8
Meter Y 1.0044
Orifice H@ 1.9371
Liner Type: ☒Glass ☐S.S. ☐Other

Probe ID 5-5
Pitot No. 5-5
Pitot Cp 0.84

Bar. Pres 28.63 in Hg
Stat. Pres -0.95 in H_2O
Probe Lgth 5 ft
Imp TC TTO-1

Sample Train Leak Rate (cfm)			
Pretest 0.00	at	10	in Hg
Posttest 0.00	at	7	in Hg
Pitot (3 in.) Pos. ☑ Neg. ☒			

Sample Point	Sample Time ΔT	Meter Volume vm, ft³	Velocity ΔP, in H_2O	Orifice ΔH, in H_2O	Ideal Meter Volume	Sample Vacuum, in Hg	Stack Temp. Ts, °F	Sample Train Temperatures, °F Probe	Filter	Impinger Outlet	Meter Inlet	Meter Outlet	Oxygen Content, %
	1304	64.25											
1-1	5	67.00	0.57	0.94	NA	5	126	240	255	41	78	78	
2	10	69.75	0.59	0.98		5	125	245	258	43	76	78	
3	15	72.58	0.63	1.04		5	126	247	255	41	76	77	
4	20	75.38	0.61	1.01		5	126	247	255	41	75	77	
5	25	78.12	0.57	0.94		5	125	246	254	41	76	76	
6	30	80.83	0.57	0.94		5	126	245	255	41	76	76	
2-1	35	83.72	0.70	1.17		6	121	245	254	42	76	76	
2	40	86.59	0.70	1.16		6	126	245	251	41	77	76	
3	45	89.47	0.68	1.13		6	125	246	251	41	77	76	
4	50	92.32	0.68	1.12		6	127	245	254	42	73	75	
5	55	95.14	0.60	0.99		6	127	245	254	44	71	74	
6	60	97.95	0.62	1.03		6	121	245	255	44	69	72	
3-1	65	100.82	0.71	1.17		6	120	245	255	45	69	70	
2	70	103.73	0.74	1.22		6	120	243	255	46	69	70	
3	75	106.70	0.71	1.17		6	121	243	254	44	70	69	
4	80	109.49	0.70	1.15		6	121	245	254	45	69	69	
5	85	112.36	0.61	1.00		6	121	245	254	45	70	69	
6	90	115.19	0.61	1.01		6	120	245	254	48	68	68	
4-1	95	118.09	0.70	1.15		6	121	242	255	48	68	68	
2	100	120.96	0.70	1.14		6	124	241	251	47	69	67	
3	105	123.81	0.72	1.17		6	126	245	251	48	69	67	
4	110	126.72	0.72	1.18		6	124	246	252	48	70	67	
5	115	129.55	0.64	1.06		6	118	245	250	49	70	67	
6	120	132.49	0.65	1.07		6	120	245	253	49	70	67	
	Ø=1512	Vm=68.24		ΔH=1.08			Ts=123.2					Tm=72.08	

	Initialization Values Meter Temp	Oxygen Content	Moisture Content	Test Run Times Start Time	End Time	ORSAT System Bag No.	Bag Vol	cc/min * at 15 in Hg	Sample Train Components Filter No.	Nozzle No.	Nozzle Dn
Run 1	78	18.0	12.8%	1304	1512	D-3	60L	0.0	400696	D-1	0.210
Run 2											

Nozzle Calibration	
Tech.	Date
Nozzle No.	
1	E-COPY
2	
3	
Avg. in.	

Moisture Recovery Data and impinger content information:

Impinger	1	2	3	4	5	6	7	Desiccant	Total
Final wt., g	912.6	777.7	764.5	736.9	725.1	765.2	758.4	963.7	
Initial wt., g	759.0	755.1	761.0	734.3	725.0	764.8	758.7	949.0	
Difference	153.6	22.6	3.5	2.6	0.1	0.4	-0.3	14.7	197.2
	1 N KCl			HNO3/H2O2	H2SO4/KMNO4				

Air Flows	
ACFM	DSCFM
~~176564~~	~~133551~~
176330	133,399

MJN

BARR

EPA METHOD 2
FIELD DATA SHEET

Project Alcelor Mittal
Sample Location Stack A SV01H
Date 4/11/17
Operators BAW
Duct Dimensions 101.75 inches
Port Length 4.0 inches
Pitot Tube No. 37 Cp 0.84
Manometer ID M-13 Bar. ID BA-19
Digital Therm ID D-14 T.C. ID 30B

	Run 1	Run 2	Run 3	Run 4
Bar Press (In Hg)	28.40			
Stat. Press (In H_2O)	-0.90			
Temp - Dry Bulb °F				
Temp - Wet Bulb °F	See M4 Sheet			
Moist Content - %				
O_2 %	See M3 sheet			
Time of Meas.				

Pitot Leak Check Positive: ✓ Negative: ✓

Traverse Point Information			Cyclonic Flow	Velocity Head - Inches H_2O				Stack Temperature - °F			
Point Number	Inches From: Wall	Port	∠°	Run 1 ΔP	Run 2 ΔP	Run 3 ΔP	Run 4 ΔP	Run 1 Temp.	Run 2 Temp.	Run 3 Temp.	Run 4 Temp.
1				0.79	0.77	0.80		See 30B sheet			
2				0.86	0.37	0.31					
3				0.99	0.39	0.36					
1				0.95	0.98	1.00					
2				1.00	1.04	0.98					
3				1.00	1.02	1.04					
1				0.70	0.76	0.78					
2				0.76	0.80	0.79					
3				0.89	0.90	0.83					
1				0.88	0.96	0.89					
2				0.96	1.00	0.96					
3				1.04	0.98	0.99					

Schematic of Duct Cross-Section

	Run 1	Run 2	Run 3	Run 4
Stack Pres. - In Hg				
Duct Area - Sq Ft.				
Mole Weight - Md				
Mole Weight - Ms				
Avg. Temp. - °F				
Average $\sqrt{\Delta P}$				
Gas Vel - Ft/Sec				
ACFM				
SCFM				
DSCFM				

BARR

EPA METHOD 2
FIELD DATA SHEET

Project ArcelorMittal
Sample Location Stack 8
Date 4/12/17
Operators BAW
Duct Dimensions 101.75 inches
Port Length 4.0 inches
Pitot Tube No. 37 Cp 0.84
Manometer ID M-13 Bar. ID BA-19
Digital Therm ID D-14 T.C. ID 30B

	Run 1	Run 2	Run 3	Run 4
Bar Press (In Hg)	28.73			
Stat. Press (In H_2O)	-0.75			
Temp - Dry Bulb °F				
Temp - Wet Bulb °F	See M4 Sheet			
Moist Content - %				
O_2 %	See M3 Sheet			
Time of Meas.				

Pitot Leak Check Positive: ✓ Negative: ✓

Traverse Point Information			Cyclonic Flow	Velocity Head - Inches H_2O				Stack Temperature - °F			
Point Number	Inches From:			Run 1	Run 2	Run 3	Run 4	Run 1	Run 2	Run 3	Run 4
	Wall	Port	∠°	ΔP	ΔP	ΔP	ΔP	Temp.	Temp.	Temp.	Temp.
1 - 1				1.02	1.00	1.01					
2				1.06	1.01	1.07		See 30B Sheet			
3				1.12	0.98	0.96					
2 - 1				0.98	0.95	0.99					
2				0.93	0.95	0.94					
3				0.90	0.96	1.00					
3 - 1				0.98	0.90	0.75					
2				1.02	0.98	1.00					
3				1.00	1.02	0.98					
4 - 1				0.93	1.03	0.97					
2				0.93	0.99	1.00					
3				0.87	1.00	1.01					

Schematic of Duct Cross-Section

	Run 1	Run 2	Run 3	Run 4
Stack Pres. - In Hg				
Duct Area - Sq Ft.				
Mole Weight - Md				
Mole Weight - Ms				
Avg. Temp. - °F				
Average $\sqrt{\Delta P}$				
Gas Vel - Ft/Sec				
ACFM				
SCFM				
DSCFM				

BARR

EPA METHOD 2
FIELD DATA SHEET

Project Arcelor Mittal
Sample Location Stack C
Date 4/11/17
Operators BAW
Duct Dimensions 104.0 inches
Port Length 12.0 inches
Pitot Tube No. 37 Cp 0.84
Manometer ID M-13 Bar. ID BA-19
Digital Therm ID D-14 T.C. ID 30B

	Run 1	Run 2	Run 3	Run 4
Bar Press (In Hg)	28.40			
Stat. Press (In H_2O)	-0.30			
Temp - Dry Bulb °F				
Temp - Wet Bulb °F	See M4 Sheet			
Moist Content - %				
O_2 %	See M3 Sheet			
Time of Meas.				

Pitot Leak Check Positive: ✓ Negative: ✓

Traverse Point Information			Cyclonic	Velocity Head - Inches H_2O				Stack Temperature - °F			
Point	Inches From:		Flow	Run 1	Run 2	Run 3	Run 4	Run 1	Run 2	Run 3	Run 4
Number	Wall	Port	∠°	ΔP	ΔP	ΔP	ΔP	Temp.	Temp.	Temp.	Temp.
1 - 1				0.82	0.75	0.70					
2				0.84	0.84	0.79		See 30B Sheet			
3				0.85	0.88	0.84					
2 - 1				1.03	0.89	0.98					
2				0.96	0.97	0.96					
3				0.87	0.94	1.00					
3 - 1				0.85	0.74	0.79					
2				0.97	0.89	0.86					
3				0.87	0.90	0.99					
4 - 1				0.98	0.88	0.89					
2				0.86	0.92	0.96					
3				0.85	0.84	0.90					

Schematic of Duct Cross-Section

	Run 1	Run 2	Run 3	Run 4
Stack Pres. - In Hg				
Duct Area - Sq Ft.				
Mole Weight - Md				
Mole Weight - Ms				
Avg. Temp. - °F				
Average $\sqrt{\Delta P}$				
Gas Vel - Ft/Sec				
ACFM				
SCFM				
DSCFM				

BARR

EPA METHOD 2
FIELD DATA SHEET

Project: Arcelor Mittal
Sample Location: Stack D
Date: 4/12/17
Operators: BAW
Duct Dimensions: 104.0 inches
Port Length: 12.0 inches
Pitot Tube No.: 37 Cp: 0.84
Manometer ID: M-13 Bar. ID: BA-19
Digital Therm ID: D-14 T.C. ID: 30B

	Run 1	Run 2	Run 3	Run 4
Bar Press (In Hg)	28.43			
Stat. Press (In H_2O)	-0.90			
Temp - Dry Bulb °F				
Temp - Wet Bulb °F	See M4 Sheet			
Moist Content - %				
O_2 %	See M3 Sheet			
Time of Meas.				

Pitot Leak Check Positive: ✓ Negative: ✓

Traverse Point Information			Cyclonic	Velocity Head - Inches H_2O				Stack Temperature - °F			
Point	Inches From:		Flow	Run 1	Run 2	Run 3	Run 4	Run 1	Run 2	Run 3	Run 4
Number	Wall	Port	∠°	ΔP	ΔP	ΔP	ΔP	Temp.	Temp.	Temp.	Temp.
1- 1				0.73	0.71	0.68					
2				0.71	0.68	0.73		See 30B Sheet			
3				0.64	0.65	0.74					
2 - 1				0.68	0.70	0.65					
2				0.67	0.71	0.68					
3				0.68	0.64	0.65					
3 - 1				0.65	0.65	0.70					
2				0.63	0.64	0.68					
3				0.64	0.68	0.70					
4 - 1				0.72	0.64	0.71					
2				0.68	0.72	0.68					
3				0.67	0.71	0.65					

Schematic of Duct Cross-Section

	Run 1	Run 2	Run 3	Run 4
Stack Pres. - In Hg				
Duct Area - Sq Ft.				
Mole Weight - Md				
Mole Weight - Ms				
Avg. Temp. - °F				
Average $\sqrt{\Delta P}$				
Gas Vel - Ft/Sec				
ACFM				
SCFM				
DSCFM				

EPA METHOD 4
FIELD DATA SHEET

Project ArcelorMittal Minorca Mine
Sample Location Furnace Stack A
Date 4/11/17 Test 1 Run —
Operators BAW Eff. Probe Length 6 ft

Meter ID C-8 Bar. Press. 28.40 in Hg
Meter Y 1.0044 Stat. Press. -0.9 in H_2O
Orifice H@ 1.9371
Liner Type: ☐ Glass ☒ S.S ☒ Other ____

Sample Train Leak Rate (cfm)				
Pretest	0.000	at	10	in Hg
Posttest	0.000	at	5	in Hg

RUN 1

Sample Point	Sample Time ΔT	Meter Reading Vm, Cu.Ft	Orifice Pressure, ΔH in H_2O	Sample Vacuum, in Hg	Sample Train Temperatures, °F					Oxygen Content, %
						Stack	Impinger Outlet	Meter Inlet	Meter Outlet	
	(830)	(132.54)								
1	5	135.30	~~0.75~~ 1.0	4		110	44	45	44	
2	10	138.05	1.0	4		110	44	45	44	
3	15	141.00	1.0	4		110	45	46	44	
4	~~20~~ 21	144.15	1.0	4		110	45	47	44	
5	25									
6	30									
7	35									
8	40									
9	45									
10	50									
11	55									
12	60									
	851 (~~850~~)									
	Ø= ~~60~~ 21	Vm= 11.61	ΔH= 1.0						Tm= 44.88	

Integrated Gas Sampling Data:
Bag No. ~~NA~~ 1
Bag Vol. 10
Leak Rate, cc/min 0.0 at 15 in Hg

Moisture Recovery Data:

Impinger	1 120	2	3	4	Desiccant	Total
Final wt., g	~~103~~	100	0		1422	
Initial wt., g	100	100	0		1419	
Difference	20	0	0		3	23

Sample Train Leak Rate (cfm)				
Pretest	0.000	at	10	in Hg
Posttest	0.000	at	5	in Hg

RUN 2

Sample Point	Sample Time ΔT	Meter Reading Vm, Cu.Ft	Orifice Pressure, ΔH in H_2O	Sample Vacuum, in Hg	Sample Train Temperatures, °F					Oxygen Content, %
						Stack	Impinger Outlet	Meter Inlet	Meter Outlet	
	(1036)	(168.03)								
1	5	170.35	1.0	4		110	44	55	53	
2	10	173.80	1.0	4		110	45	56	54	
3	15	176.50	1.0	4		111	41	57	54	
4	~~20~~ 21	179.80	1.0	4		111	41	57	54	
5	25									
6	30									
7	35									
8	40									
9	45									
10	50									
11	55									
12	60									
	(1057)									
	Ø= 21	Vm= 11.77	ΔH= 1.0						Tm= 55.00	

Integrated Gas Sampling Data:
Bag No. 2
Bag Vol. 10
Leak Rate, cc/min 0.0 at 15 in Hg

Moisture Recovery Data: ✓123

Impinger	1	2	3	4	Desiccant	Total
Final wt., g	~~130~~	100	0		1424	
Initial wt., g	100	100	0		1422	
Difference	123	0	0		2	25

EPA METHOD 4
FIELD DATA SHEET

Project ArcelorMittal Minorca Mine
Sample Location Furnace Stack A
Date 4/11/17 Test 1 Run ~~0~~ —
Operators Bdw Eff. Probe Length 6 ft

Meter ID C-8 Bar. Press. 28.40 in Hg
Meter Y 1.0044 Stat. Press. -0.9 in H_2O
Orifice H@ 1.9371
Liner Type: ☐ Glass ☒ S.S. ☐ Other ______

Sample Train Leak Rate (cfm)			
Pretest 0.000	at	10	in Hg
Posttest 0.000	at	5	in Hg

RUN 3

Sample Point	Sample Time ΔT	Meter Reading Vm, Cu.Ft	Orifice Pressure, ΔH in H_2O	Sample Vacuum, in Hg	Sample Train Temperatures, °F					Oxygen Content, %
						Stack	Impinger Outlet	Meter Inlet	Meter Outlet	
	(1200)	(180.03)								
1	5	182.86	1.0	4		110	50	55	55	
2	10	185.66	1.0	4		110	47	56	55	
3	15	188.70	1.0	4		111	44	57	56	
4	~~20~~ 21	191.81	1.0	4		110	43	57	56	
5	25									
6	30									
7	35									
8	40									
9	45									
10	50									
11	55									
12	60									
	(1221)									
	Ø= 21	Vm= 11.78	ΔH= 1.0						Tm= 56.13	

Integrated Gas Sampling Data:
Bag No. 3
Bag Vol. 10
Leak Rate, cc/min 0.0 at 15 in Hg

Moisture Recovery Data:

Impinger	1	2	3	4	Desiccant	Total
Final wt., g	118	100	0		1426	
Initial wt., g	100	100	0		1424	
Difference	18	0	0		2	20

Sample Train Leak Rate (cfm)		
Pretest	at	in Hg
Posttest	at	in Hg

RUN 4

Sample Point	Sample Time ΔT	Meter Reading Vm, Cu.Ft	Orifice Pressure, ΔH in H_2O	Sample Vacuum, in Hg	Sample Train Temperatures, °F					Oxygen Content, %
						Stack	Impinger Outlet	Meter Inlet	Meter Outlet	
	( )	( )								
1	5									
2	10									
3	15									
4	20									
5	25									
6	30									
7	35									
8	40									
9	45									
10	50									
11	55									
12	60									
	( )									
	Ø=	Vm=	ΔH=						Tm=	

Integrated Gas Sampling Data:
Bag No. ______
Bag Vol. ______
Leak Rate, cc/min ______ at 15 in Hg

Moisture Recovery Data:

Impinger	1	2	3	4	Desiccant	Total
Final wt., g						
Initial wt., g	100	100	0			
Difference						

EPA METHOD 4
FIELD DATA SHEET

Project ArcelorMittal Minorca Mine
Sample Location Furnace Stack 8
Date 4/12/17 Test 2 Run —
Operators BAu Eff. Probe Length 6 ft

Meter ID C-8 Bar. Press. 28.43 in Hg
Meter Y 1.0244 Stat. Press. -0.75 in H_2O
Orifice H@ 1.733
Liner Type: ☐ Glass ☒ S.S. ☐ Other ______

Sample Train Leak Rate (cfm)			
Pretest 0.000	at	10	in Hg
Posttest 0.000	at	6	in Hg

RUN 1

Sample Point	Sample Time ΔT	Meter Reading Vm, Cu.Ft	Orifice Pressure, ΔH in H_2O	Sample Vacuum, in Hg	Sample Train Temperatures, °F					Oxygen Content, %
						Stack	Impinger Outlet	Meter Inlet	Meter Outlet	
	(736)	(204.01)								
1	5	206.80	1.0	5		110	38	46	46	
2	10	209.53	1.0	5		111	37	46	47	
3	15	212.32	1.0	5		112	37	47	47	
4	~~20~~ 21	215.68	1.0	5		112	37	49	47	
5	25									
6	30									
7	35									
8	40									
9	45									
10	50									
11	55									
12	60									
	(757)									
	Ø= 21	Vm= 11.67	ΔH= 1.0						Tm= 46.88	

Integrated Gas Sampling Data:
Bag No. 1
Bag Vol. 10
Leak Rate, cc/min 0.0 at 15 in Hg

Moisture Recovery Data:

Impinger	1	2	3	4 BW	Desiccant	Total
Final wt., g	124	100	0	~~1428~~	1428	
Initial wt., g	100	100	0	~~1426~~	1426	
Difference	24	0	0	~~2~~	2	26

Sample Train Leak Rate (cfm)			
Pretest 0.000	at	10	in Hg
Posttest 0.000	at	6	in Hg

RUN 2

Sample Point	Sample Time ΔT	Meter Reading Vm, Cu.Ft	Orifice Pressure, ΔH in H_2O	Sample Vacuum, in Hg	Sample Train Temperatures, °F					Oxygen Content, %
						Stack	Impinger Outlet	Meter Inlet	Meter Outlet	
	(936)	(239.37)								
1	5	242.18	1.0	5		111	44	54	53	
2	10	244.98	1.0	5		112	42	55	54	
3	15	247.77	1.0	5		112	40	56	54	
4	~~20~~ 21	251.13	1.0	5		113	40	57	54	
5	25									
6	30									
7	35									
8	40									
9	45									
10	50									
11	55									
12	60									
	(957)									
	Ø= 21	Vm= 11.76	ΔH= 1.0						Tm= 54.63	

Integrated Gas Sampling Data:
Bag No. 2
Bag Vol. 10
Leak Rate, cc/min 0.0 at 15 in Hg

Moisture Recovery Data:

Impinger	1	2	3	4	Desiccant	Total
Final wt., g	118	100	0		1430	
Initial wt., g	100	100	0		1428	
Difference	18	0	0		2	20

BARR

EPA METHOD 4
FIELD DATA SHEET

Project ArcelorMittal Minorca Mine
Sample Location Furnace Stack B
Date 4/12/17 Test 2 Run —
Operators BAW Eff. Probe Length 6 ft

Meter ID C-8 Bar. Press. 28.43 in Hg
Meter Y 1.0044 Stat. Press. -0.75 in H_2O
Orifice H@ 1.9371
Liner Type: ☐ Glass ☒ S.S. ☐ Other

Sample Train Leak Rate (cfm)			
Pretest 0.000	at	10	in Hg
Posttest 0.000	at	6	in Hg

RUN 3

Sample Point	Sample Time ΔT	Meter Reading Vm, Cu.Ft	Orifice Pressure, ΔH in H_2O	Sample Vacuum, in Hg	Sample Train Temperatures, °F					Oxygen Content, %
						Stack	Impinger Outlet	Meter Inlet	Meter Outlet	
	(1030)	(251.22)								
1	5	254.02	1.0	5		112	54	54	57	
2	10	256.35	1.0	5		113	50	61	58	
3	15	259.64	1.0	5		114	50	63	58	
4	~~20~~ 21	263.01	1.0	5		114	51	65	59	
5	25									
6	30									
7	35									
8	40									
9	45									
10	50									
11	55									
12	60									
	(1051)									
	Ø= 21	Vm= 11.79	ΔH= 1.0						Tm= 60.00	

Integrated Gas Sampling Data:
Bag No. 3
Bag Vol. 10
Leak Rate, cc/min 0.0 at 15 in Hg

Moisture Recovery Data:

Impinger	1	2	3	4	Desiccant	Total
Final wt., g	126	100	0		1432	
Initial wt., g	100	100	0		1430	
Difference	26	0	0		2	28

Sample Train Leak Rate (cfm)		
Pretest	at	in Hg
Posttest	at	in Hg

RUN 4

Sample Point	Sample Time ΔT	Meter Reading Vm, Cu.Ft	Orifice Pressure, ΔH in H_2O	Sample Vacuum, in Hg	Sample Train Temperatures, °F					Oxygen Content, %
						Stack	Impinger Outlet	Meter Inlet	Meter Outlet	
	( )	( )								
1	5									
2	10									
3	15									
4	20									
5	25									
6	30									
7	35									
8	40									
9	45									
10	50									
11	55									
12	60									
	( )									
	Ø=	Vm=	ΔH=						Tm=	

Integrated Gas Sampling Data:
Bag No.
Bag Vol.
Leak Rate, cc/min at 15 in Hg

Moisture Recovery Data:

Impinger	1	2	3	4	Desiccant	Total
Final wt., g						
Initial wt., g	100	100	0			
Difference						

BARR

EPA METHOD 4
FIELD DATA SHEET

Project ArcelorMittal Minorca Mine
Sample Location Furnace Stack C
Date 4/11/17 Test 3 Run –
Operators SAW Eff. Probe Length 6 ft

Meter ID C-8
Meter Y 1.0044
Orifice H@ 1.9377
Bar. Press. 28.40 in Hg
Stat. Press. -0.80 in H_2O
Liner Type: ☐ Glass ☒ S.S. ☐ Other ______

Sample Train Leak Rate (cfm)				
Pretest	0.000	at	10	in Hg
Posttest	0.000	at	6	in Hg

RUN 1

Sample Point	Sample Time ΔT	Meter Reading Vm, Cu.Ft	Orifice Pressure, ΔH in H_2O	Sample Vacuum, in Hg		Sample Train Temperatures, °F Stack	Impinger Outlet	Meter Inlet	Meter Outlet	Oxygen Content, %
	(905)	(144.27)	BW							
1	5	147.03	1.08	~~1.0~~ 5		122	38	48	46	
2	10	149.80	1.05	~~1.0~~ 5		122	38	48	46	
3	15	152.58	1.08	~~1.0~~ 5		122	38	49	47	
4	~~20~~ 21	155.89	1.08	1.0 5		122	37	51	47	
5	25									
6	30									
7	35									
8	40									
9	45									
10	50									
11	55									
12	60									
	(926)									
	Ø= 21	Vm= 11.62	ΔH= 1.0						Tm= 47.75	

Integrated Gas Sampling Data:
Bag No. 1
Bag Vol. 10
Leak Rate, cc/min 6.0 at 15 in Hg

Moisture Recovery Data:

Impinger	BW 1	2	3	4	Desiccant	Total
Final wt., g	120	102	0		1426	
Initial wt., g	100	100	0		1423	
Difference	20	2	0		3	25

Sample Train Leak Rate (cfm)				
Pretest	0.000	at	10	in Hg
Posttest	0.000	at	6	in Hg

RUN 2

Sample Point	Sample Time ΔT	Meter Reading Vm, Cu.Ft	Orifice Pressure, ΔH in H_2O	Sample Vacuum, in Hg		Sample Train Temperatures, °F Stack	Impinger Outlet	Meter Inlet	Meter Outlet	Oxygen Content, %
	(1004)	(156.10)								
1	5	158.39	1.0	5		121	40	53	51	
2	10	161.10	1.0	5		121	37	53	51	
3	15	164.44	1.0	5		122	36	54	52	
4	~~20~~ 21	167.82	1.0	5		122	36	55	52	
5	25									
6	30									
7	35									
8	40									
9	45									
10	50									
11	55									
12	60									
	(1025)									
	Ø= 21	Vm= 11.72	ΔH= 1.0						Tm= 52.63	

Integrated Gas Sampling Data:
Bag No. 2
Bag Vol. 10
Leak Rate, cc/min 0.0 at 15 in Hg

Moisture Recovery Data:

Impinger	1	2	3	4	Desiccant	Total
Final wt., g	130	100	0		1438	
Initial wt., g	100	100	0		1436	
Difference	30	0	0		2	32

BARR

EPA METHOD 4
FIELD DATA SHEET

Project ArcelorMittal Minorca Mine
Sample Location Furnace Stack C
Date 4/11/17 Test ______ Run ______
Operators DAW Eff. Probe Length 6 ft

Meter ID C-8 Bar. Press. 28.40 in Hg
Meter Y 1.0044 Stat. Press. -0.80 in H_2O
Orifice H@ 1.9371
Liner Type: ☐ Glass ☒ S.S. ☐ Other ______

Sample Train Leak Rate (cfm)			
Pretest 0.000	at	10	in Hg
Posttest 0.000	at	6	in Hg

RUN 3

Sample Point	Sample Time ΔT	Meter Reading Vm, Cu.Ft	Orifice Pressure, ΔH in H_2O	Sample Vacuum, in Hg	Sample Train Temperatures, °F					Oxygen Content, %
						Stack	Impinger Outlet	Meter Inlet	Meter Outlet	
	(1232)	(192.03)								
1	5	194.86	1.0	5		121	48	59	57	
2	10	197.65	1.0	5		122	45	61	57	
3	15	200.80	1.0	5		123	42	62	58	
4	~~20~~ 21	203.36	1.0	5		123	42	62	58	
5	25									
6	30									
7	35									
8	40									
9	45									
10	50									
11	55									
12	60									
	(1253)									
	Ø= 21	Vm= 11.83	ΔH= 1.0						Tm= 59.25	

Integrated Gas Sampling Data:
Bag No. 3
Bag Vol. 10
Leak Rate, cc/min 0.0 at 15 in Hg

Moisture Recovery Data:

Impinger	1	2	3	4	Desiccant	Total
Final wt., g	135	100	0		1430	
Initial wt., g	100	100	0		1428	
Difference	35	0	0		2	37

Sample Train Leak Rate (cfm)		
Pretest	at	in Hg
Posttest	at	in Hg

RUN 4

Sample Point	Sample Time ΔT	Meter Reading Vm, Cu.Ft	Orifice Pressure, ΔH in H_2O	Sample Vacuum, in Hg	Sample Train Temperatures, °F					Oxygen Content, %
						Stack	Impinger Outlet	Meter Inlet	Meter Outlet	
	( )	( )								
1	5									
2	10									
3	15									
4	20									
5	25									
6	30									
7	35									
8	40									
9	45									
10	50									
11	55									
12	60									
	( )									
	Ø=	Vm=	ΔH=						Tm=	

Integrated Gas Sampling Data:
Bag No. ______
Bag Vol. ______
Leak Rate, cc/min ______ at 15 in Hg

Moisture Recovery Data:

Impinger	1	2	3	4	Desiccant	Total
Final wt., g						
Initial wt., g	100	100	0			
Difference						

BARR

EPA METHOD 4
FIELD DATA SHEET

Project ArcelorMittal Minorca Mine
Sample Location Furnace Stack D
Date 4/12/17 Test 4 Run _______
Operators BAW Eff. Probe Length 6 ft

Meter ID C-8 Bar. Press. 28.43 in Hg
Meter Y 1.0044 Stat. Press. -0.90 in H_2O
Orifice H@ 1.9371
Liner Type: ☐ Glass ☐ S.S. ☒ Other ________

Sample Train Leak Rate (cfm)			
Pretest 0.000	at	10	in Hg
Posttest 0.000	at	6	in Hg

RUN 1

Sample Point	Sample Time ΔT	Meter Reading Vm, Cu.Ft	Orifice Pressure, ΔH in H_2O	Sample Vacuum, in Hg	Sample Train Temperatures, °F	Stack	Impinger Outlet	Meter Inlet	Meter Outlet	Oxygen Content, %
	(308)	(215.78)								
1	5	218.55	1.0	5		126	37	48	48	
2	10	221.31	1.0	5		126	41	51	48	
3	15	224.05	1.0	5		126	37	52	49	
4	~~20~~ 21	227.39	1.0	5		126	38	54	49	
5	25									
6	30									
7	35									
8	40									
9	45									
10	50									
11	55									
12	60									
	(834)									
	Ø= 21	Vm= 11.61	ΔH= 1.0						Tm= 49.88	

Integrated Gas Sampling Data:
Bag No. 1
Bag Vol. 10
Leak Rate, cc/min 0.0 at 15 in Hg

Moisture Recovery Data:

Impinger	1	2	3	4	Desiccant	Total
Final wt., g	130	100	0		1432	
Initial wt., g	100	100	0		1430	
Difference	30	0	0		2	32

Sample Train Leak Rate (cfm)			
Pretest 0.000	at	10	in Hg
Posttest 0.000	at	6	in Hg

RUN 2

Sample Point	Sample Time ΔT	Meter Reading Vm, Cu.Ft	Orifice Pressure, ΔH in H_2O	Sample Vacuum, in Hg	Sample Train Temperatures, °F	Stack	Impinger Outlet	Meter Inlet	Meter Outlet	Oxygen Content, %
	(906)	(227.51)								
1	5	230.33	1.0	5		125	41	52	52	
2	10	233.13	1.0	5		126	40	52	52	
3	15	235.93	1.0	5		126	39	53	52	
4	~~20~~ 21	238.25	1.0	5		127	39	54	52	
5	25									
6	30									
7	35									
8	40									
9	45									
10	50									
11	55									
12	60									
	(927)									
	Ø= 21	Vm= 11.74	ΔH= 1.0						Tm= 52.38	

Integrated Gas Sampling Data:
Bag No. 2
Bag Vol. 10
Leak Rate, cc/min 0.0 at 15 in Hg

Moisture Recovery Data:

Impinger	1	2	3	4	Desiccant	Total
Final wt., g	132	100	0		1934	
Initial wt., g	100	100	0		1932	
Difference	32	0	0		2	34

EPA METHOD 4
FIELD DATA SHEET

Project ArcelorMittal Minorca Mine
Sample Location Furnace Stack D
Date 4/12/17 Test 4 Run
Operators BAW Eff. Probe Length 6 ft

Meter ID C-8
Meter Y 1.0044
Orifice H@ 1.9371
Bar. Press. 28.43 in Hg
Stat. Press. -0.90 in H_2O
Liner Type: ☐ Glass ☒ S.S. ☐ Other

Sample Train Leak Rate (cfm)			
Pretest 0.000	at	10	in Hg
Posttest 0.000	at	6	in Hg

RUN 3

Sample Point	Sample Time ΔT	Meter Reading Vm, Cu.Ft	Orifice Pressure, ΔH in H_2O	Sample Vacuum, in Hg	Sample Train Temperatures, °F					Oxygen Content, %
						Stack	Impinger Outlet	Meter Inlet	Meter Outlet	
	(1100)	(263.13)								
1	5	265.98	1.0	3		125	57	65	62	
2	10	268.77	1.0	3		126	56	68	62	
3	15	271.59	1.0	3		126	57	70	65	
4	~~20~~ 21	274.98	1.0	3		127	56	71	65	
5	25									
6	30									
7	35									
8	40									
9	45									
10	50									
11	55									
12	60									
	(1121)									
	Ø= 21	Vm=11.85	ΔH= 1.0						Tm=65.75	

Integrated Gas Sampling Data:
Bag No. 3
Bag Vol. 10
Leak Rate, cc/min 0.0 at 15 in Hg

Moisture Recovery Data:

Impinger	1	2	3	4	Desiccant	Total
Final wt., g	132	100	0		1436	
Initial wt., g	100	100	0		1434	
Difference	32	100	0		2	34

Sample Train Leak Rate (cfm)		
Pretest	at	in Hg
Posttest	at	in Hg

RUN 4

Sample Point	Sample Time ΔT	Meter Reading Vm, Cu.Ft	Orifice Pressure, ΔH in H_2O	Sample Vacuum, in Hg	Sample Train Temperatures, °F					Oxygen Content, %
						Stack	Impinger Outlet	Meter Inlet	Meter Outlet	
	( )	( )								
1	5									
2	10									
3	15									
4	20									
5	25									
6	30									
7	35									
8	40									
9	45									
10	50									
11	55									
12	60									
	( )									
	Ø=	Vm=	ΔH=						Tm=	

Integrated Gas Sampling Data:
Bag No.
Bag Vol.
Leak Rate, cc/min at 15 in Hg

Moisture Recovery Data:

Impinger	1	2	3	4	Desiccant	Total
Final wt., g						
Initial wt., g	100	100	0			
Difference						

BARR

EPA Method 30B
FIELD DATA SHEET

Project ArcelorMittal Minorca Mine
Sample Location Furnace Stack A SV014
Date 4-11-17
Operators TMR/BAW

Meter ID DVA-1, 2
Meter A γ 1.0176
Meter B γ 0.98857
Sample Rate 0.5 lpm
Bar. Press. 28.60 in. Hg

Test 1
Run 1

Sample Time ΔT	Meter A Volume Vma, liters	Meter B Volume Vmb, liters	Stack Temp °F	Sample A Vacuum, in Hg	Sample B Vacuum, in Hg	Sorbent Ts, °F	Probe Tp, °F	Meter A Outlet Temp	Meter B Outlet Temp	Notes
(0830)	0.000	0.000								
5	3.082	2.583	110	3.5	2.0	301	304	66	66	
10	6.104	5.319	110	3.5	2.0	301	304	66	66	
15	9.185	8.087	111	3.5	2.5	301	303	66	66	
20	12.063	10.789	111	3.5	2.5	301	303	66	66	
25	15.058	13.476	111	3.5	2.5	301	303	66	67	
30	18.073	16.162	111	3.5	2.5	301	302	66	67	
35	21.173	18.876	110	3.5	2.5	301	303	67	67	
40	24.128	21.573	111	3.5	2.5	301	303	67	68	
45	27.167	24.287	110	3.5	2.5	301	302	68	68	
50	30.217	27.116	110	3.5	2.5	301	302	68	69	
55	33.088	29.712	110	3.5	2.5	301	302	69	69	
60	36.084	32.380	111	3.5	2.5	301	302	69	70	
0930										
Ø= 60	Vma=36084	Vmb=32.380	Ts= 110.5					Tma=67.0	Tmb= 67.4	

Sample Train A Leak Rate (lpm)
Pretest 0 at 10 in Hg
Posttest 0 at 5 in Hg

Sample Train B Leak Rate (lpm)
Pretest 0 at 10 in Hg
Posttest 0 at 5 in Hg

Trap A ID OLC043081
Spike Y/N N
Spike Level

Trap B ID 0L411154
Spike Y/N Y
Spike Level 50

BARR

EPA Method 30B
FIELD DATA SHEET

Project ArcelorMittal Minorca Mine
Sample Location Furnace Stack A SV014
Date 4-11-17
Operators TMZ/BAW

Meter ID DVA-1
Meter A γ 1.0176
Meter B γ 0.9857
Sample Rate 0.5 lpm
Bar. Press. 28.60 in. Hg

Test 1
Run 2

Sample Time ΔT	Meter A Volume Vma, liters	Meter B Volume Vmb, liters	Stack Temp °F	Sample A Vacuum, in Hg	Sample B Vacuum, in Hg	Sorbent Ts, °F	Probe Tp, °F	Meter A Outlet Temp	Meter B Outlet Temp	Notes
(1000)	0.000	0.000								
5	2.857	2.646	107	3.5	2.5	301	302	71	71	
10	6.004	5.233	108	3.5	2.5	301	302	71	71	
15	8.991	7.839	110	3.5	2.5	301	302	71	71	
20	11.906	10.345	111	3.5	2.5	301	302	71	72	
25	14.884	12.292	110	3.5	2.5	301	302	72	72	
30	17.749	15.497	110	3.5	2.5	301	302	72	72	
35	20.643	18.049	111	3.5	2.5	301	302	72	72	
40	23.734	20.841	111	3.5	2.5	301	302	72	73	
45	26.534	23.199	111	3.5	2.5	301	302	73	73	
50	29.392	25.690	110	3.5	2.5	301	302	73	73	
55	32.373	28.223	111	3.5	2.5	301	302	73	73	
60	35.316	30.808	112	3.5	2.5	301	302	73	74	
1100										
Θ= 60	Vma=35.316	Vmb=30.808	Ts=110.2					Tma=72.0	Tmb=72.3	

Sample Train A Leak Rate (lpm)
Pretest 0 at 10 in Hg
Posttest 0 at 5 in Hg

Sample Train B Leak Rate (lpm)
Pretest 0 at 10 in Hg
Posttest 0 at 5 in Hg

Trap A ID 0LC043452
Spike Y/N N
Spike Level

Trap B ID 0L411134
Spike Y/N Y
Spike Level 50

BARR

EPA Method 30B
FIELD DATA SHEET

Project ArcelorMittal Minorca Mine
Sample Location Furnace Stack A SV014
Date 4-11-17
Operators TMZ/BAW

Meter ID DVA-1
Meter A γ 1.0176
Meter B γ 0.9857
Sample Rate 0.5 lpm
Bar. Press. 28.60 in. Hg

Test 1
Run 3

Sample Time ΔT	Meter A Volume Vma, liters	Meter B Volume Vmb, liters	Stack Temp °F	Sample A Vacuum, in Hg	Sample B Vacuum, in Hg	Sorbent Ts, °F	Probe Tp, °F	Meter A Outlet Temp	Meter B Outlet Temp	Notes
(1200)	0,000	0.000								
5	2.922	2,850	110	3.5	2.5	301	303	75	75	
10	5.723	5.335	109	3.5	2.5	301	303	75	75	
15	8.602	7.830	111	3.5	2.5	301	302	75	75	
20	11.452	10.371	111	3.5	2.5	301	302	75	75	
25	14.493	12.845	110	3.5	2.5	301	302	75	75	
30	17.336	15.278	111	3.5	2.5	301	303	75	76	
35	20.188	17.767	111	3.5	2.5	301	302	76	76	
40	23.130	20.225	111	3.5	2.5	301	303	76	77	
45	25.927	22.677	110	3.5	2.5	300	302	77	77	
50	28.729	25.128	110	3.5	2.5	300	303	77	78	
55	31.610	27.616	110	3.5	2.5	301	302	78	79	
60	34.362	29.999	110	3.5	2.5	300	303	78	79	
1300										
Ø= 60	Vma=34.362	Vmb=29.999	Ts=110.3					Tma=76.0	Tmb=76.4	

Sample Train A Leak Rate (lpm)
Pretest 0 at 10 in Hg
Posttest 0 at 5 in Hg

Sample Train B Leak Rate (lpm)
Pretest 0 at 10 in Hg
Posttest 0 at 5 in Hg

Trap A ID 0LC043076
Spike Y/N N
Spike Level

Trap B ID 0L411192
Spike Y/N Y
Spike Level 50

BARR

EPA Method 30B
FIELD DATA SHEET

Project ArcelorMittal Minorca Mine

Sample Location Furnace Stack B SV015

Date 4-12-17

Operators TMR/BAW

Meter ID DVA

Meter A γ 1.0176

Meter B γ 0.9857

Sample Rate 0.5 lpm

Bar. Press. 28.65 in. Hg

Test 2

Run 1

Sample Time ΔT	Meter A Volume Vma, liters	Meter B Volume Vmb, liters	Stack Temp °F	Sample A Vacuum, in Hg	Sample B Vacuum, in Hg	Sorbent Ts, °F	Probe Tp, °F	Meter A Outlet Temp	Meter B Outlet Temp	Notes
0736)	0.000	0.000								
5	2.789	2.593	110	3.0	2.5	301	302	76	76	
10	5.535	5.135	110	3.0	2.5	301	302	76	96	
15	8.084	7.713	111	3.0	2.5	301	302	76	76	
20	10.826	10.228	112	3.0	2.5	301	301	76	76	
25	13.502	12.660	112	3.0	2.5	300	301	76	76	
30	16.104	15.160	112	3.0	2.5	301	302	76	77	
35	18.675	17.710	112	3.0	2.5	301	302	77	77	
40	21.373	20.163	112	3.0	2.5	301	302	77	77	
45	23.967	22.608	113	3.0	2.5	300	302	77	78	
50	26.530	25.090	113	3.0	2.5	301	302	77	78	
55	29.701	27.569	112	3.0	2.5	300	302	78	78	
60	32.142	29.988	112	3.0	2.5	301	302	78	79	
0836										
θ= 60	Vma=32.142	Vmb=29.980	Ts= 111.8					Tma= 76.7	Tmb= 77.0	

Sample Train A Leak Rate (lpm)
Pretest 0 at 10 in Hg
Posttest 0 at 5 in Hg

Sample Train B Leak Rate (lpm)
Pretest 0 at 10 in Hg
Posttest 0 at 5 in Hg

Trap A ID 0LC043153
Spike Y/N N
Spike Level

Trap B ID 0L411174
Spike Y/N Y
Spike Level 50

BARR

EPA Method 30B
FIELD DATA SHEET

Project ArcelorMittal Minorca Mine
Sample Location Furnace Stack B SV015
Date 4-12-17
Operators TMR/BAW

Meter ID DVA
Meter A γ 1.0176
Meter B γ 0.9857
Sample Rate 0.5 lpm
Bar. Press. 28.65 in. Hg

Test 2
Run 2

Sample Time ΔT	Meter A Volume Vma, liters	Meter B Volume Vmb, liters	Stack Temp °F	Sample A Vacuum, in Hg	Sample B Vacuum, in Hg	Sorbent Ts, °F	Probe Tp, °F	Meter A Outlet Temp	Meter B Outlet Temp	Notes
0906)	0.000	0.000								
5	2.670	2.550	110	3.0	2.5	301	303	80	80	
10	5.321	5.093	111	3.0	2.5	301	302	80	80	
15	8.032	7.567	111	3.0	2.5	301	302	80	80	
20	10.732	10.041	111	3.0	2.5	300	302	80	80	
25	13.363	12.497	111	3.0	2.5	300	302	80	81	
30	15.941	15.018	112	3.0	2.5	300	302	80	81	
35	18.600	17.467	112	3.0	2.5	300	302	81	81	
40	21.270	19.923	113	3.0	2.5	300	302	81	81	
45	23.962	22.428	113	3.0	2.5	301	302	81	82	
50	26.634	24.902	113	3.0	2.5	301	302	81	82	
55	29.277	27.346	113	3.0	2.5	301	302	81	82	
60	31.910	29.797	113	3.0	2.5	300	302	81	82	
1006										
Ø= 60	Vma=31.910	Vmb=29.797	Ts=111.9					Tma= 80.5	Tmb= 81.0	

Sample Train A Leak Rate (lpm)
Pretest 0 at 10 in Hg
Posttest 0 at 5 in Hg

Sample Train B Leak Rate (lpm)
Pretest 0 at 10 in Hg
Posttest 0 at 5 in Hg

Trap A ID 0LC043415
Spike Y/N N
Spike Level

Trap B ID 0L411166
Spike Y/N Y
Spike Level 50

BARR

EPA Method 30B
FIELD DATA SHEET

Project ArcelorMittal Minorca Mine
Sample Location Furnace Stack B SV015
Date 4-12-17
Operators TMR/BAN

Meter ID DVA
Meter A γ 1.0176
Meter B γ 0.9857
Sample Rate 0.5 lpm
Bar. Press. 28.65 in. Hg

Test 2
Run 3

Sample Time ΔT	Meter A Volume Vma, liters	Meter B Volume Vmb, liters	Stack Temp °F	Sample A Vacuum, in Hg	Sample B Vacuum, in Hg	Sorbent Ts, °F	Probe Tp, °F	Meter A Outlet Temp	Meter B Outlet Temp	Notes
1030	0.000	0.000								
5	2.413	2.519	111	3.0	2.5	301	302	81	82	
10	4.937	5.020	111	3.0	2.5	301	302	81	82	
15	7.578	7.537	112	3.0	2.5	301	302	81	81	
20	10.217	10.032	111	3.0	2.5	301	302	81	81	
25	12.825	12.575	112	3.0	2.5	301	302	80	81	
30	15.447	15.027	112	3.0	2.5	301	302	80	81	
35	17.973	17.528	114	3.0	2.5	301	302	80	81	
40	20.563	20.004	114	3.0	2.5	301	302	80	81	
45	23.156	22.504	114	3.0	2.5	301	302	80	81	
50	25.803	24.919	114	3.0	2.5	301	302	80	81	
55	28.380	27.417	114	3.0	2.5	301	302	80	81	
60	30.975	29.903	114	3.0	2.5	301	302	81	81	
1130										
Ø= 60	Vma=30.975	Vmb=29.903	Ts=112.8					Tma=80.4	Tmb=81.2	

Sample Train A Leak Rate (lpm)
Pretest 0 at 10 in Hg
Posttest 0 at 5 in Hg

Sample Train B Leak Rate (lpm)
Pretest 0 at 10 in Hg
Posttest 0 at 5 in Hg

Trap A ID OLC043121
Spike Y/N N
Spike Level

Trap B ID OL411193
Spike Y/N Y
Spike Level 50

BARR

EPA Method 30B
FIELD DATA SHEET

Project	ArcelorMittal Minorca Mine	Meter ID	DVB-1	Test	3
Sample Location	Furnace Stack C SV016	Meter A γ	1.0141	Run	1
Date	4-11-17	Meter B γ	1.0063		
Operators	TMZ/BAW	Sample Rate	0.5 lpm		
		Bar. Press.	28.60 in. Hg		

Sample Time ΔT	Meter A Volume Vma, liters	Meter B Volume Vmb, liters	Stack Temp °F	Sample A Vacuum, in Hg	Sample B Vacuum, in Hg	Sorbent Ts, °F	Probe Tp, °F	Meter A Outlet Temp	Meter B Outlet Temp	Notes
(0830)	0.000	0.000								
5	1.802	1.991	122	2.0	2.0	302	303	65	65	
10	3.734	4.179	121	2.0	2.0	302	302	66	66	
15	5.673	6.294	122	2.0	2.0	302	303	67	67	
20	7.596	8.403	122	2.0	2.0	302	303	67	67	
25	9.585	10.569	122	2.0	2.0	302	303	68	68	
30	11.505	12.707	122	2.0	2.0	302	303	69	69	
35	13.456	14.842	122	2.0	2.0	301	302	70	70	
40	15.383	16.948	121	2.0	2.0	301	302	71	70	
45	17.509	19.244	122	2.0	2.0	301	302	71	71	
50	19.756	21.627	122	2.0	2.0	302	303	72	71	
55	21.760	23.821	122	2.0	2.0	301	302	73	72	
60	23.893	26.083	122	2.0	2.0	301	302	73	72	
0930										
Ø= 60	$\overline{\text{Vma}}$= 23.893	$\overline{\text{Vmb}}$= 26.033	$\overline{\text{Ts}}$= 121.33					$\overline{\text{Tma}}$= 69.3	$\overline{\text{Tmb}}$= 69.0	

Sample Train A Leak Rate (lpm)			Sample Train B Leak Rate (lpm)			Trap A ID	0LC043459	Trap B ID	0L411122
Pretest	0	at 10 in Hg	Pretest	0	at 10 in Hg	Spike Y/N	N	Spike Y/N	Y
Posttest	0	at 5 in Hg	Posttest	0	at 5 in Hg	Spike Level		Spike Level	50

EPA Method 30B
FIELD DATA SHEET

Project ArcelorMittal Minorca Mine
Sample Location Furnace Stack C SV016
Date 4-11-17
Operators TMZ/BAW

Meter ID DVB-1
Meter A γ 1.0141
Meter B γ 1.0063
Sample Rate 0.5 lpm
Bar. Press. 28.60 in. Hg

Test 3
Run 2

Sample Time ΔT	Meter A Volume Vma, liters	Meter B Volume Vmb, liters	Stack Temp °F	Sample A Vacuum, in Hg	Sample B Vacuum, in Hg	Sorbent Ts, °F	Probe Tp, °F	Meter A Outlet Temp	Meter B Outlet Temp	Notes
1000)	0.000	0.000								
5	2.226	2.438	116	2.5	2.5	302	302	71	71	
10	4.604	5.068	121	2.5	2.5	301	302	72	71	
15	6.914	7.681	121	2.5	2.5	301	302	72	72	
20	9.289	10.079	122	2.5	2.5	301	303	73	72	
25	11.707	12.482	121	2.5	2.5	302	302	73	73	
30	14.163	14.961	121	2.5	2.5	302	303	74	73	
35	16.587	17.372	122	2.5	2.5	302	301	74	74	
40	19.05)	19.743	122	2.5	2.5	302	302	75	74	
45	21 456	22.198	120	2.5	2.5	301	302	75	74	
50	23.914	24.572	119	2.5	2.5	301	302	75	74	
55	26.300	26.943	121	2.5	2.5	301	302	75	75	
60	28.733	29.317	122	2.5	2.5	302	302	76	75	
1100										
Ø= 60	Vma=28.733	Vmb=29.317	Ts=120.67					Tma=73.8	Tmb=73.2	

Sample Train A Leak Rate (lpm)
Pretest 0 at 10 in Hg
Posttest 0 at 5 in Hg

Sample Train B Leak Rate (lpm)
Pretest 0 at 10 in Hg
Posttest 0 at 5 in Hg

Trap A ID 02413031
Spike Y/N N
Spike Level

Trap B ID 02411171
Spike Y/N Y
Spike Level 50

BARR

EPA Method 30B
FIELD DATA SHEET

Project: ArcelorMittal Minorca Mine
Sample Location: Furnace Stack C SV016
Date: 4-11-17
Operators: TMZ /BAW

Meter ID: DVB-1
Meter A γ: 1.0141
Meter B γ: 1.0063
Sample Rate: 0.5 lpm
Bar. Press.: 28.60 in. Hg

Test: 3
Run: 3

Sample Time ΔT	Meter A Volume Vma, liters	Meter B Volume Vmb, liters	Stack Temp °F	Sample A Vacuum, in Hg	Sample B Vacuum, in Hg	Sorbent Ts, °F	Probe Tp, °F	Meter A Outlet Temp	Meter B Outlet Temp	Notes
(1200)	0.000	0.000								
5	2.276	2.776	120	2.5	3.0	302	302	74	74	
10	4.834	5.351	120	2.5	3.0	302	303	74	74	
15	7.409	7.681	123	2.5	3.0	302	302	75	75	
20	10.028	9.971	123	2.5	3.0	302	303	76	76	
25	12.640	12.277	122	2.5	3.0	301	302	77	77	
30	15.205	14.545	123	2.5	3.0	301	302	79	78	
35	17.780	16.818	123	2.5	3.0	301	302	80	79	
40	20.346	19.130	123	2.5	3.0	301	302	81	80	
45	23.000	21.381	121	2.5	3.0	301	302	82	81	
50	25.549	24.000	121	2.5	3.0	301	302	82	82	
55	28.104	26.561	122	2.5	3.0	301	302	83	83	
60	30.650	29.142	121	2.5	3.0	301	302	84	83	
1300										
Ø= 60	Vma=30.650	Vmb=29.142	Ts=121.83					Tma=78.9	Tmb=78.5	

Sample Train A Leak Rate (lpm)
Pretest 0 at 10 in Hg
Posttest 0 at 5 in Hg

Sample Train B Leak Rate (lpm)
Pretest 0 at 10 in Hg
Posttest 0 at 5 in Hg

Trap A ID: OLC043422
Spike Y/N: N
Spike Level:

Trap B ID: OL411153
Spike Y/N: Y
Spike Level: 50

BARR

EPA Method 30B
FIELD DATA SHEET

Project ArcelorMittal Minorca Mine
Sample Location Furnace Stack D SV017
Date 4-12-17
Operators TMR/BAW

Meter ID DVB
Meter A γ 1.0141
Meter B γ 1.0063
Sample Rate 0.5 lpm
Bar. Press. 28.65 in. Hg

Test 4
Run 1

Sample Time ΔT	Meter A Volume Vma, liters	Meter B Volume Vmb, liters	Stack Temp °F	Sample A Vacuum, in Hg	Sample B Vacuum, in Hg	Sorbent Ts, °F	Probe Tp, °F	Meter A Outlet Temp	Meter B Outlet Temp	Notes
0736	0.000	0.000								
5	2,207	2.579	120	2.0	3.0	302	303	75	75	
10	4.527	5.062	121	2.0	3.0	302	302	75	76	
15	6.899	7.567	125	2.0	3.0	302	302	76	76	
20	9.323	10.040	126	2.0	3.0	302	302	77	77	
25	11,903	12.589	126	2.0	3.0	302	302	77	77	
30	14,503	15.119	126	2.5	3.0	301	302	78	78	
35	17,043	17.589	126	2.5	3.0	301	302	79	78	
40	19,602	20.086	126	2.5	3.0	301	302	79	79	
45	22,163	22,605	126	2.5	3.0	301	302	80	79	
50	24.750	25.160	126	2.5	3.0	301	302	80	80	
55	27.342	27.738	126	2.5	3.0	301	302	81	80	
60	29.236	30,189	126	2.5	3.0	301	302	82	81	
0836										
θ= 60	Vma=29.836	Vmb=30.189	Ts=125.0					Tma=78.3	Tmb=78.0	

Sample Train A Leak Rate (lpm)
Pretest 0 at 10 in Hg
Posttest 0 at 5 in Hg

Sample Train B Leak Rate (lpm)
Pretest 0 at 10 in Hg
Posttest 0 at 5 in Hg

Trap A ID OLC043472
Spike Y/N N
Spike Level

Trap B ID OL411172
Spike Y/N Y
Spike Level 50

EPA Method 30B
FIELD DATA SHEET

Project ArcelorMittal Minorca Mine
Sample Location Furnace Stack D SV017
Date 4-12-17
Operators TMR/DAW

Meter ID DVB
Meter A γ 1.0141
Meter B γ 1.0063
Sample Rate 0.5 lpm
Bar. Press. 28.65 in. Hg

Test 4
Run 2

Sample Time ΔT	Meter A Volume Vma, liters	Meter B Volume Vmb, liters	Stack Temp °F	Sample A Vacuum, in Hg	Sample B Vacuum, in Hg	Sorbent Ts, °F	Probe Tp, °F	Meter A Outlet Temp	Meter B Outlet Temp	Notes
0906	0.000	0.000								
5	2.775	2.667	121	3.0	3.0	302	303	80	80	
10	5.283	5.406	125	3.0	3.0	302	303	80	80	
15	7.933	8.070	126	3.0	3.0	302	302	80	80	
20	10.587	10.744	126	3.0	3.0	302	302	81	81	
25	13.078	13.233	126	3.0	3.0	301	302	82	81	
30	15.258	15.652	126	2.5	2.5	301	302	82	82	
35	17.446	18.063	126	2.5	2.5	301	302	83	82	
40	19.645	20.251	126	2.5	2.5	301	302	83	82	
45	21.857	22.438	127	2.5	2.5	301	302	83	82	
50	24.003	24.635	127	2.5	2.5	301	302	83	82	
55	26.142	26.853	127	2.5	2.5	301	302	83	82	
60	28.317	29.291	127	2.5	2.5	301	302	83	82	
1006										
Θ= 60	Vma= 28317	Vmb= 29291	Ts= 125.83					Tma= 81.9	Tmb= 81.8	

Sample Train A Leak Rate (lpm)
Pretest 0 at 10 in Hg
Posttest 0 at 5 in Hg

Sample Train B Leak Rate (lpm)
Pretest 0 at 10 in Hg
Posttest 0 at 5 in Hg

Trap A ID 0LC043364
Spike Y/N N
Spike Level

Trap B ID 0L411102
Spike Y/N Y
Spike Level 50

BARR

EPA Method 30B
FIELD DATA SHEET

Project ArcelorMittal Minorca Mine
Sample Location Furnace Stack D SV017
Date 4-12-17
Operators TMZ/BAW

Meter ID DVB
Meter A γ 1.0141
Meter B γ 1.0063
Sample Rate 0.5 lpm
Bar. Press. 28.65 in. Hg Barometer BA-04 (TMZ)

Test 4
Run 3

Sample Time ΔT	Meter A Volume Vma, liters	Meter B Volume Vmb, liters	Stack Temp °F	Sample A Vacuum, in Hg	Sample B Vacuum, in Hg	Sorbent Ts, °F	Probe Tp, °F	Meter A Outlet Temp	Meter B Outlet Temp	Notes
1030)	0.000	0.000								
5	2.276	2.499	121	2.5	2.5	301	302	79	79	
10	4.717	5.016	123	2.5	2.5	301	302	79	79	
15	7.106	7.453	127	2.5	2.5	301	302	79	79	
20	9.635	9.879	126	2.5	2.5	301	302	80	79	
25	12.203	12.374	126	2.5	2.5	302	302	80	79	
30	14.817	14.947	125	2.5	2.5	301	302	80	79	
35	17.372	17.503	126	2.5	2.5	301	302	80	80	
40	19.935	20.042	127	2.5	2.5	301	302	80	80	
45	22.538	22.550	126	2.5	2.5	301	302	80	80	
50	25.062	25.082	126	2.5	2.5	301	302	80	80	
55	27.625	27.633	126	2.5	2.5	301	302	81	80	
60	30.146	30.196	127	2.5	2.5	301	302	81	80	
1130										
Ø= 60	Vma= 30.146	Vmb= 30.196	Ts= 125.5					Tma= 79.9	Tmb= 79.5	

Sample Train A Leak Rate (lpm)
Pretest 0 at 10 in Hg
Posttest 0 at 5 in Hg

Sample Train B Leak Rate (lpm)
Pretest 0 at 10 in Hg
Posttest 0 at 5 in Hg

Trap A ID 0L413042
Spike Y/N N
Spike Level

Trap B ID 0L411132
Spike Y/N Y
Spike Level 50

Appendix C

Laboratory Reports and Sample Chain of Custody

trap id	s1 area	s2 area	s1 ng	s2 ng	ccv, %
Stack A R1 TA	38900	1100	42.53	1.17	
Stack A R2 TA	65100	2130	71.18	2.26	
Stack A R3 TA	46300	2190	50.62	2.32	
Stack A R1 TB	201000	2560	219.77	2.71	
Stack A R2 TB	155000	1580	169.47	1.67	
Stack A R3 TB	194000	3050	212.11	3.23	
ccv	64500		70.52	0.00	94.03
Stack B R1 TA	51000	2090	54.94	2.21	
Stack B R2 TA	72300	1640	77.89	1.74	
Stack B R3 TA	60700	1930	65.39	2.04	
Stack B R1 TB	184000	1940	198.22	2.06	
Stack B R2 TB	212000	1240	228.39	1.31	
Stack B R3 TB	171000	818	184.22	0.87	
ccv	64500		69.49	0.00	92.65
Stack C R1 TA	85800	4440	91.57	4.70	
Stack C R2 TA	85000	4550	90.72	4.82	
Stack C R3 TA	98300	1980	104.91	2.10	
Stack C R1 TB	211600	2160	225.83	2.29	
Stack C R2 TB	256000	3170	273.21	3.36	
Stack C R3 TB	247000	2970	263.61	3.15	
ccv	87400		93.28		93.28
Stack D R1 TA	123000	1290	131.27	1.37	
Stack D R2 TA	130000	1070	138.74	1.13	
Stack D R3 TA	125000	1320	133.40	1.40	
Stack D R1 TB	206000	939	219.85	0.99	
Stack D R2 TB	263000	795	280.68	0.84	
Stack D R3 TB	253000	728	270.01	0.77	
ccv	94300		100.64		100.64

BPAC Screening

trap id	s1 area	s2 area	s1 ng	s2 ng	ccv, %
C, R1B	41300	2350	104.40	5.62	
C, R1A	21900	1840	55.36	4.40	
D, R1A	32000	1310	80.89	3.13	
D, R1B	51800	911	130.94	2.18	
CCV	29500		74.57	0.00	99.43
C, R2B	42300	1930	106.93	4.62	
C, R2A	23200	2070	58.65	4.95	
D, R2A	30400	891	76.85	2.13	
D, R2B	46300	732	117.04	1.75	
CCV	28400		71.79	0.00	95.72
C, R3A	22200	2020	56.12	4.83	
C, R3B	41700	2040	105.41	4.88	
D, R3A	29600	915	74.82	2.19	
D, R3B	46500	928	117.54	2.22	
CCV	28300		71.54	0.00	95.38

HPAC Screening

trap id	s1 area	s2 area	s1 ng	s2 ng	ccv, %
C, R1B	22900	2090	54.45	5.23	
C, R1A	41600	1820	98.91	4.55	
D, R1A	28200	642	67.05	1.61	
D, R1B	48800	292	116.02	0.73	
CCV	29300		69.66	0.00	92.88
C, R2B	19800	1720	47.08	4.30	
C, R2A	38300	1970	91.06	4.93	
D, R2A	25800	807	61.34	2.02	
D, R2B	44800	596	106.51	1.49	
CCV	28400		67.52	0.00	90.03
CCV	29900		71.09	0.00	94.79
C, R3A	19900	1790	47.31	4.48	
C, R3B	40400	1830	96.05	4.58	
D, R3A	26300	639	62.53	1.60	
D, R3B	43900	1110	104.37	2.78	
CCV	28500		67.76	0.00	90.35

LABORATORY REPORT

FILTERABLE PARTICULATE MATTER RESULTS

CLIENT ArcelorMittal
PROJECT NO. 23/69-1843.00 LONG-200
TEST T1
TEST DATE 2/8/2017
SOURCE ID Stack A SV014 - Longterm 1
SAMPLING LOCATION Stack
SAMPLES COLLECTED BY BAW

AIR FILTERS: 4" Quartz **ANALYZED ON:** 2/14 **ANALYSIS PERFORMED BY** ROB

Run	Filter ID	Description	Gross Weight	Date/Time	Tare Weight	Date/Time	Uncorrected Net Mass (g)
R1	4Q0588	Red particulate	0.6908 0.6911	2/15/2017 13:50 2/16/2017 18:33	0.6705 0.6708	6/17/2016 12:40 6/26/2016 16:22	0.02036
R2	4Q0599	Red particulate	0.6676 0.6678	2/15/2017 13:51 2/16/2017 18:32	0.6456 0.6457	6/17/2016 12:52 6/26/2016 15:54	0.02208
R3	4Q0592	Red particulate	0.6769 0.6771	2/15/2017 13:54 2/16/2017 18:30	0.6570 0.6572	6/17/2016 12:44 6/26/2016 16:08	0.01984
R0 Filter Blank	4Q0597	Blank	0.6773 0.6776 0.6779	2/15/2017 13:44 2/16/2017 18:34 2/17/2017 13:37	0.6783 0.6786	6/17/2016 12:50 6/26/2016 15:57	-0.00071

PROBE RINSE: ACETONE

Run	Beaker ID	Description	Gross Weight	Date/Time	Tare Weight	Date/Time	Uncorrected Net Mass (g)	Solvent Volume (ml)	Evidence of Sample Loss?
R1	1001	Dark particulate	122.5630 122.5632	2/16/2017 19:01 2/21/2017 12:02	122.55890 122.55872	2/13/2017 18:03 2/14/2017 9:39	0.00430	135	No
R2	1002	Dark particulate	125.3048 125.3047	2/16/2017 19:08 2/21/2017 12:01	125.29965 125.29951	2/13/2017 18:04 2/14/2017 9:38	0.00517	135	No
R3	1003	Dark particulate	127.3613 127.3611	2/16/2017 19:09 2/21/2017 12:00	127.35699 127.35664	2/13/2017 18:05 2/14/2017 9:37	0.00437	115	No
R0 Reagent Blank	1013	Blank	103.9175 103.9173	2/16/2017 19:22 2/21/2017 11:38	103.91681 103.91664	2/13/2017 18:17 2/14/2017 9:16	0.00066	200	No

Results of Gravimetric Particulate Analysis
Indurating Furnace Stack A (SV014)
Test Date: February 8, 2017
Longterm 1

Method 5 Particulate Mass Determination

Inputs	Symbol	Units	Run 1	Run 2	Run 3	Blanks
Air Filter - Net Particulate Mass	M_{af}	g	0.02036	0.02208	0.01984	-0.00071
Probe Wash - Net Residue Mass	M_{pw}	g	0.00430	0.00517	0.00437	0.00066
Probe Wash Volume	V_{pw}	ml	135	135	115	200
Calculations						
Probe Wash Blank Correction Amount $C_{pw} = V_{pw} \times M_{pw(blank)} \div V_{pw(blank)}$	C_{pw}	g	0.00045	0.00045	0.00038	
Probe Wash Final Mass $M_{pwf} = M_{pw} - C_{pw}$	M_{pwf}	g	0.00385	0.00472	0.00400	
Filterable Particulate Matter (PM) Mass $\mathbf{M_{PM} = M_{af} + M_{pwf}}$	$\mathbf{M_{PM}}$	**g**	**0.02421**	**0.02680**	**0.02383**	

LABORATORY REPORT

FILTERABLE PARTICULATE MATTER RESULTS

CLIENT ArcelorMittal

PROJECT NO. 23/69-1843.00 LONG-201

TEST T2

TEST DATE 2/9/2017

SOURCE ID Stack B SV015 - Longterm 1

SAMPLING LOCATION Stack

SAMPLES COLLECTED BY BAW

AIR FILTERS: 4" Quartz

ANALYZED ON: 2/14

ANALYSIS PERFORMED BY ROB

Run	Filter ID	Description	Gross Weight	Date/Time	Tare Weight	Date/Time	Uncorrected Net Mass (g)
R1	4Q0427	Grey-red particulate	0.7510	2/15/2017 14:01	0.7303	8/21/2014 11:32	0.02115
			0.7511	2/16/2017 18:23	0.7300	8/22/2014 10:15	
					0.7298	8/25/2014 14:45	
R2	4Q0574	Grey-red particulate	0.6954	2/15/2017 14:02	0.6713	4/28/2016 10:49	0.02436
			0.6954	2/16/2017 18:21	0.6709	4/29/2016 11:06	
R3	4Q0593	Grey-red particulate	0.7025	2/15/2017 14:03	0.6800	6/17/2016 12:45	0.02238
			0.7025	2/16/2017 18:21	0.6802	6/26/2016 16:06	
R0 Filter Blank	4Q0597	Blank	0.6773	2/15/2017 13:44	0.6783	6/17/2016 12:50	-0.00071
			0.6776	2/16/2017 18:34	0.6786	6/26/2016 15:57	
			0.6779	2/17/2017 13:37			

PROBE RINSE: ACETONE

Run	Beaker ID	Description	Gross Weight	Date/Time	Tare Weight	Date/Time	Uncorrected Net Mass (g)	Solvent Volume (ml)	Evidence of Sample Loss?
R1	1004	Dark particulate	104.6714	2/16/2017 19:11	104.66774	2/13/2017 18:06	0.00365	145	No
			104.6710	2/21/2017 11:59	104.66733	2/14/2017 9:36			
R2	1005	Dark particulate, filter media	126.6502	2/16/2017 19:12	126.64273	2/13/2017 18:07	0.00747	150	No
			126.6500	2/21/2017 11:58	126.64254	2/14/2017 9:36			
R3	1006	Dark particulate, filter media	127.4315	2/16/2017 19:17	127.42757	2/13/2017 18:10	0.00395	135	No
			127.4318	2/21/2017 11:57	127.42783	2/14/2017 9:33			
R0 Reagent Blank	1013	Blank	103.9175	2/16/2017 19:22	103.91681	2/13/2017 18:17	0.00066	200	No
			103.9173	2/21/2017 11:38	103.91664	2/14/2017 9:16			

Results of Gravimetric Particulate Analysis
Indurating Furnace Stack B (SV015)
Test Date: February 9, 2017
Longterm 1

Method 5 Particulate Mass Determination

Inputs	Symbol	Units	Run 1	Run 2	Run 3	Blanks
Air Filter - Net Particulate Mass	M_{af}	g	0.02115	0.02436	0.02238	-0.00071
Probe Wash - Net Residue Mass	M_{pw}	g	0.00365	0.00747	0.00395	0.00066
Probe Wash Volume	V_{pw}	ml	145	150	135	200
Calculations						
Probe Wash Blank Correction Amount $C_{pw} = V_{pw}$ x $M_{pw(blank)} \div V_{pw(blank)}$	C_{pw}	g	0.00048	0.00049	0.00045	
Probe Wash Final Mass $M_{pwf} = M_{pw} - C_{pw}$	M_{pwf}	g	0.00317	0.00698	0.00350	
Filterable Particulate Matter (PM) Mass $M_{PM} = M_{af} + M_{pwf}$	M_{PM}	**g**	**0.02432**	**0.03134**	**0.02588**	

LABORATORY REPORT

FILTERABLE PARTICULATE MATTER RESULTS

CLIENT ArcelorMittal

PROJECT NO. 23/69-1843.00 LONG-202

TEST T3

TEST DATE 2/8/2017

SOURCE ID Stack C SV016 - Longterm 1

SAMPLING LOCATION Stack

SAMPLES COLLECTED BY BAW

AIR FILTERS: 4" Quartz

ANALYZED ON: 2/14

ANALYSIS PERFORMED BY ROB

Run	Filter ID	Description	Gross Weight	Date/Time	Tare Weight	Date/Time	Uncorrected Net Mass (g)
R1	4Q0594	Gray particulate	0.6979	2/15/2017 14:05	0.6743	6/17/2016 12:46	0.02352
			0.6979	2/16/2017 18:29	0.6745	6/26/2016 16:04	
R2	4Q0595	Gray particulate	0.7054	2/15/2017 14:09	0.6785	6/17/2016 12:47	0.02680
			0.7054	2/16/2017 18:28	0.6787	6/26/2016 16:01	
R3	4Q0596	Gray particulate	0.6847	2/15/2017 14:10	0.6601	6/17/2016 12:49	0.02437
			0.6846	2/16/2017 18:27	0.6604	6/26/2016 15:59	
R0 Filter Blank	4Q0597	Blank	0.6773	2/15/2017 13:44	0.6783	6/17/2016 12:50	-0.00071
			0.6776	2/16/2017 18:34	0.6786	6/26/2016 15:57	
			0.6779	2/17/2017 13:37			

PROBE RINSE: ACETONE

Run	Beaker ID	Description	Gross Weight	Date/Time	Tare Weight	Date/Time	Uncorrected Net Mass (g)	Solvent Volume (ml)	Evidence of Sample Loss?
R1	1007	Dark particulate	126.6395	2/16/2017 19:19	126.63369	2/13/2017 18:11	0.00557	140	No
			126.6393	2/21/2017 11:56	126.63397	2/14/2017 9:31			
R2	1008	Dark particulate, filter media	125.0269	2/16/2017 19:16	125.01904	2/13/2017 18:13	0.00751	150	No
			125.0265	2/21/2017 11:56	125.01932	2/14/2017 9:30			
R3	1009	Dark particulate, filter media	125.9055	2/16/2017 19:13	125.89818	2/13/2017 18:14	0.00727	145	No
			125.9053	2/21/2017 11:55	125.89808	2/14/2017 9:30			
R0 Reagent Blank	1013	Blank	103.9175	2/16/2017 19:22	103.91681	2/13/2017 18:17	0.00066	200	No
			103.9173	2/21/2017 11:38	103.91664	2/14/2017 9:16			

Results of Gravimetric Particulate Analysis

Indurating Furnace Stack C (SV016)

Test Date: February 8, 2017

Longterm 1

Method 5 Particulate Mass Determination

Inputs	Symbol	Units	Run 1	Run 2	Run 3	Blanks
Air Filter - Net Particulate Mass	M_{af}	g	0.02352	0.02680	0.02437	-0.00071
Probe Wash - Net Residue Mass	M_{pw}	g	0.00557	0.00751	0.00727	0.00066
Probe Wash Volume	V_{pw}	ml	140	150	145	200
Calculations						
Probe Wash Blank Correction Amount $C_{pw} = V_{pw} \times M_{pw(blank)} \div V_{pw(blank)}$	C_{pw}	g	0.00046	0.00049	0.00048	
Probe Wash Final Mass $M_{pwf} = M_{pw} - C_{pw}$	M_{pwf}	g	0.00511	0.00702	0.00679	
Filterable Particulate Matter (PM) Mass $\mathbf{M_{PM} = M_{af} + M_{pwf}}$	$\mathbf{M_{PM}}$	**g**	**0.02863**	**0.03382**	**0.03116**	

LABORATORY REPORT

FILTERABLE PARTICULATE MATTER RESULTS

CLIENT ArcelorMittal

PROJECT NO. 23/69-1843.00 LONG-203

TEST T4

TEST DATE 2/9/2017

SOURCE ID Stack D SV017 - Longterm 1

SAMPLING LOCATION Stack

SAMPLES COLLECTED BY BAW

AIR FILTERS: 4" Quartz

ANALYZED ON: 2/14

ANALYSIS PERFORMED BY ROB

Run	Filter ID	Description	Gross Weight	Date/Time	Tare Weight	Date/Time	Uncorrected Net Mass (g)
R1	4Q0648	Gray particulate	0.8078	2/15/2017 14:11	0.7822	9/24/2016 15:17	0.02559
			0.8078	2/16/2017 18:26	0.7822	9/28/2016 22:13	
R2	4Q0544	Gray particulate	0.6720	2/15/2017 14:14	0.6448	6/17/2015 15:03	0.02717
			0.6720	2/16/2017 18:25	0.6449	6/18/2015 8:39	
R3	4Q0649	Gray particulate	0.8004	2/15/2017 14:17	0.7743	9/24/2016 15:16	0.02622
			0.8004	2/16/2017 18:24	0.7741	9/28/2016 22:14	
R0 Filter Blank	4Q0597	Blank	0.6773	2/15/2017 13:44	0.6783	6/17/2016 12:50	-0.00071
			0.6776	2/16/2017 18:34	0.6786	6/26/2016 15:57	
			0.6779	2/17/2017 13:37			

PROBE RINSE: ACETONE

Run	Beaker ID	Description	Gross Weight	Date/Time	Tare Weight	Date/Time	Uncorrected Net Mass (g)	Solvent Volume (ml)	Evidence of Sample Loss?
R1	1010	Dark particulate	128.4139	2/16/2017 19:20	128.40853	2/13/2017 18:15	0.00543	190	No
			128.4140	2/21/2017 11:54	128.40848	2/14/2017 9:24			
R2	1011	Dark particulate	125.4605	2/16/2017 19:21	125.45469	2/13/2017 18:16	0.00563	190	No
			125.4605	2/21/2017 11:53	125.45506	2/14/2017 9:22			
R3	1012	Dark particulate, filter media	127.8997	2/16/2017 19:23	127.89476	2/13/2017 18:16	0.00516	195	No
			127.8997	2/21/2017 11:52	127.89439	2/14/2017 9:19			
R0 Reagent Blank	1013	Blank	103.9175	2/16/2017 19:22	103.91681	2/13/2017 18:17	0.00066	200	No
			103.9173	2/21/2017 11:38	103.91664	2/14/2017 9:16			

Results of Gravimetric Particulate Analysis
Indurating Furnace Stack D (SV017)
Test Date: February 9, 2017
Longterm 1

Method 5 Particulate Mass Determination

Inputs	Symbol	Units	Run 1	Run 2	Run 3	Blanks
Air Filter - Net Particulate Mass	M_{af}	g	0.02559	0.02717	0.02622	-0.00071
Probe Wash - Net Residue Mass	M_{pw}	g	0.00543	0.00563	0.00516	0.00066
Probe Wash Volume	V_{pw}	ml	190	190	195	200
Calculations						
Probe Wash Blank Correction Amount $C_{pw} = V_{pw} \times M_{pw(blank)} \div V_{pw(blank)}$	C_{pw}	g	0.00063	0.00063	0.00064	
Probe Wash Final Mass $M_{pwf} = M_{pw} - C_{pw}$	M_{pwf}	g	0.00480	0.00500	0.00451	
Filterable Particulate Matter (PM) Mass $M_{PM} = M_{af} + M_{pwf}$	M_{PM}	**g**	**0.03039**	**0.03217**	**0.03073**	

4 of 5

BARR

Request for Laboratory Analytical Services

№ 12729

LONG

Report Results To

Check One:

☒ *Barr Engineering Company*
4700 West 77th Street
Minneapolis, MN 55435-4803
(952) 832-2600

☒ 5150 W 76th
~~*Barr Engineering Company*~~
~~*7390 Ohms Lane*~~
~~*Edina, MN 55439-2330*~~
~~*(952) 832-2600*~~

Attention: BAW (Print Name) (Direct Phone No.)

Send Invoice To

Project Number 23/69-1343.00

Barr Engineering Company
4700 West 77th Street
Minneapolis, MN 55435-4803
Ph. (952) 832-2600 Fax (952) 832-2601

Attention: (Print Name)

Special instructions and/or specific regulatory requirements:
(method, limit of detection, etc.)

Send to element one after analysis

	Sample Identification	Date/Time Collected	Media I.D. #	Type: Grab	Type: Comp.	Type: QC	EPA Method 5	EPA Method 202	Filter	Acetone Rinse	Wet Catch	MECL 2R inse	Total No. of Containers	Remarks
1.	STACK A R1	02/08/17 1145 ~~1200~~ *	4Q0588		X		X		1	1			2	
2.	│ R2	02/08/17 1500	4Q0599		│		│		1	1			2	
3.	│ R3	02/08/17 1830	4Q0592		│		│		1	1			2	
4.	STACK B R1	02/09/17 1145	4Q0427		│		│		1	1			2	
5.	│ R2	02/09/17 1430	4Q0574		│		│		1	1			2	
6.	│ R3	02/09/17 1700	4Q0593		│		│		1	1			2	
7.	STACK C R1	02/08/17 1200	4Q0594		│		│		1	1			2	
8.	│ R2	02/08/17 1515	4Q0595		│		│		1	1			2	
9.	│ R3	02/08/17 1730	4Q0596		│		│		1	1			2	
10.														

Chain of Custody

Collected by (Print Name): BEN WILTSE

Relinquished by: Ben Wiltse Date/Time 2/13/17 11:00

Relinquished by: Date/Time

Method of Shipment: ☐ Sampler ☒ FedEx ☐ UPS Other: ______

Collectors Signature: Date: 2/9/17

LABORATORY:

Received by: R Berg Barr Eng. Co. Date/Time 2/13/17 11:00

Received by: Date/Time

Received at Lab by: Date/Time

Sample Condition upon Receipt: ☐ Acceptable ☐ Other (explain)

Distribution: White-Original Accompanies Shipment to Lab; Yellow - Field Copy

JAR 2

Rev. 03/01

W:\Business Units\EM\Subunit Admin\Technical & Support Services\Air Sampling\Datasheets\Other\Chain of Custody.CDR RLG 07-30-08

5 of 5

BARR

Request for Laboratory Analytical Services

№ 12730

LONG

Report Results To

Check One:

☐ ***Barr Engineering Company***
4700 West 77th Street
Minneapolis, MN 55435-4803
(952) 832-2600

5150 W 76th

☒ ~~***Barr Engineering Company***~~
~~***7390 Ohms Lane***~~
~~***Edina, MN 55439-2330***~~
~~***(952) 832-2600***~~

Attention: BAW (Print Name) (Direct Phone No.)

Send Invoice To

Project Number 23/69-1843/00

Barr Engineering Company
4700 West 77th Street
Minneapolis, MN 55435-4803
Ph. (952) 832-2600 Fax (952) 832-2601

Attention: ______ (Print Name)

Special instructions and/or specific regulatory requirements:
(method, limit of detection, etc.)

send to element one after analysis

	Sample Identification	Date/Time Collected	Media I.D. #	Type: Grab	Type: Comp.	Type: QC	EPA Method 5	EPA Method 202										Filter	Acetone Rinse	Wet Catch	MECL $_2$R inse	Total No. of Containers	Remarks
1.	STACK D R1	02/09/17 1400	4Q0648		X		X											1	1			2	
2.	| R2	02/09/17 1700	4Q0544		|		|											1	1			2	
3.	| R3	02/09/17 1830	4Q0649		|		|											1	1			2	
4.																							
5.	BLANKS	02/08/17 1500	4Q0597		X		X											1	1			2	
6.																							
7.																							
8.																							
9.																							
10.																							

Chain of Custody

Collected by (Print Name): BEN WILTSE

Relinquished by: Ben Wiltse Date/Time 2/13/17 11:00

Relinquished by: Date/Time

Method of Shipment: ☐ Sampler ☒ FedEx ☐ UPS Other: ______

Collectors Signature: Date: 2/9/17

LABORATORY:

Received by: Berg Barr Eng. Co. Date/Time 7/13/17 11:00

Received by: Date/Time

Received at Lab by: Date/Time

Sample Condition upon Receipt: ☐ Acceptable ☐ Other (explain)

Distribution: White-Original Accompanies Shipment to Lab; Yellow - Field Copy

Rev. 03/01

W:\Business Units\EM\Subunit Admin\Technical & Support Services\Air Sampling\Datasheets\Other\Chain of Custody.CDR RLG 07-30-08

Barr Engineering

5150 W. 76th Street
Edina, MN 55439-2330

Project Number: 23/69-1843.00 LONG 002

Mercury

Ontario Hydro Method Analysis

Analytical Report
28937

el1

Element One, Inc.
6319-D Carolina Beach Rd., Wilmington, NC 28412
910-793-0128 FAX:910-792-6853 e1lab@e1lab.com

*Note: Analytical data on file at Barr and available upon request

The following data for Analytical Report 28937
has been reviewed for completeness, accuracy,
adherence to method protocol,
and compliance with quality assurance guidelines.

Review by:

Katie Strickland, B.S. Chemist
March 7, 2017

Report Reviewed and Finalized By:

Ken Smith, Laboratory Director
March 7, 2017

SUMMARY OF RESULTS

Summary of Analysis

Summary of OHM Mercury Analysis

Run Number		Average Total Catch, µg	Filter µg	FH Rinse µg	KCl µg	H_2O_2/HNO_3 µg	$KMnO_4$ µg
Stack A-OHM-R1	# 1	4.84	1.09	0.018	1.24	0.002	2.54
	# 2		1.07	0.017	1.23	0.001	2.49
Stack A-OHM-R2	# 1	4.98	1.29	0.030	0.924	0.015	2.70
	# 2		1.29	0.027	0.931	0.014	2.76
Stack A-OHM-R3	# 1	4.55	0.656	0.016	1.16	< 0.013	2.74
	# 2		0.644	0.017	1.18	< 0.013	2.69
Stack B-OHM-R1	# 1	4.81	1.65	0.031	0.632	0.021	2.50
	# 2		1.69	0.029	0.619	0.021	2.42
Stack B-OHM-R2	# 1	5.73	1.74	0.029	0.944	< 0.013	3.05
	# 2		1.71	0.030	0.919	< 0.013	3.04
Stack B-OHM-R3	# 1	5.35	1.67	0.042	0.657	< 0.013	2.99
	# 2		1.68	0.041	0.656	< 0.013	2.96
Stack C-OHM-R1	# 1	5.54	2.09	0.074	0.249	< 0.013	3.13
	# 2		2.05	0.069	0.240	< 0.013	3.17
Stack C-OHM-R2	# 1	7.08	2.24	0.114	0.472	< 0.013	4.24
	# 2		2.19	0.113	0.472	< 0.013	4.31
Stack C-OHM-R3	# 1	6.19	1.82	0.091	0.515	< 0.013	3.74
	# 2		1.83	0.089	0.508	< 0.013	3.79
Stack D-OHM-R1	# 1	7.18	3.13	0.108	0.337	< 0.013	3.63
	# 2		3.14	0.108	0.342	< 0.013	3.57
Stack D-OHM-R2	# 1	7.59	3.32	0.126	0.292	< 0.013	3.80
	# 2		3.36	0.127	0.293	< 0.013	3.86
Stack D-OHM-R3	# 1	7.56	2.69	0.094	0.496	0.016	4.27
	# 2		2.71	0.093	0.490	0.015	4.25

Summary of Analysis

Reagent Blank - Summary of OHM Mercury Analysis

Run Number		Filter µg	FH Rinse µg	KCl µg	H_2O_2/HNO_3 µg	$KMnO_4$ µg	Hydroxylamine Hydrochloride µg
-----------------	-----	-------------	-------------	-------------	-------------	-------------	-------------
Reagent Blank	#1	< 0.005	< 0.03	< 0.06	< 0.013	< 0.025	< 0.025
	#2	< 0.005	< 0.03	< 0.06	< 0.013	< 0.025	< 0.025

ANALYTICAL NARRATIVE

Element One Analytical Narrative

Client:	Barr Engineering	Element One #:	28937
Client ID:	23/69-1843.00 LONG 002	Analyst:	LAW
Method:	OHM	Dates Received:	02/14 & 22/17
Analytes:	Hg	Dates Analyzed:	02/27-03/06/17

Summary of Analysis

The Ontario Hydro Method (OHM) samples were prepared and analyzed according to method protocol. Samples were analyzed for mercury on a PS Analytical Millennium Galahad CVAF analyzer mercury analyzer.

Ontario Hydro Mercury Catch Summary

The Ontario Hydro Method employs five different fractions to collect mercury in its various states in a flue gas stream. Particle-bound mercury is collected in the filter and front-half rinse. Oxidized mercury (Hg_2^{2+} and Hg^{2+}) is collected in the potassium chloride (KCl) fraction. The acidified hydrogen peroxide (H_2O_2/HNO_3) and potassium permanganate ($KMnO_4$) fractions are utilized to collect elemental mercury (Hg^0). Total mercury refers to all mercury, however generated or entrained, in the flue gas stream.

Detection Limits

The Ontario Hydro Method Millennium Galahad CVAF instrument reporting limit for mercury was 0.001 µg per aliquot analyzed, which is 0.05 µg/L for a 20 ml aliquot.

Analysis QA/QC

Duplicate analyses relative percent difference (RPD), triplicate analysis relative standard deviation (RSD), and spike sample recovery are summarized in the Quality Control Section. All QA/QC data was within the criteria of the method.

Additional Comments

The reported results have not been corrected for any blank values or spike recovery values. The reported results relate only to the items tested or calibrated.

QUALITY CONTROL SUMMARY

Summary of Quality Control Data

Mercury Duplicate Analysis RPD

(OHM QC limits: ±10% for RPD)

Run Number	Filter	FH Rinse	KCl	H_2O_2/HNO_3	$KMnO_4$	Hydroxylamine Hydrochloride
Stack A-OHM-R1	1.8%	8.1%	0.3%	13.3%	1.9%	---
Stack A-OHM-R2	0.2%	8.5%	0.7%	8.5%	2.3%	---
Stack A-OHM-R3	1.8%	4.2%	1.9%	NA	1.7%	---
Stack B-OHM-R1	2.5%	3.7%	2.0%	0.5%	3.1%	---
Stack B-OHM-R2	2.0%	1.4%	2.7%	NA	0.4%	---
Stack B-OHM-R3	0.2%	4.1%	0.2%	NA	1.0%	---
Stack C-OHM-R1	2.2%	6.8%	3.5%	NA	1.0%	---
Stack C-OHM-R2	2.1%	1.6%	0.1%	NA	1.7%	---
Stack C-OHM-R3	1.0%	2.1%	1.3%	NA	1.5%	---
Stack D-OHM-R1	0.1%	0.3%	1.4%	NA	1.7%	---
Stack D-OHM-R2	1.3%	0.6%	0.4%	NA	1.6%	---
Stack D-OHM-R3	0.4%	0.5%	1.2%	1.3%	0.6%	---
Reagent Blank	NA	NA	NA	NA	NA	NA

Mercury Triplicate Analysis RSD

(OHM QC limits: ±10% for RSD)

Run Number	Filter	FH Rinse	KCl	H_2O_2/HNO_3	$KMnO_4$
Stack A-OHM-R2	0.5%	6.3%	0.4%	4.9%	1.2%
Stack B-OHM-R2	1.9%	0.7%	1.3%	NA	0.8%
Stack C-OHM-R2	1.6%	0.9%	0.3%	NA	0.9%
Stack D-OHM-R2	0.8%	0.6%	0.5%	NA	0.8%

Mercury Spike Recoveries

(QC limits: 85%-115% for Spike Recoveries)

Run Number		Filter	FH Rinse	KCl	H2O2/HNO3	KMnO4
Stack A-OHM-R3	# 1	93%	114%	100%	90%	87%
	# 2	95%	114%	97%	89%	92%
Stack B-OHM-R3	# 1	91%	108%	102%	111%	103%
	# 2	92%	112%	108%	111%	102%
Stack C-OHM-R3	# 1	98%	107%	105%	108%	92%
	# 2	100%	110%	106%	108%	92%
Stack D-OHM-R3	# 1	103%	112%	110%	113%	95%
	# 2	102%	113%	112%	111%	92%

SAMPLE CUSTODY

Barr Engineering Co. Chain of Custody

BARR

Request for Laboratory Analytical Services

Sample Origination State:
☐ IA ☐ ND ☐ WI
☐ MI ☐ SD Other:
☒ MN ☐ WI

COC Number: **10121**

COC 1 of 5

Report Results To

Check One:

☐ **Barr Engineering Company**
3128 14th Avenue East
Hibbing, MN 55435-4803
(218) 262-8600

☒ **Barr Engineering Company**
5150 West 76th Street
Edina, MN 55439-2330
(952) 832-2600

Project Contact: B4W (Print Name) BAW@BARR.COM (email)

Send Invoice To

Project Number 23/69-1843.00 LONG 002

Barr Engineering Company
Attn: Accounts Payable
4300 Marketpointe Drive
Minneapolis, MN 55435-4803
Ph. (952) 832-2600 Fax (952) 832-2601

28937

Special instructions and/or specific regulatory requirements:
(method, limit of detection, etc.)
ONTARIO HYDRO Fibres/and FH Acetone will arrive in separate shipment after gravimetrics

Requested Due Date:
☒ Standard Turn Around Time
☐ Rush ______ (mm/dd/yyyy)

Sample Identification	Date/Time Collected	Media I.D. #	Type			METHOD						SAMPLE FRACTION									Total No. of Containers	Remarks
			Grab	Comp.	QC	ONTARIO HYDRO						FH 0.1N NITRIC	IMP 1-3 RINSE	IMP 4 RINSE	IMP 5-7 RINSE							
1. STACK A R1	02/08/17 1145	NA		X		X						1	1	1	1						4	
2. | R2	02/08/17 1500	|		|		|						1	1	1	1						4	
3. | R3	02/08/17 1830	|		|		|						1	1	1	1						4	
4. STACK B R1	02/09/17 1145	|		|		|						1	1	1	1						4	
5. | R2	02/09/17 1430	|		|		|						1	1	1	1						4	
6. | R3	02/09/17 1700	|		|		|						1	1	1	1						4	
7. STACK C R1	02/08/17 1200	|		|		|						1	1	1	1						4	
8. | R2	02/08/17 1515	|		|		|						1	1	1	1						4	
9. | R3	02/08/17 1730	|		|		|						1	1	1	1						4	
10.																						

Chain of Custody

Collected by (Print Name): BEN WILTSE
Collector's Signature: Date/Time: 2/9/17 2000
Laboratory: ELEMENT ONE
Method of Shipment: ☐ Sampler ☒ FedEx ☐ UPS Other:
Sample Condition upon Receipt: ☒ Acceptable ☐ Other (explain)
Samples received in good condition. No empty containers.

Relinquished by:	Received by:	Date/Time:
		2/13/17 12:30
Received at Lab by:		2-14-17 1050

Distribution: White-Original Accompanies Shipment to Lab; Yellow - Field Copy

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Version 2 - Created 06/01/14

W:\Business Units\EM\Subunit Admin\Technical & Support Services\Air Sampling\Datasheets\Other\COC V2.CDR RLG 05-18-16

Barr Engineering Co. Chain of Custody

BARR

Request for Laboratory Analytical Services

Sample Origination State:
☐ IA ☐ ND ☐ WI
☐ MI ☐ SD Other:
☒ MN ☐ WI

COC Number: **10122**

COC 2 of 5

Report Results To

Check One:

☐ **Barr Engineering Company**
3128 14th Avenue East
Hibbing, MN 55435-4803
(218) 262-8600

☒ **Barr Engineering Company**
5150 West 76th Street
Edina, MN 55439-2330
(952) 832-2600

Project Contact: BEN WILTSE (Print Name) B4W@BARR.COM (email)

Send Invoice To

Project Number 23/69-1843.00 LONG 002

Barr Engineering Company
Attn: Accounts Payable
4300 Marketpointe Drive
Minneapolis, MN 55435-4803
Ph. (952) 832-2600 Fax (952) 832-2601

28937

Special instructions and/or specific regulatory requirements:
(method, limit of detection, etc.)

ONTARIO HYDRO

Requested Due Date:
☒ Standard Turn Around Time
☐ Rush _______ (mm/dd/yyyy)

	Sample Identification	Date/Time Collected	Media I.D. #	Type			METHOD						SAMPLE FRACTION										Remarks
				Grab	Comp.	QC	ONTARIO HYDRO						FH 0.1N NITRIC	IMP 1-3 RINSE	IMP 4 RINSE	IMP 5-7 RINSE						Total No. of Containers	
1.	STACK D R1	02/09/17 1400	NA		X		|						1	1	1	1						4	
2.	| R2	02/09/17 1700	|		|		|						1	1	1	1						4	
3.	R3	02/09/17 1830											1	1	1	1						4	
4.																							
5.																							
6.																							
7.																							
8.																							
9.																							
10.																							

Chain of Custody

Collected by (Print Name): BEN WILTSE

Collector's Signature: Date/Time: 2/9/17 2000

Laboratory: ELEMENT ONE

Method of Shipment: ☐ Sampler ☒ FedEx ☐ UPS Other:

Sample Condition upon Receipt: ☒ Acceptable ☐ Other (explain)

Relinquished by:	Received by:	Date/Time:
		2/13/17 12:30

Received at Lab by: 2-14-17 1050

Distribution: White-Original Accompanies Shipment to Lab; Yellow - Field Copy

Version 2 - Created 06/01/14

Barr Engineering Co. Chain of Custody

Request for Laboratory Analytical Services

Sample Origination State:
☐ IA ☐ ND ☐ WI
☐ MI ☐ SD Other: ____
☒ MN ☐ WI

COC Number: **10123**
COC 3 of 5

Report Results To

Check One:

☐ **Barr Engineering Company**
3128 14th Avenue East
Hibbing, MN 55435-4803
(218) 262-8600

☐ **Barr Engineering Company**
5150 West 76th Street
Edina, MN 55439-2330
(952) 832-2600

Project Contact: BEN WITSE (Print Name) BAW@BARR.COM (email)

Send Invoice To

Project Number 23/69-184300 LONG 002

Barr Engineering Company
Attn: Accounts Payable
4300 Marketpointe Drive
Minneapolis, MN 55435-4803
Ph. (952) 832-2600 Fax (952) 832-2601

28937

Special instructions and/or specific regulatory requirements: (method, limit of detection, etc.)

ONTARIO HYDRO

Requested Due Date:
☐ Standard Turn Around Time
☐ Rush ____ (mm/dd/yyyy)

	Sample Identification	Date/Time Collected	Media I.D. #	Type: Grab	Type: Comp.	Type: QC	METHOD: ONTARIO HYDRO	METHOD	METHOD	METHOD	METHOD	METHOD	SAMPLE FRACTION: 0.1 N HNO3	SAMPLE FRACTION: KCL	SAMPLE FRACTION: 5% HNO3/10% H2O2	SAMPLE FRACTION: 4% KMNO4/10% H2SO4	SAMPLE FRACTION: Hydroxylamine	SAMPLE FRACTION: ~~Filter~~ *	SAMPLE FRACTION	SAMPLE FRACTION	SAMPLE FRACTION	Total No. of Containers	Remarks
1.	BLANKS	02/09/17 1500			X		X						1	1	1	1	1	~~1~~				~~6~~	5*
2.																							
3.																							
4.																							
5.																							
6.																							
7.																							
8.																							
9.																							
10.																							

Chain of Custody

Collected by (Print Name): BEN WILTSE
Collector's Signature: Date/Time: 2/9/17 2000
Laboratory: ELEMENT ONE
Method of Shipment: ☐ Sampler ☒ FedEx ☐ UPS Other: ____
Sample Condition upon Receipt: ☒ Acceptable ☐ Other (explain)

Relinquished by:	Received by:	Date/Time:
		2/13/17 12:30
Received at Lab by:		2-14-17 1050

Distribution: White-Original Accompanies Shipment to Lab; Yellow - Field Copy

Version 2 - Created 06/01/14

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* J4AZ 02/13/17

4 of 5

BARR

Request for Laboratory Analytical Services

№ 12729

LONG

Report Results To

Check One:

☒ **Barr Engineering Company**
4700 West 77th Street
Minneapolis, MN 55435-4803
(952) 832-2600

☒ ~~**Barr Engineering Company**~~
~~**7390 Ohms Lane**~~
~~**Edina, MN 55439-2330**~~
~~**(952) 832-2600**~~
5150 W 76th

Attention: BAW (Print Name) (Direct Phone No.)

Project Number 23/69-1843.00

Send Invoice To

Barr Engineering Company
4700 West 77th Street
Minneapolis, MN 55435-4803
Ph. (952) 832-2600 Fax (952) 832-2601

28937

Attention: (Print Name)

Special instructions and/or specific regulatory requirements:
(method, limit of detection, etc.)

Send to element one after analysis

Sample Identification		Date/Time Collected	Media I.D. #	Type			EPA Method 5	EPA Method 202										Filter	Acetone Rinse	Wet Catch	MECL $_2$R inse	Total No. of Containers	Remarks Beaker #
				Grab	Comp.	QC																	
1. STACK A	R1	02/09/17 1145 ~~1200~~ *	4Q0588		X		X											1	1			2	1001
2. │	R2	02/08/17 1500	4Q0599		│		│											1	1			2	1002
3. │	R3	02/08/17 1830	4Q0592		│		│											1	1			2	1003
4. STACK B	R1	02/09/17 1145	4Q0427		│		│											1	1			2	1004
5. │	R2	02/09/17 1430	4Q0574		│		│											1	1			2	1005
6. │	R3	02/09/17 1700	4Q0593		│		│											1	1			2	1006
7. STACK C	R1	02/08/17 1200	4Q0594		│		│											1	1			2	1007
8. │	R2	02/08/17 1515	4Q0595		│		│											1	1			2	1008
9. │	R3	02/08/17 1730	4Q0596		│		│											1	1			2	1009
10.																							

Chain of Custody

Collected by (Print Name): BEN WILTSE

Relinquished by: Ben Wiltse — Date/Time 2/13/17 11:00

Relinquished by: R Berg — Date/Time 2/21/17 1420

Method of Shipment: ☐ Sampler ☒ FedEx ☐ UPS Other: ______

Collectors Signature: ______ Date: 2/9/17

LABORATORY: Element One

Received by: R Berg Barr Eng. Co. — Date/Time 2/13/17 11:00

Received by: — Date/Time

Received at Lab by: Lisa B — Date/Time 2-22-17 1000

Sample Condition upon Receipt: ☒ Acceptable ☐ Other (explain)

Distribution: White-Original Accompanies Shipment to Lab; Yellow - Field Copy

#5+R 2

Rev. 03/01

\# 5 of 5

BARR

Request for Laboratory Analytical Services

№ 12730

LONG

Report Results To

Check One:

☐ *Barr Engineering Company*
4700 West 77th Street
Minneapolis, MN 55435-4803
(952) 832-2600

5150 W 76th
☒ ~~*Barr Engineering Company*~~
~~*7390 Ohms Lane*~~
~~*Edina, MN 55439-2330*~~
~~*(952) 832-2600*~~

Attention: BAW (Print Name) (Direct Phone No.)

Send Invoice To

Project Number 23/69-1843.00

28937

Barr Engineering Company
4700 West 77th Street
Minneapolis, MN 55435-4803
Ph. (952) 832-2600 Fax (952) 832-2601

Attention: (Print Name)

Special instructions and/or specific regulatory requirements:
(method, limit of detection, etc.)

Send to element one after analysis

	Sample Identification	Date/Time Collected	Media I.D. #	Type			EPA Method 5	EPA Method 202										Filter	Acetone Rinse	Wet Catch	MECL 2R inse	Total No. of Containers	Remarks
				Grab	Comp.	QC																	
1.	STACK D R1	02/09/17 1400	4Q0648		X		X											1	1			2	1010
2.	| R2	02/09/17 1700	4Q0544		|		|										1	1			2	1011
3.	| R3	02/09/17 1830	4Q0649		|		|										1	1			2	1012
4.																							
5.	BLANKS	02/08/17 1500	4Q0597		X		X											1	1			2	1013
6.																							
7.																							
8.																							
9.																							
10.																							

Chain of Custody

Collected by (Print Name): BEN WILTSE

Relinquished by: Ben Wiltse Date/Time 2/13/17 11:00

Relinquished by: KBerg Date/Time 2/21/17 1430

Method of Shipment: ☐ Sampler ☒ FedEx ☐ UPS Other:

Collectors Signature: Date: 2/9/17

LABORATORY:

Received by: KBerg Barr Eng. Co. Date/Time 2/13/17 11:00

Received by: Date/Time

Received at Lab by: Lisa Braten Date/Time 2-22-17 1000

Sample Condition upon Receipt: ☑ Acceptable ☐ Other (explain)

Distribution: White-Original Accompanies Shipment to Lab; Yellow - Field Copy

Rev. 03/01

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LABORATORY REPORT
FILTERABLE PARTICULATE MATTER RESULTS

CLIENT ArcelorMittal
PROJECT NO. 23/69-1843.00 LONG-200
TEST A
TEST DATE 3/28/2017
SOURCE ID Stack A SV014 - Longterm 2
SAMPLING LOCATION Stack
SAMPLES COLLECTED BY JAR2

AIR FILTERS: 4" Quartz **ANALYZED ON:** 3/30 **ANALYSIS PERFORMED BY** ROB

Run	Filter ID	Description	Gross Weight	Date/Time	Tare Weight	Date/Time	Uncorrected Net Mass (g)
R1	4Q0650	Gray particulate	0.7989	4/1/2017 18:54	0.7800	3/2/2017 10:17	0.01900
			0.7989	4/2/2017 15:36	0.7799	3/3/2017 10:49	
R2	4Q0654	Gray particulate	0.7980	4/1/2017 18:55	0.7785	3/2/2017 10:24	0.01958
			0.7981	4/2/2017 15:35	0.7785	3/3/2017 10:54	
R3	4Q0690	Gray particulate	0.8016	4/1/2017 18:57	0.7792	3/3/2017 11:32	0.02249
			0.8017	4/2/2017 15:34	0.7792	3/5/2017 21:08	
R0 Filter Blank	4Q0697	Gray particulate	0.7829	4/1/2017 19:12	0.7827	3/3/2017 11:40	0.00014
			0.7828	4/2/2017 15:12	0.7827	3/5/2017 21:17	

PROBE RINSE: ACETONE

Run	Beaker ID	Description	Gross Weight	Date/Time	Tare Weight	Date/Time	Uncorrected Net Mass (g)	Solvent Volume (ml)	Evidence of Sample Loss?
R1	1014	Black particulte	120.9470	4/1/2017 18:35	120.94252	2/13/2017 18:19	0.00465	120	No
			120.9470	4/2/2017 14:01	120.94233	3/5/2017 22:00			
					120.94234	3/30/2017 15:52			
R2	1015	Black particulte	127.3580	4/1/2017 18:36	127.35412	2/15/2017 14:49	0.00377	125	No
			127.3580	4/2/2017 14:06	127.35427	3/5/2017 21:58			
					127.35419	3/30/2017 15:53			
R3	1016	Black particulte	125.4527	4/1/2017 18:37	125.44854	2/15/2017 14:48	0.00395	140	No
			125.4528	4/2/2017 14:07	125.44887	3/5/2017 21:58			
					125.44879	3/30/2017 15:56			
R0 Reagent Blank	1026	Black particulte	96.7174	4/1/2017 18:51	96.71624	2/15/2017 15:09	0.00044	100	No
			96.7173	4/2/2017 14:19	96.71690	3/5/2017 21:49			
					96.71690	3/30/2017 17:05			

Results of Gravimetric Particulate Analysis
Indurating Furnace Stack A (SV014)
Test Date: March 28, 2017
Longterm 2

Method 5 Particulate Mass Determination

Inputs	Symbol	Units	Run 1	Run 2	Run 3	Blanks
Air Filter - Net Particulate Mass	M_{af}	g	0.01900	0.01958	0.02249	0.00014
Probe Wash - Net Residue Mass	M_{pw}	g	0.00465	0.00377	0.00395	0.00044
Probe Wash Volume	V_{pw}	ml	120	125	140	100
Calculations						
Probe Wash Blank Correction Amount $C_{pw} = V_{pw} \times M_{pw(blank)} \div V_{pw(blank)}$	C_{pw}	g	0.00053	0.00056	0.00062	
Probe Wash Final Mass $M_{pwf} = M_{pw} - C_{pw}$	M_{pwf}	g	0.00412	0.00321	0.00332	
Filterable Particulate Matter (PM) Mass $\mathbf{M_{PM} = M_{af} + M_{pwf}}$	$\mathbf{M_{PM}}$	**g**	**0.02311**	**0.02279**	**0.02581**	

LABORATORY REPORT
FILTERABLE PARTICULATE MATTER RESULTS

CLIENT ArcelorMittal
PROJECT NO. 23/69-1843.00 LONG-200
TEST B
TEST DATE 3/29/2017
SOURCE ID Stack B SV015 - Longterm 2
SAMPLING LOCATION Stack

SAMPLES COLLECTED BY JAR2

AIR FILTERS: 4" Quartz **ANALYZED ON:** 3/30 **ANALYSIS PERFORMED BY** ROB

Run	Filter ID	Description	Gross Weight	Date/Time	Tare Weight	Date/Time	Uncorrected Net Mass (g)
R1	4Q0691	Gray particulate	0.7998 0.7998	4/1/2017 18:58 4/2/2017 15:32	0.7819 0.7819	3/3/2017 11:34 3/5/2017 21:09	0.01795
R2	4Q0694	Gray particulate	0.7978 0.7978	4/1/2017 19:01 4/2/2017 15:31	0.7763 0.7762	3/3/2017 11:37 3/5/2017 21:12	0.02151
R3	4Q0695	Gray particulate	0.7976 0.7976	4/1/2017 19:02 4/2/2017 15:28	0.7769 0.7769	3/3/2017 11:37 3/5/2017 21:13	0.02072
R0 Filter Blank	4Q0697	Gray particulate	0.7829 0.7828	4/1/2017 19:12 4/2/2017 15:12	0.7827 0.7827	3/3/2017 11:40 3/5/2017 21:17	0.00014

PROBE RINSE: ACETONE

Run	Beaker ID	Description	Gross Weight	Date/Time	Tare Weight	Date/Time	Uncorrected Net Mass (g)	Solvent Volume (ml)	Evidence of Sample Loss?
R1	1017	Black particulte	128.9371 128.9371	4/1/2017 18:38 4/2/2017 14:08	128.93127 128.93130 128.93133	2/15/2017 14:46 3/5/2017 21:57 3/30/2017 16:01	0.00581	120	No
R2	1018	Black particulte	123.0330 123.0330	4/1/2017 18:39 4/2/2017 14:09	123.02777 123.02776 123.02794	2/15/2017 14:46 3/5/2017 21:56 3/30/2017 16:07	0.00515	135	No
R3	1019	Black particulte	122.4033 122.4033	4/1/2017 18:39 4/2/2017 14:10	122.39649 122.39695 122.39671	2/15/2017 15:28 3/5/2017 21:55 3/30/2017 16:10	0.00651	120	No
R0 Reagent Blank	1026	Black particulte	96.7174 96.7173	4/1/2017 18:51 4/2/2017 14:19	96.71624 96.71690 96.71690	2/15/2017 15:09 3/5/2017 21:49 3/30/2017 17:05	0.00044	100	No

Results of Gravimetric Particulate Analysis
Indurating Furnace Stack B (SV015)
Test Date: March 29, 2017
Longterm 2

Method 5 Particulate Mass Determination

Inputs	Symbol	Units	Run 1	Run 2	Run 3	Blanks
Air Filter - Net Particulate Mass	M_{af}	g	0.01795	0.02151	0.02072	0.00014
Probe Wash - Net Residue Mass	M_{pw}	g	0.00581	0.00515	0.00651	0.00044
Probe Wash Volume	V_{pw}	ml	120	135	120	100
Calculations						
Probe Wash Blank Correction Amount $C_{pw} = V_{pw} \times M_{pw(blank)} \div V_{pw(blank)}$	C_{pw}	g	0.00053	0.00060	0.00053	
Probe Wash Final Mass $M_{pwf} = M_{pw} - C_{pw}$	M_{pwf}	g	0.00527	0.00455	0.00597	
Filterable Particulate Matter (PM) Mass $\mathbf{M_{PM} = M_{af} + M_{pwf}}$	$\mathbf{M_{PM}}$	**g**	**0.02322**	**0.02605**	**0.02669**	

BARR

LABORATORY REPORT

FILTERABLE PARTICULATE MATTER RESULTS

CLIENT ArcelorMittal

PROJECT NO. 23/69-1843.00 LONG-200

TEST C

TEST DATE 3/28/2017

SOURCE ID Stack C SV016 - Longterm 2

SAMPLING LOCATION Stack

SAMPLES COLLECTED BY JAR2

AIR FILTERS: 4" Quartz **ANALYZED ON:** 3/30 **ANALYSIS PERFORMED BY** ROB

Run	Filter ID	Description	Gross Weight	Date/Time	Tare Weight	Date/Time	Uncorrected Net Mass (g)
R1	4Q0651	Gray particulate	0.7961	4/1/2017 19:03	0.7750	3/2/2017 10:21	0.02112
			0.7962	4/2/2017 15:25	0.7750	3/3/2017 10:52	
R2	4Q0653	Gray particulate	0.8029	4/1/2017 19:06	0.7806	3/2/2017 10:23	0.02225
			0.8029	4/2/2017 15:24	0.7807	3/3/2017 10:53	
R3	4Q0652	Gray particulate	0.7989	4/1/2017 19:08	0.7773	3/2/2017 10:21	0.02145
			0.7989	4/2/2017 15:23	0.7775	3/3/2017 10:52	
R0 Filter Blank	4Q0697	Gray particulate	0.7829	4/1/2017 19:12	0.7827	3/3/2017 11:40	0.00014
			0.7828	4/2/2017 15:12	0.7827	3/5/2017 21:17	

PROBE RINSE: ACETONE

Run	Beaker ID	Description	Gross Weight	Date/Time	Tare Weight	Date/Time	Uncorrected Net Mass (g)	Solvent Volume (ml)	Evidence of Sample Loss?
R1	1020	Black particulte	120.5493	4/1/2017 18:47	120.54066	2/15/2017 15:27	0.00865	115	No
			120.5494	4/2/2017 14:12	120.54076	3/5/2017 21:54			
					120.54066	3/30/2017 16:51			
R2	1021	Black particulte	127.3719	4/1/2017 18:41	127.36339	2/15/2017 15:25	0.00750	145	No
			127.3719	4/2/2017 14:13	127.36441	3/5/2017 21:53			
					127.36431	3/30/2017 16:54			
R3	1022	Black particulte	127.0840	4/1/2017 18:48	127.08086	2/15/2017 15:17	0.00300	95	No
			127.0841	4/2/2017 14:13	127.08106	3/5/2017 21:52			
					127.08107	3/30/2017 16:57			
R0 Reagent Blank	1026	Black particulte	96.7174	4/1/2017 18:51	96.71624	2/15/2017 15:09	0.00044	100	No
			96.7173	4/2/2017 14:19	96.71690	3/5/2017 21:49			
					96.71690	3/30/2017 17:05			

Results of Gravimetric Particulate Analysis
Indurating Furnace Stack C (SV016)
Test Date: March 28, 2017
Longterm 2

Method 5 Particulate Mass Determination

Inputs	Symbol	Units	Run 1	Run 2	Run 3	Blanks
Air Filter - Net Particulate Mass	M_{af}	g	0.02112	0.02225	0.02145	0.00014
Probe Wash - Net Residue Mass	M_{pw}	g	0.00865	0.00750	0.00300	0.00044
Probe Wash Volume	V_{pw}	ml	115	145	95	100
Calculations						
Probe Wash Blank Correction Amount $C_{pw} = V_{pw} \times M_{pw(blank)} \div V_{pw(blank)}$	C_{pw}	g	0.00051	0.00065	0.00042	
Probe Wash Final Mass $M_{pwf} = M_{pw} - C_{pw}$	M_{pwf}	g	0.00814	0.00686	0.00258	
Filterable Particulate Matter (PM) Mass $\mathbf{M_{PM} = M_{af} + M_{pwf}}$	$\mathbf{M_{PM}}$	**g**	**0.02926**	**0.02911**	**0.02403**	

LABORATORY REPORT

FILTERABLE PARTICULATE MATTER RESULTS

CLIENT ArcelorMittal
PROJECT NO. 23/69-1843.00 LONG-200
TEST D
TEST DATE 3/29/2017
SOURCE ID Stack D SV017 - Longterm 2
SAMPLING LOCATION Stack

SAMPLES COLLECTED BY JAR2

AIR FILTERS: 4" Quartz **ANALYZED ON:** 3/30 **ANALYSIS PERFORMED BY** ROB

Run	Filter ID	Description	Gross Weight	Date/Time	Tare Weight	Date/Time	Uncorrected Net Mass (g)
R1	4Q0692	Gray particulate	0.80642	4/1/2017 19:09	0.78331	3/3/2017 11:35	0.02318
			0.80652	4/2/2017 15:21	0.78328	3/5/2017 21:10	
R2	4Q0693	Gray particulate	0.80315	4/1/2017 19:10	0.78125	3/3/2017 11:36	0.02197
			0.80328	4/2/2017 15:19	0.78124	3/5/2017 21:11	
R3	4Q0696	Gray particulate	0.79406	4/1/2017 19:11	0.77181	3/3/2017 11:38	0.02223
			0.79402	4/2/2017 15:15	0.77180	3/5/2017 21:15	
R0 Filter Blank	4Q0697	Gray particulate	0.78290	4/1/2017 19:12	0.78274	3/3/2017 11:40	0.00014
			0.78280	4/2/2017 15:12	0.78268	3/5/2017 21:17	

PROBE RINSE: ACETONE

Run	Beaker ID	Description	Gross Weight	Date/Time	Tare Weight	Date/Time	Uncorrected Net Mass (g)	Solvent Volume (ml)	Evidence of Sample Loss?
R1	1023	Black particulte	126.12877	4/1/2017 18:42	126.12175	2/15/2017 15:16	0.00616	115	No
			126.12868	4/2/2017 14:14	126.12254	3/5/2017 21:51			
					126.12259	3/30/2017 17:01			
R2	1024	Black particulte	106.97100	4/1/2017 18:49	106.96593	2/15/2017 15:14	0.00486	165	No
			106.97088	4/2/2017 14:17	106.96608	3/5/2017 21:51			
					106.96607	3/30/2017 17:02			
R3	1025	Black particulte	127.20378	4/1/2017 18:50	127.19754	2/15/2017 15:12	0.00621	135	No
			127.20378	4/2/2017 14:18	127.19764	3/5/2017 21:50			
					127.19750	3/30/2017 17:03			
R0 Reagent Blank	1026	Black particulte	96.71743	4/1/2017 18:51	96.71624	2/15/2017 15:09	0.00044	100	No
			96.71726	4/2/2017 14:19	96.71690	3/5/2017 21:49			
					96.71690	3/30/2017 17:05			

Results of Gravimetric Particulate Analysis
Indurating Furnace Stack D (SV017)
Test Date: March 29, 2017
Longterm 2

Method 5 Particulate Mass Determination

Inputs	Symbol	Units	Run 1	Run 2	Run 3	Blanks
Air Filter - Net Particulate Mass	M_{af}	g	0.02318	0.02197	0.02223	0.00014
Probe Wash - Net Residue Mass	M_{pw}	g	0.00616	0.00486	0.00621	0.00044
Probe Wash Volume	V_{pw}	ml	115	165	135	100
Calculations						
Probe Wash Blank Correction Amount $C_{pw} = V_{pw} \times M_{pw(blank)} \div V_{pw(blank)}$	C_{pw}	g	0.00051	0.00073	0.00060	
Probe Wash Final Mass $M_{pwf} = M_{pw} - C_{pw}$	M_{pwf}	g	0.00565	0.00413	0.00561	
Filterable Particulate Matter (PM) Mass $\mathbf{M_{PM} = M_{af} + M_{pwf}}$	$\mathbf{M_{PM}}$	**g**	**0.02882**	**0.02610**	**0.02784**	

Barr Engineering Co. Chain of Custody

BARR **Request for Laboratory Analytical Services Particulate Testing**

Sample Origination State:
☐ IA ☐ ND ☐ WI
☐ MI ☐ SD Other: ____
☒ MN ☐ WI

COC Number: **20174**

COC 1 of 2

Report Results To

Check One:

☐ **Barr Engineering Company**
3128 14th Avenue East
Hibbing, MN 55435-4803
(218) 262-8600

☒ **Barr Engineering Company**
5150 West 76th Street
Edina, MN 55439-2330
(952) 832-2600

Project Contact: BAW (Print Name) ____ (email)

Send Invoice To

Project Number 23/69-1843.00 LONG 002

Barr Engineering Company
Attn: Accounts Payable
4300 Marketpointe Drive
Minneapolis, MN 55435-4803
Ph. (952) 832-2600 Fax (952) 832-2601

Special instructions and/or specific regulatory requirements:
(method, limit of detection, etc.)
Send to element one after analysis

Requested Due Date:
☒ Standard Turn Around Time
☐ Rush ____ (mm/dd/yyyy)

	Sample Identification		Date/Time Collected	Media I.D. #	Type: Grab	Type: Comp.	Type: QC	METHOD: EPA Method [✓ 5] or 17	METHOD: EPA Method 201A	METHOD: EPA Method 202	METHOD: EPA Method 202 (Pre Jan. 2011)	SAMPLE FRACTION: Probe Wash (>PM_{10})	SAMPLE FRACTION: Probe Wash (PM_{10}>$PM_{2.5}$)	SAMPLE FRACTION: Probe Wash (<$PM_{2.5}$)	SAMPLE FRACTION: Filter	SAMPLE FRACTION: Probe Wash (Acetone)	SAMPLE FRACTION: CPM #1 (H_2O)	SAMPLE FRACTION: CPM #2 (Hexane, Acetone)	SAMPLE FRACTION: CPM #3 (CPM Filter)	Total No. of Containers	Remarks
1.	Stack A	R1	03/28/17 1115	4Q0650		X		X							1	1				2	
2.	|	R2	03/28/17 1400	4Q0654		|		X							1	1				2	
3.	|	R3	03/28/17 1600	4Q0690		|		X							1	1				2	
4.	Stack B	R1	03/29/17 1100	4Q0691		|		X							1	1				2	
5.	|	R2	03/29/17 1330	4Q0694		|		X							1	1				2	
6.	|	R3	03/29/17 1600	4Q0695		|		X							1	1				2	
7.	Stack C	R1	03/28/17 1115	4Q0651		|		X							1	1				2	
8.	|	R2	03/28/17 1400	4Q0653		|		X							1	1				2	
9.	|	R3	03/28/17 1600	4Q0652		|		X							1	1				2	
10.																					

Chain of Custody

Collected by (Print Name): JOHN ROONEY

Collector's Signature: John R. Date/Time: 3/29/17 1700

Laboratory: BARR / ELEMENT ONE

Method of Shipment: ☒ Sampler ☒ FedEx ☐ UPS Other: ____

Sample Condition upon Receipt: ☐ Acceptable ☐ Other (explain)

Relinquished by:	Received by:	Date/Time:
	BARR	3/30/17 1212
Received at Lab by:		

Distribution: White-Original Accompanies Shipment to Lab; Yellow - Field Copy

Version 3 - Created 06/01/16

W:\Business Units\EM\Subunit Admin\Technical & Support Services\Air Sampling\Datasheets\Other\COC Particulate Testing V3.CDR RLG 05-18-16

Barr Engineering Co. Chain of Custody

Request for Laboratory Analytical Services Particulate Testing

Sample Origination State:
☐ IA ☐ ND ☐ WI
☐ MI ☐ SD Other:
☒ MN ☐ WI

COC Number: **20173**

COC 2 of 2

Report Results To

Check One:

☐ **Barr Engineering Company**
3128 14th Avenue East
Hibbing, MN 55435-4803
(218) 262-8600

☒ **Barr Engineering Company**
5150 West 76th Street
Edina, MN 55439-2330
(952) 832-2600

Project Contact: BAW (Print Name) (email)

Send Invoice To

Project Number 23/69-1843.00 LONG 002

Barr Engineering Company
Attn: Accounts Payable
4300 Marketpointe Drive
Minneapolis, MN 55435-4803
Ph. (952) 832-2600 Fax (952) 832-2601

Special instructions and/or specific regulatory requirements:
(method, limit of detection, etc.)

send to Element one after analysis

Requested Due Date:
☒ Standard Turn Around Time
☐ Rush ______ (mm/dd/yyyy)

				Type			METHOD				SAMPLE FRACTION									
	Sample Identification	Date/Time Collected	Media I.D. #	Grab	Comp.	QC	EPA Method ⑤ or 17	EPA Method 201A	EPA Method 202	EPA Method 202 (Pre Jan. 2011)	Probe Wash ($>PM_{10}$)	Probe Wash ($PM_{10} > PM_{2.5}$)	Probe Wash ($<PM_{2.5}$)	Filter	Probe Wash (Acetone)	CPM #1 (H_2O)	CPM #2 (Hexane, Acetone)	CPM #3 (CPM Filter)	Total No. of Containers	Remarks
1.	Stack D R1	3/29/17 1100	~~4Q0691~~ BARL 4Q0692		X		X							1	1				2	
2.	| R2	03/29/17 1330	4Q0693		|		X							1	1				2	
3.	R3	03/29/17 1600	4Q0696				X							1	1				2	
4.	Filter Blank	03/28/17 1300	4Q0697			X	X												1	
5.	Acetone Blank	03/28/17 1300	—			X	X												1	
6.																				
7.																				
8.																				
9.																				
10.																				

Chain of Custody

Collected by (Print Name): JOHN ROONEY

Collector's Signature: John R Date/Time: 3/29/17 1700

Laboratory: BARR/ELEMENT ONE

Method of Shipment: ☒ Sampler ☒ FedEx ☐ UPS Other: ______

Sample Condition upon Receipt: ☐ Acceptable ☐ Other (explain)

Relinquished by:	Received by:	Date/Time:
	R Berg BARR	3/30/17 1412
Received at Lab by:		

Distribution: White-Original Accompanies Shipment to Lab; Yellow - Field Copy

Version 3 - Created 06/01/16

W:\Business Units\EM\Subunit Admin\Technical & Support Services\Air Sampling\Datasheets\Other\COC Particulate Testing V3.CDR RLG 05-18-16

Barr Engineering

5150 W. 76th Street
Edina, MN 55439-2330

Project Number: 23/69-1843.00 LONG 002

Mercury

Ontario Hydro Method Analysis

Analytical Report
29227

el1
Element One, Inc.
6319-D Carolina Beach Rd., Wilmington, NC 28412
910-793-0128 FAX:910-792-6853 e1lab@e1lab.com

*Note: Analytical data on file at Barr and available upon request

The following data for Analytical Report 29227
has been reviewed for completeness, accuracy,
adherence to method protocol,
and compliance with quality assurance guidelines.

Review by:

Katie Strickland, B.S. Chemist
April 18, 2017

Report Reviewed and Finalized By:

Ken Smith, Laboratory Director
April 18, 2017

SUMMARY OF RESULTS

Summary of Analysis

Summary of OHM Mercury Analysis

Run Number		Average Total Catch, µg	Filter µg	FH Rinse µg	KCl µg	H_2O_2/HNO_3 µg	$KMnO_4$ µg
Stack A-OHM–R1	# 1	3.41	0.722	0.038	0.853	0.013	1.78
	# 2		0.724	0.035	0.857	0.014	1.78
Stack A-OHM–R2	# 1	3.10	0.412	< 0.01	0.883	0.013	1.79
	# 2		0.411	< 0.01	0.874	0.013	1.80
Stack A-OHM–R3	# 1	3.39	0.511	< 0.01	0.990	0.017	1.85
	# 2		0.511	< 0.01	1.00	0.017	1.87
Stack B-OHM–R1	# 1	3.63	1.10	< 0.01	0.550	0.021	1.96
	# 2		1.10	< 0.01	0.544	0.020	1.95
Stack B-OHM–R2	# 1	3.32	0.739	< 0.01	0.603	0.018	1.95
	# 2		0.749	< 0.01	0.597	0.018	1.97
Stack B-OHM–R3	# 1	3.33	0.895	0.015	0.579	0.022	1.82
	# 2		0.899	0.014	0.579	0.023	1.82
Stack C-OHM–R1	# 1	4.39	2.10	0.013	0.175	< 0.013	2.10
	# 2		2.10	0.012	0.171	< 0.013	2.11
Stack C-OHM–R2	# 1	4.34	1.82	0.049	0.283	0.014	2.18
	# 2		1.83	0.048	0.281	0.014	2.17
Stack C-OHM–R3	# 1	4.13	1.26	< 0.1	0.379	0.023	2.45
	# 2		1.27	< 0.1	0.375	0.023	2.49
Stack D-OHM–R1	# 1	4.12	1.52	0.038	0.157	0.021	2.38
	# 2		1.52	0.037	0.163	0.020	2.39
Stack D-OHM–R2	# 1	3.79	1.59	< 0.01	0.142	0.024	2.02
	# 2		1.59	< 0.01	0.142	0.026	2.04
Stack D-OHM–R3	# 1	3.90	1.62	0.01	0.149	0.019	2.10
	# 2		1.61	0.01	0.147	0.019	2.12
Field Blank	# 1	0.014	---	---	< 0.05	0.013	< 0.035
	# 2		---	---	< 0.05	0.014	< 0.035

Summary of Analysis

Reagent Blank Summary of OHM Mercury Analysis

Run Number		Filter µg	FH Rinse µg	KCl µg	H_2O_2/HNO_3 µg	$KMnO_4$ µg	Hydroxylamine Hydrochloride µg
-----------------	-----	-------------	-------------	-------------	-------------	-------------	-------------
Reagent Blank	#1	< 0.005	< 0.01	< 0.05	0.016	0.052	< 0.025
	#2	< 0.005	< 0.01	< 0.05	0.016	0.050	< 0.025

ANALYTICAL NARRATIVE

Element One Analytical Narrative

Client:	Barr Engineering	Element One #:	29227
Client ID:	23/69-1843.00 LONG 002	Analyst:	LAW & JBP
Method:	OHM	Dates Received:	04/04/17
Analytes:	Hg	Dates Analyzed:	04/07-13/17

Summary of Analysis

The Ontario Hydro Method (OHM) samples were prepared and analyzed according to method protocol. Samples were analyzed for mercury on a PS Analytical Millennium Galahad CVAF and PerkinElmer FIMS-100 CVAA analyzer mercury analyzer.

Ontario Hydro Mercury Catch Summary

The Ontario Hydro Method employs five different fractions to collect mercury in its various states in a flue gas stream. Particle-bound mercury is collected in the filter and front-half rinse. Oxidized mercury (Hg_2^{2+} and Hg^{2+}) is collected in the potassium chloride (KCl) fraction. The acidified hydrogen peroxide (H_2O_2/HNO_3) and potassium permanganate ($KMnO_4$) fractions are utilized to collect elemental mercury (Hg^0). Total mercury refers to all mercury, however generated or entrained, in the flue gas stream.

Detection Limits

The Ontario Hydro Method Millennium Galahad CVAF instrument reporting limit for mercury was 0.001 µg per aliquot analyzed, which is 0.05 µg/L for a 20 ml aliquot. The FIMS-100 CVAA instrument reporting limit for mercury was 0.004 µg per aliquot analyzed.

Analysis QA/QC

Duplicate analyses relative percent difference (RPD), triplicate analysis relative standard deviation (RSD), and spike sample recovery are summarized in the Quality Control Section.
*Ref. page 10; the sample spike recovery for Stack B-OHM-R3 H2O2/HNO3 fraction was slightly outside of laboratory guidelines of 85-115% with 84%. Sample was reanalyzed at a two-fold dilution resulting in 96% recovery.
All other QA/QC data was within the criteria of the method.

Additional Comments

The reported results have not been corrected for any blank values or spike recovery values. The reported results relate only to the items tested or calibrated.

QUALITY CONTROL SUMMARY

Summary of Quality Control Data

Mercury Duplicate Analysis RPD

(OHM QC limits: ≤ 10% for RPD)

Run Number	Filter	FH Rinse	KCl	H_2O_2/HNO_3	$KMnO_4$	Hydroxylamine Hydrochloride
Stack A-R1	0.3%	7.7%	0.5%	7.7%	0.0%	---
Stack A-R2	0.4%	NA	1.1%	4.6%	0.1%	---
Stack A-R3	0.0%	NA	1.0%	1.2%	1.2%	---
Stack B-R1	0.6%	NA	1.2%	5.8%	0.4%	---
Stack B-R2	1.4%	NA	0.9%	2.8%	0.8%	---
Stack B-R3	0.4%	6.1%	0.1%	5.7%	0.1%	---
Stack C-R1	0.4%	9.0%	2.7%	NA	0.2%	---
Stack C-R2	0.6%	2.9%	0.6%	1.5%	0.4%	---
Stack C-R3	0.4%	NA	1.2%	0.4%	1.4%	---
Stack D-R1	0.0%	1.1%	4.3%	7.9%	0.3%	---
Stack D-R2	0.3%	NA	0.1%	7.9%	1.2%	---
Stack D-R3	0.3%	0.7%	1.4%	1.1%	0.6%	---
Field Blank	---	---	NA	8.8%	NA	---
Reagent Blank	NA	NA	NA	2.5%	3.0%	NA

Mercury Triplicate Analysis RSD

(OHM QC limits: ≤ 10% for RSD)

Run Number	Filter	FH Rinse	KCl	H_2O_2/HNO_3	$KMnO_4$
Stack A-R2	0.6%	NA	1.1%	2.3%	0.3%
Stack B-R2	1.3%	NA	0.5%	2.0%	0.4%
Stack C-R2	0.4%	1.7%	0.4%	0.7%	1.2%
Stack D-R2	3.3%	NA	0.6%	4.9%	0.7%

Summary of Quality Control Data

Mercury Spike Recoveries

(QC limits: 85%-115% for Spike Recoveries)

Run Number		Filter	FH Rinse	KCl	H_2O_2/HNO_3	$KMnO_4$
Stack A-R3	# 1	90%	109%	106%	89%	95%
	# 2	90%	111%	107%	91%	96%
Stack B-R3	# 1	90%	105%	111%	84%*	95%
	# 2	90%	105%	112%	86%	95%
Stack C-R3	# 1	88%	93%	115%	90%	91%
	# 2	91%	93%	115%	91%	91%
Stack D-R3	# 1	99%	91%	112%	88%	95%
	# 2	101%	93%	113%	88%	97%

*See Analytical Narrative, page 7.

SAMPLE CUSTODY

29227

Barr Engineering Co. Chain of Custody

Request for Laboratory Analytical Services Particulate Testing

Sample Origination State:
☐ IA ☐ ND ☐ WI
☐ MI ☐ SD Other:
☒ MN ☐ WI

COC Number: **20174**
COC 1 of 2

Report Results To

Check One:

☐ **Barr Engineering Company**
3128 14th Avenue East
Hibbing, MN 55435-4803
(218) 262-8600

☒ **Barr Engineering Company**
5150 West 76th Street
Edina, MN 55439-2330
(952) 832-2600

Project Contact: BAW (Print Name) (email)

Send Invoice To

Project Number 23/69-1843.00 LONG 002

Barr Engineering Company
Attn: Accounts Payable
4300 Marketpointe Drive
Minneapolis, MN 55435-4803
Ph. (952) 832-2600 Fax (952) 832-2601

Special instructions and/or specific regulatory requirements:
(method, limit of detection, etc.)
Send to element one after analysis

Requested Due Date:
☒ Standard Turn Around Time
☐ Rush ______ (mm/dd/yyyy)

				Type			METHOD						SAMPLE FRACTION											
	Sample Identification	Date/Time Collected	Media I.D. #	Grab	Comp.	QC	EPA Method [✓ 5] or 17	EPA Method 201A	EPA Method 202	EPA Method 202 (Pre Jan. 2011)			Probe Wash ($>PM_{10}$)	Probe Wash ($PM_{10} > PM_{2.5}$)	Probe Wash ($<PM_{2.5}$)		Filter	Probe Wash (Acetone)	CPM #1 (H_2O)	CPM #2 (Hexane, Acetone)	CPM #3 (CPM Filter)	Total No. of Containers	Remarks
1.	Stack A R1	03/28/17 1115	4Q0650		X		X										1	1				2	1014
2.	| R2	03/28/17 1400	4Q0654		|		X										1	1				2	1015
3.	R3	03/28/17 1600	4Q0690		|		X										1	1				2	1016
4.	Stack B R1	03/29/17 1100	4Q0691		|		X										1	1				2	1017
5.	| R2	03/29/17 1330	4Q0694		|		X										1	1				2	1018
6.	R3	03/29/17 1600	4Q0695		|		X										1	1				2	1019
7.	Stack C R1	03/28/17 1115	4Q0651		|		X										1	1				2	1020
8.	| R2	03/28/17 1400	4Q0653		|		X										1	1				2	1021
9.	R3	03/28/17 1600	4Q0652		|		X										1	1				2	2022
10.																							

Chain of Custody

Collected by (Print Name): JOHN ROONEY
Collector's Signature: John Rooney Date/Time: 3/29/17 1700
Laboratory: BARR / ELEMENT ONE
Method of Shipment: ☒ Sampler ☒ FedEx ☐ UPS Other: ______
Sample Condition upon Receipt: ☒ Acceptable ☐ Other (explain)
Samples received in good condition. No empty container

Relinquished by:	Received by:	Date/Time:
	RBorg BARR	3/30/17 / 1112
RBorg		4/2/17 13:56
Received at Lab by: Lisa Bratten		4-4-17 1050

Distribution: White-Original Accompanies Shipment to Lab; Yellow - Field Copy

Version 3 - Created 06/01/16

W:\Business Units\EM\Subunit Admin\Technical & Support Services\Air Sampling\Datasheets\Other\COC Particulate Testing V3.CDR RLG 05-18-16

Barr Engineering Co. Chain of Custody

Request for Laboratory Analytical Services Particulate Testing

Sample Origination State:
☐ IA ☐ ND ☐ WI
☐ MI ☐ SD Other: ______
☒ MN ☐ WI

COC Number: **20173**
COC 2 of 2

Report Results To

Check One:

☐ **Barr Engineering Company**
3128 14th Avenue East
Hibbing, MN 55435-4803
(218) 262-8600

☒ **Barr Engineering Company**
5150 West 76th Street
Edina, MN 55439-2330
(952) 832-2600

Project Contact: BAW (Print Name) ______ (email)

Project Number 23/69-1843.00 LONG 002

Send Invoice To

Barr Engineering Company
Attn: Accounts Payable
4300 Marketpointe Drive
Minneapolis, MN 55435-4803
Ph. (952) 832-2600 Fax (952) 832-2601

Special instructions and/or specific regulatory requirements:
(method, limit of detection, etc.)
Send to Element One after analysis

Requested Due Date:
☒ Standard Turn Around Time
☐ Rush ______ (mm/dd/yyyy)

			Type			METHOD						SAMPLE FRACTION										
Sample Identification	Date/Time Collected	Media I.D. #	Grab	Comp.	QC	EPA Method 5 or 17	EPA Method 201A	EPA Method 202	EPA Method 202 (Pre Jan. 2011)			Probe Wash (>PM_{10})	Probe Wash (PM_{10} >$PM_{2.5}$)	Probe Wash (<$PM_{2.5}$)		Filter	Probe Wash (Acetone)	CPM #1 (H_2O)	CPM #2 (Hexane, Acetone)	CPM #3 (CPM Filter)	Total No. of Containers	Remarks Beaker IDs
1. Stack D R1	3/29/17 1100	~~4Q0691~~ SMRL 4Q0692		X		X										1	1				2	~~1014~~ 1023
2. R2	03/29/17 1330	4Q0693		|		X										1	1				2	~~1015~~ 1024
3. R3	03/29/17 1600	4Q0696		|		X										1	1				2	~~1016~~ 1025
4. Filter Blank	03/28/17 1300	4Q0697			X	X															1	
5. Acetone Blank	03/28/17 1300	—			X	X															1	1026
6.																						
7.																						
8.																						
9.																						
10.																						

Chain of Custody

Collected by (Print Name): JOHN ROONEY
Collector's Signature: John Rooney Date/Time: 3/29/17 1700
Laboratory: BARR / ELEMENT ONE
Method of Shipment: ☒ Sampler ☒ FedEx ☐ UPS Other: ______
Sample Condition upon Receipt: ☒ Acceptable ☐ Other (explain)

Relinquished by:	Received by:	Date/Time:
	BARR	3/30/17 1412
		4/2/17 1352

Received at Lab by: Lisa B

4-4-17 1050

Distribution: White-Original Accompanies Shipment to Lab; Yellow - Field Copy

Version 3 - Created 06/01/16

W:\Business Units\EM\Subunit Admin\Technical & Support Services\Air Sampling\Datasheets\Other\COC Particulate Testing V3.CDR RLG 05-18-16

29227

Barr Engineering Co. Chain of Custody

Request for Laboratory Analytical Services

Sample Origination State:
☐ IA ☐ ND ☐ WI
☐ MI ☐ SD Other: ______
☒ MN ☐ WI

COC Number: **10125**
COC 1 of 2

Report Results To

Check One:

☐ **Barr Engineering Company**
3128 14th Avenue East
Hibbing, MN 55435-4803
(218) 262-8600

☒ **Barr Engineering Company**
5150 West 76th Street
Edina, MN 55439-2330
(952) 832-2600

Project Contact: Ben Wiltse (Print Name) bwiltse@barr.com (email)

Send Invoice To

Project Number 23/69-1843.00 LONG 003

Barr Engineering Company
Attn: Accounts Payable
4300 Marketpointe Drive
Minneapolis, MN 55435-4803
Ph. (952) 832-2600 Fax (952) 832-2601

Special instructions and/or specific regulatory requirements: (method, limit of detection, etc.) Ontario Hydro
FH Samples will arrive in separate shipment.

Requested Due Date:
☒ Standard Turn Around Time
☐ Rush ______ (mm/dd/yyyy)

			Type			METHOD						SAMPLE FRACTION											
Sample Identification	Date/Time Collected	Media I.D. #	Grab	Comp.	QC	Ontario Hydro						FH 0.1 N HNO3	Imp. 1-3 Rinse	Imp. 4 Rinse	Imp. 5-7 Rinse							Total No. of Containers	Remarks
1. Stack A R1	03/28/17 1115	NA		X		X						1	1	1	1							4	
2. | R2	03/28/17 1400	|		|		X						1	1	1	1							4	
3. R3	03/28/17 1600					X						1	1	1	1							4	
4. Stack B R1	03/29/17 1100					X						1	1	1	1							4	
5. | R2	03/29/17 1330					X						1	1	1	1							4	
6. R3	03/29/17 1600					X						1	1	1	1							4	
7. Stack C R1	03/28/17 1115					X						1	1	1	1							4	
8. | R2	03/28/17 1400					X						1	1	1	1							4	
9. R3	03/28/17 1600					X						1	1	1	1							4	
10.																							

Chain of Custody

Collected by (Print Name): BEN WILTSE
Collector's Signature: Julia [illegible] Date/Time: 03/29/17 1600
Laboratory: ELEMENT ONE
Method of Shipment: ☐ Sampler ☒ FedEx ☐ UPS Other: ______
Sample Condition upon Receipt: ☒ Acceptable ☐ Other (explain)

Relinquished by:	Received by:	Date/Time:
Julia [illegible]	Pete Lamula	04/03/17 1000
Pete Lamula		04/03/17 1645
Received at Lab by:		4-4-17 1050

Distribution: White-Original Accompanies Shipment to Lab; Yellow - Field Copy

Version 2 - Created 06/01/14

W:\Business Units\EM\Subunit Admin\Technical & Support Services\Air Sampling\Datasheets\Other\COC V2.CDR RLG 05-18-16

29227

Barr Engineering Co. Chain of Custody

Request for Laboratory Analytical Services

Sample Origination State:
☐ IA ☐ ND ☐ WI
☐ MI ☐ SD Other:
☒ MN ☐ WI

COC Number: **10126**
COC 2 of 2

Report Results To

Check One:

☐ Barr Engineering Company
3128 14th Avenue East
Hibbing, MN 55435-4803
(218) 262-8600

☒ Barr Engineering Company
5150 West 76th Street
Edina, MN 55439-2330
(952) 832-2600

Project Contact: Ben Wiltse (Print Name) bwiltse@barr.com (email)

Send Invoice To

Project Number 26/69-1843.00 LONG 002

Barr Engineering Company
Attn: Accounts Payable
4300 Marketpointe Drive
Minneapolis, MN 55435-4803
Ph. (952) 832-2600 Fax (952) 832-2601

Special instructions and/or specific regulatory requirements: (method, limit of detection, etc.) Ontario Hydro
FH samples will arrive in separate shipment.

Requested Due Date:
☒ Standard Turn Around Time
☐ Rush ______ (mm/dd/yyyy)

	Sample Identification	Date/Time Collected	Media I.D. #	Type: Grab	Type: Comp.	Type: QC	METHOD: Ontario Hydro						SAMPLE FRACTION: FH 0.1 N HNO3	Imp. 1-3 Rinse	Imp 4 Rinse	Imp 5-7 Rinse						Total No. of Containers	Remarks
1.	Stack D R1	03/29/17 1100	NA		X		X						1	1	1	1						4	
2.	| R2	03/29/17 1330	|		|		X						1	1	1	1						4	
3.	R3	03/29/17 1600	|		|		X						1	1	1	1						4	
4.	Field Blank	03/28/17 13:00	|		|		X						1	1	1	1						4	Did not receive FH 0.1 N HNO3 4.4.17
5.	Blank 0.1 N HNO3	|	|			X	X															1	
6.	Blank KCl	|	|			X	X															1	
7.	Blank 5% HNO3/10% H2O2	|	|			X	X															1	
8.	Blank 4% KMnO4/10% H2SO4	|	|			X	X															1	
9.	Blank Hydroxylamine	↓	↓			X	X															1	
10.																							

Chain of Custody

Collected by (Print Name): BEN WILTSE
Collector's Signature: Date/Time: 03/29/17 16:00
Laboratory: ELEMENT ONE
Method of Shipment: ☐ Sampler ☒ FedEx ☐ UPS Other:
Sample Condition upon Receipt: ☒ Acceptable ☐ Other (explain)

Relinquished by:	Received by:	Date/Time:
	Pete Lamb	04/03/17 1000
Pete Lamb		04/03/17 1245
Received at Lab by:		4-4-17 1050

Distribution: White-Original Accompanies Shipment to Lab; Yellow - Field Copy

W:\Business Units\EM\Subunit Admin\Technical & Support Services\Air Sampling\Datasheets\Other\COC V2.CDR RLG 05-18-16

Version 2 - Created 06/01/14

Sorbent Trap Analysis Report

Plant: Barr Engineering
Project Number: 2010076
Contact: Ben Wiltse
Phone: 651.278.2196
Turn-around: Expedited Compliance
Email: bwiltse@gmail.com

Date: 4/21/2017
Analyst(s): Alejandra Ng-Feng
Method: EPA 7473
Method Uncertainty: ± 10%

Trap ID	AGS Mass (ng)	Section 1 Mass (ng)	Section 2 Mass (ng)	Total Mass (ng)[1]	Section 3 Mass (ng)	Spike Level (ng)	Breakthrough (%)[2]	Spike Recovery (%)[3]	Source	Notes
OLC043081		39.4	4.4	**43.8**			11.17%		Stack A R1	
OL411154		83.5	4.5	**88.0**		50	5.39%		Stack A R1	
OLC043452		33.6	3.3	**36.9**			9.82%		Stack A R2	
OL411134		79.8	2.6	**82.4**		50	3.26%		Stack A R2	
OLC043076		42.3	4.7	**47.0**			11.11%		Stack A R3	
OL411192		83.0	4.4	**87.4**		50	5.30%		Stack A R3	
OLC043153		43.8	3.3	**47.1**			7.53%		Stack B R1	
OL411174		89.8	3.2	**93.0**		50	3.56%		Stack B R1	
OLC043415		43.9	2.8	**46.7**			6.38%		Stack B R2	
OL411166		85.4	3.6	**89.0**		50	4.22%		Stack B R2	
OLC043121		41.1	2.8	**43.9**			6.81%		Stack B R3	
OL411193		86.6	3.3	**89.9**		50	3.81%		Stack B R3	
OLC043459		53.4	1.0	**54.4**			1.88%		Stack C R1	
OL411122		107.7	1.0	**108.7**		50	0.92%		Stack C R1	
OL413031		62.9	1.2	**64.1**			1.85%		Stack C R2	
OL411171		115.6	1.6	**117.2**		50	1.37%		Stack C R2	
OLC043422		71.6	1.4	**73.0**			1.89%		Stack C R3	
OL411153		112.7	0.9	**113.6**		50	0.76%		Stack C R3	

MDL = 0.24 ng	LOQ = 2 ng

[1] Total Mass = PF+AGS+S1+S2

[2] Breakthrough = S2 / (PF+AGS+S1)

[3] Spike Recovery = S3 / Spike Level
For PS-12B Only

R = Data invalidation qualifier. Refer to notes

Sorbent Trap Analysis Report

Project Number: 2010076 p2

Turn-around: Expedited Compliance

Plant: Barr Engineering

Contact: Ben Wiltse

Phone: 651.278.2196

Email: bwiltse@gmail.com

Date: 4/21/2017

Analyst(s): Alejandra Ng-Feng

Method: EPA 7473

Method Uncertainty: ± 10%

Trap ID	AGS Mass (ng)	Section 1 Mass (ng)	Section 2 Mass (ng)	Total Mass (ng)[1]	Section 3 Mass (ng)	Spike Level (ng)	Breakthrough (%)[2]	Spike Recovery (%)[3]	Source	Notes
OLC043472		81.3	0.7	**82.0**			0.91%		Stack D R1	
OL411172		134.1	1.1	**135.2**		50	0.79%		Stack D R1	
OLC043364		73.6	1.0	**74.6**			1.31%		Stack D R2	tip of trap broken
OL411102		126.7	1.5	**128.2**		50	1.16%		Stack D R2	
OL413042		80.2	1.0	**81.2**			1.29%		Stack D R3	
OL411132		130.5	1.0	**131.5**		50	0.80%		Stack D R3	

MDL = 0.24 ng	LOQ = 2 ng

[1] Total Mass = PF+AGS+S1+S2

[2] Breakthrough = S2 / (PF+AGS+S1)

[3] Spike Recovery = S3 / Spike Level

For PS-12B Only

R = Data invalidation qualifier. Refer to notes

Barr Engineering

Date: April 21, 2017

Analyst: Alejandra Ng-Feng	**Temperature (°C):** 680
File Name: 170421_ANF_BarrEngineering	**Flow Rate (L/min):** 1.00
Analyzer: 140	**MDL (ng):** 0.24
Cell type: Medium	**SD:** 2.0

	ID #	PF Mass (ng)	AGS Mass (ng)	Section 1 Mass (ng)	Section 2 Mass (ng)	Section 3 Mass (ng)	Section 4 Mass (ng)	Spike Level (ng)	Source:	Notes:
1	OLC043081			39.4	4.4				Stack A R1	
2	OL411154			83.5	4.5			50	Stack A R1	
3	OLC043452			33.6	3.3				Stack A R2	
4	OL411134			79.8	2.6			50	Stack A R2	
5	OLC043076			42.3	4.7				Stack A R3	
6	OL411192			83.0	4.4			50	Stack A R3	
7	OLC043153			43.8	3.3				Stack B R1	
8	OL411174			89.8	3.2			50	Stack B R1	
9	OLC043415			43.9	2.8				Stack B R2	
10	OL411166			85.4	3.6			50	Stack B R2	
11	OLC043121			41.1	2.8				Stack B R3	
12	OL411193			86.6	3.3			50	Stack B R3	
13	OLC043459			53.4	1.0				Stack C R1	
14	OL411122			107.7	1.0			50	Stack C R1	
15	OL413031			62.9	1.2				Stack C R2	
16	OL411171			115.6	1.6			50	Stack C R2	
17	OLC043422			71.6	1.4				Stack C R3	
18	OL411153			112.7	0.9			50	Stack C R3	
19										
20										

Additional Notes: all front plugs slightly pink

Daily Calibration*		
Lot # Std.	Std. (ng)	Calculated (ng)
K2-MEB603126 B	2.0	*see cal. report*
K2-MEB603126 B	5.0	*see cal. report*
K2-MEB631041 B	50.0	*see cal. report*
K2-MEB631041 B	100.0	*see cal. report*
K2-HG650192 B	500.0	*see cal. report*
K2-HG650192 B	1000.0	*see cal. report*
		see cal. report

Continuing Calibration Verifications****		
Lot # Std.	Std. (ng)	Calculated (ng)
K2-MEB631041 B	100.0	98.1
OL407281	75.0	74.1
OL407176	50.0	49.9
K2-MEB631041 B	100.0	97.6
OL387128	100.0	99.9

Active Hg Standard Bank*****		
Concentration (µg/mL)	Lot #/Bottle ID	Exp. Date
0.1	K2-MEB603126 B	10/31/2017
1	K2-MEB631041 B	4/17/2018
10	K2-HG650192 B	11/10/2017
100	K2-MEB631040 B	4/17/2018
1000	J2-HG02133	5/24/2017
0.1	K2-MEB603126 A	10/31/2017
1	K2-MEB631041 A	4/17/2018
10	K2-HG650192 A	4/17/2018
100	K2-MEB631040 A	7/6/2017
1 (Independent)	K2-HG02144	4/17/2018
10 (Independent)	J2-MEB600156	10/31/2017
100 (Independent)	K2-MEB631050	4/17/2018

Independent Calibration Verification**		
Lot # Std.	Std. (ng)	Calculated (ng)
K2-HG02144	50.0	51.6

Response Factor (Method 30B Only)***		
Lot # Std.	Std. (ng)	(area count/mass)
K2-MEB603126 B	1.0	390
RF Pipette ID (if different from cal):		L3

*Performed daily prior to analysis of sorbent traps, Refer to SOP for Instrument Calibration for acceptance criteria

**Performed immediately after calibration curve is verified, must come within 10% of expected value

***Response factor value must fall between the LOQ and MDL

****Performed between every 10 samples and every analytical batch

*****Subject to change, for analyst convenience only

Pipette Identification
AB

Immediately report any QA/QC failures or anything suspicious to the QA/QC Manager

OHIO LUMEX

Analyst Signature:

By signing this report I confirm that the above data are true to the best of my knowledge.

Date: 04.21.17

Barr Engineering **Date: April 21, 2017**

Analyst: Alejandra Ng-Feng
File Name: 170421_ANF_BarrEngineering_2
Analyzer: 140
Cell type: Medium

Temperature (°C): 680
Flow Rate (L/min): 1.00
MDL (ng): 0.24
SD: 2.0

	ID #	PF Mass (ng)	AGS Mass (ng)	Section 1 Mass (ng)	Section 2 Mass (ng)	Section 3 Mass (ng)	Section 4 Mass (ng)	Spike Level (ng)	Source:	Notes:
1	OLC043472			81.3	0.7				Stack D R1	
2	OL411172			134.1	1.1			50	Stack D R1	
3	OLC043364			73.6	1.0				Stack D R2	tip of trap broken
4	OL411102			126.7	1.5			50	Stack D R2	
5	OL413042			80.2	1.0				Stack D R3	
6	OL411132			130.5	1.0			50	Stack D R3	
7										
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										

Additional Notes: all front plugs slightly pink

Daily Calibration*		
Lot # Std.	**Std. (ng)**	**Calculated (ng)**
K2-MEB603126 B	2.0	*see cal. report*
K2-MEB603126 B	5.0	*see cal. report*
K2-MEB631041 B	50.0	*see cal. report*
K2-MEB631041 B	100.0	*see cal. report*
K2-HG650192 B	500.0	*see cal. report*
K2-HG650192 B	1000.0	*see cal. report*
		see cal. report

Independent Calibration Verification**		
Lot # Std.	**Std. (ng)**	**Calculated (ng)**
K2-HG02144	50.0	51.6

Response Factor (Method 30B Only)***		
Lot # Std.	**Std. (ng)**	**(area count/mass)**
K2-MEB603126 B	1.0	390
RF Pipette ID (if different from cal):		L3

Immediately report any QA/QC failures or anything suspicious to the QA/QC Manager

Continuing Calibration Verifications****		
Lot # Std.	**Std. (ng)**	**Calculated (ng)**
OL407253	25.0	23.9
OL407481	25.0	24.1

*Performed daily prior to analysis of sorbent traps, Refer to SOP for Instrument Calibration for acceptance criteria

**Performed immediately after calibration curve is verified, must come within 10% of expected value

***Response factor value must fall between the LOQ and MDL

****Performed between every 10 samples and every analytical batch

*****Subject to change, for analyst convenience only

Active Hg Standard Bank*****		
Concentration (µg/mL)	**Lot #/Bottle ID**	**Exp. Date**
0.1	K2-MEB603126 B	10/31/2017
1	K2-MEB631041 B	4/17/2018
10	K2-HG650192 B	11/10/2017
100	K2-MEB631040 B	4/17/2018
1000	J2-HG02133	5/24/2017
0.1	K2-MEB603126 A	10/31/2017
1	K2-MEB631041 A	4/17/2018
10	K2-HG650192 A	4/17/2018
100	K2-MEB631040 A	7/6/2017
1 (Independent)	K2-HG02144	4/17/2018
10 (Independent)	J2-MEB600156	10/31/2017
100 (Independent)	K2-MEB631050	4/17/2018

Pipette Identification
AB

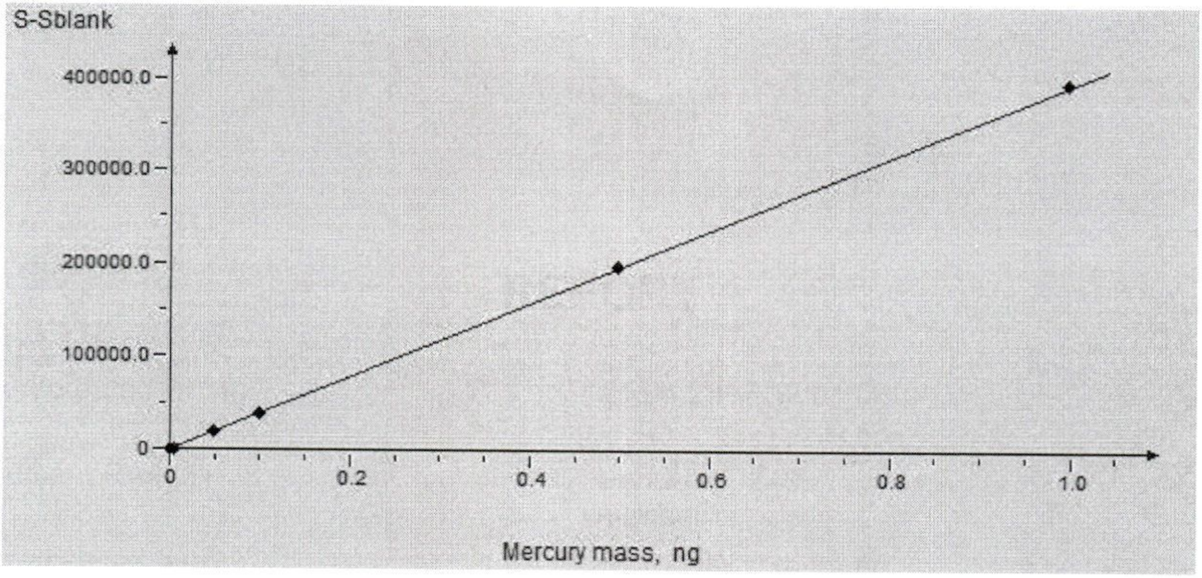
Analyst Signature:

By signing this report I confirm that the above data are true to the best of my knowledge.

Date: 04.21.17

REPORT

Report created	21.04.2017 12:51:08
Instrument RA915+	Serial number 140
Calibration created	21.04.2017 10:18:00
Calibration name	170421_ANS_2-1000



Results

N	Mercury mass, ng	S-Sblank	Ref.data, ng/g	Calculated, ng/g	d, %
1	1.00	397800	1000.0	1008.4	0.8
2	0.50	198500	500.0	503.2	0.6
3	0.10	39060	100.0	99.0	-1.0
4	0.05	19650	50.0	49.8	-0.4
5	0.01	1952	5.0	4.9	-1.1
6	0.00	796	2.0	2.0	0.9

Calibration	S - Sblank = a·m
Algorithm	WLSM
Correlation coefficient	0.999998
Residual standard deviation	2.848819

Appendix D

Calibration Data

BARR

Routine Dry Gas Meter Calibration

Control Module:	C-7	Leak checks			Barometric Press. --	29.61
Date:	12/09/16	Negative	pass	>5 W.C.	Previous Y --	1.0135
Technician:	JAR2	Positive -	pass	> in.Hg	Previous Delta H --	1.8250

Orifice Diff Pressure H	Wet Test Volume, Ft^3	Dry Gas Meter Temp, F		Wet Test Meter Temp, F	Dry Gas Volume Ft^3	Elapsed Time of Cal. Point		Meter Coefficient Y	Orifice Coefficient dH@
		Inlet	Outlet						
Nominal 0.500	Initial 2445.00	Initial 75.0	Initial 68.0	Initial 70.0	Initial 765.400				
Actual	Final 2452.00	Final 75.0	Final 70.0	Final 70.0	Final 772.290	Minutes 17	SEC 3.25		
0.50	Total 7.00	Average 75.0	Average 69.0	Average 70.0	Total 6.890	Minutes 17.05		1.0185	1.6871
		72.0							
Nominal 1.000	Initial 2453.00	Initial 76.0	Initial 70.0	Initial 70.0	Initial 773.260				
Actual	Final 2458.00	Final 77.0	Final 71.0	Final 70.0	Final 778.160	Minutes 8.0	SEC 52.81		
1.00	Total 5.00	Average 76.5	Average 70.5	Average 70.0	Total 4.900	8.88		1.0246	1.7881
		73.5	Tm						
Nominal 2.000	Initial 2438.00	Initial 72.0	Initial 67.0	Initial 70.0	Initial 758.570				
Actual	Final 2443.00	Final 75.0	Final 68.0	Final 70.0	Final 763.460	Minutes 6	SEC 22.29		
2.00	Total 5.00	Average 73.5	Average 67.5	Average 70.0	Total 4.890	6.37		1.0184	1.8515
		70.5	Tm						
Nominal 3.000	Initial 2560.00	Initial 79.0	Initial 71.0	Initial 70.0	Initial 780.100				
Actual	Final 2565.00	Final 81.0	Final 72.0	Final 70.0	Final 785.020	Minutes 5.0	SEC 19.71		
3.00	Total 5.00	Average 80.0	Average 71.5	Average 70.0	Total 4.920	5.33		1.0197	1.9278
		75.8	Tm						
Nominal 4.000	Initial 2470.00	Initial 83.0	Initial 73.0	Initial 70.0	Initial 789.980				
Actual	Final 2480.00	Final 84.0	Final 74.0	Final 70.0	Final 799.990	Minutes 9.0	SEC 10.31		
4.00	Total 10.00	Average 83.5	Average 73.5	Average 70.0	Total 10.010	9.17		1.0050	1.8968
		78.5	Tm			**Average**		**1.0173**	**1.8303**

Routine Dry Gas Meter Calibration

Control Module:	C-8	Leak checks			Barometric Press. --	29.22
Date:	03/23/17	Negative	Pass	>5 W.C.	Previous Y --	1.0040
Technician:	RMP	Positive -	Pass	> in.Hg	Previous Delta H --	1.9144

Orifice Diff Pressure H	Wet Test Volume, Ft^3	Dry Gas Meter Temp, F		Wet Test Meter Temp, F	Dry Gas Volume Ft^3	Elapsed Time of Cal. Point		Meter Coefficient Y	Orifice Coefficient dH@
		Inlet	Outlet						
Nominal	Initial	Initial	Initial	Initial	Initial				
0.500	3702.00	79.0	74.0	71.5	682.850				
Actual	Final	Final	Final	Final	Final	Minutes	SEC		
	3708.00	77.0	74.0	71.5	688.850	15	17.79		
0.50	Total	Average	Average	Average	Total	Minutes			
	6.00	78.0	74.0	71.5	6.000	15.30		1.0072	1.8651
		76.0							
Nominal	Initial	Initial	Initial	Initial	Initial				
1.000	3695.00	84.0	74.0	72.0	675.820				
Actual	Final	Final	Final	Final	Final	Minutes	SEC		
	3701.00	80.0	74.0	72.0	681.840	10.0	47.43		
1.00	Total	Average	Average	Average	Total				
	6.00	82.0	74.0	72.0	6.020	10.79		1.0054	1.8597
		78.0	Tm						
Nominal	Initial	Initial	Initial	Initial	Initial				
2.000	3668.00	80.0	71.0	72.0	648.820				
Actual	Final	Final	Final	Final	Final	Minutes	SEC		
	3676.00	81.0	72.0	72.0	656.800	10	34.31		
2.00	Total	Average	Average	Average	Total				
	8.00	80.5	71.5	72.0	7.980	10.57		1.0050	2.0177
		76.0	Tm						
Nominal	Initial	Initial	Initial	Initial	Initial				
3.000	3677.00	82.0	72.0	72.0	657.800				
Actual	Final	Final	Final	Final	Final	Minutes	SEC		
	3683.00	83.0	73.0	72.0	663.800	6.0	24.78		
3.00	Total	Average	Average	Average	Total				
	6.00	82.5	72.5	72.0	6.000	6.41		1.0028	1.9762
		77.5	Tm						
Nominal	Initial	Initial	Initial	Initial	Initial				
4.000	3684.00	83.0	73.0	72.0	664.810				
Actual	Final	Final	Final	Final	Final	Minutes	SEC		
	3694.00	85.0	74.0	72.0	674.820	9.0	14.59		
4.00	Total	Average	Average	Average	Total				
	10.00	84.0	73.5	72.0	10.010	9.24		1.0016	1.9668
		78.8	Tm			**Average**		**1.0044**	**1.9371**

BARR

Routine Dry Gas Meter Calibration

Control Module:	C-9	Leak checks			Barometric Press. --	29.64
Date:	03/22/17	Negative	Pass	>5 W.C.	Previous Y --	1.0054
Technician:	RMP	Positive -	Pass	> in.Hg	Previous Delta H --	1.9374

Orifice Diff Pressure H	Wet Test Volume, Ft³	Dry Gas Meter Temp, F		Wet Test Meter Temp, F	Dry Gas Volume Ft^3	Elapsed Time of Cal. Point		Meter Coefficient Y	Orifice Coefficient dH@
		Inlet	Outlet						
Nominal	Initial	Initial	Initial	Initial	Initial				
0.500	3612.00	76.0	70.0	71.5	833.910				
Actual	Final	Final	Final	Final	Final	Minutes	SEC		
	3618.00	77.0	72.0	72.0	839.880	15	28.06		
0.50	Total	Average	Average	Average	Total	Minutes			
	6.00	76.5	71.0	71.8	5.970	15.47		1.0076	1.8924
		73.8							
Nominal	Initial	Initial	Initial	Initial	Initial				
1.000	3603.00	80.0	71.0	71.5	824.970				
Actual	Final	Final	Final	Final	Final	Minutes	SEC		
	3611.00	77.0	71.0	71.5	832.910	14.0	39.09		
1.00	Total	Average	Average	Average	Total				
	8.00	78.5	71.0	71.5	7.940	14.65		1.0112	1.9084
		74.8	Tm						
Nominal	Initial	Initial	Initial	Initial	Initial				
2.000	3576.00	75.0	65.0	72.0	798.450				
Actual	Final	Final	Final	Final	Final	Minutes	SEC		
	3584.00	78.0	67.0	72.0	806.320	10	28.09		
2.00	Total	Average	Average	Average	Total				
	8.00	76.5	66.0	72.0	7.870	10.47		1.0101	1.9707
		71.3	Tm						
Nominal	Initial	Initial	Initial	Initial	Initial				
3.000	3585.00	79.0	68.0	72.0	807.300				
Actual	Final	Final	Final	Final	Final	Minutes	SEC		
	3590.00	79.0	68.0	72.0	812.220	5.0	24.91		
3.00	Total	Average	Average	Average	Total				
	5.00	79.0	68.0	72.0	4.920	5.42		1.0116	2.0173
		73.5	Tm						
Nominal	Initial	Initial	Initial	Initial	Initial				
4.000	3591.00	79.0	68.0	72.0	813.200				
Actual	Final	Final	Final	Final	Final	Minutes	SEC		
	3601.00	82.0	70.0	71.5	823.000	9.0	21.53		
4.00	Total	Average	Average	Average	Total				
	10.00	80.5	69.0	71.8	9.800	9.36		1.0161	2.0028
		74.8 Tm				**Average**		**1.0113**	**1.9583**

Routine Dry Gas Meter Calibration

Control Module:	C-10	Leak checks			Barometric Press. -- 29.35
Date:	12/02/16	Negative	0.0	>5 W.C.	Previous Y -- 0.9893
Technician:	DAH	Positive -	0.0	> in.Hg	Previous Delta H -- 1.8944

Orifice Diff Pressure H	Wet Test Volume, Ft³	Dry Gas Meter Temp, F		Wet Test Meter Temp, F	Dry Gas Volume Ft³	Elapsed Time of Cal. Point		Meter Coefficient Y	Orifice Coefficient dH@
		Inlet	Outlet						
Nominal	Initial	Initial	Initial	Initial	Initial				
0.500	2329.50	81.0	76.0	74.0	415.160				
Actual	Final	Final	Final	Final	Final	Minutes	SEC		
	2334.50	79.0	76.0	74.0	420.220	12	42.5		
0.50	Total	Average	Average	Average	Total	Minutes			
	5.00	80.0	76.0	74.0	5.060	12.71		0.9943	1.8560
		78.0							
Nominal	Initial	Initial	Initial	Initial	Initial				
1.000	2324.00	84.0	76.0	74.0	409.610				
Actual	Final	Final	Final	Final	Final	Minutes	SEC		
	2329.00	82.0	76.0	74.0	414.650	8.0	59.88		
1.00	Total	Average	Average	Average	Total				
	5.00	83.0	76.0	74.0	5.040	9.00		0.9998	1.8609
		79.5	Tm						
Nominal	Initial	Initial	Initial	Initial	Initial				
2.000	2297.00	81.0	74.0	75.0	382.490				
Actual	Final	Final	Final	Final	Final	Minutes	SEC		
	2302.00	82.0	74.0	75.0	387.500	6	23.06		
2.00	Total	Average	Average	Average	Total				
	5.00	81.5	74.0	75.0	5.010	6.38		0.9981	1.8877
		77.8	Tm						
Nominal	Initial	Initial	Initial	Initial	Initial				
3.000	2303.00	82.0	74.0	74.0	388.510				
Actual	Final	Final	Final	Final	Final	Minutes	SEC		
	2309.00	83.0	74.0	74.0	394.520	6.0	18.18		
3.00	Total	Average	Average	Average	Total				
	6.00	82.5	74.0	74.0	6.010	6.30		0.9988	1.9094
		78.3	Tm						
Nominal	Initial	Initial	Initial	Initial	Initial				
4.000	2310.00	83.0	74.0	74.0	395.530				
Actual	Final	Final	Final	Final	Final	Minutes	SEC		
	2323.00	85.0	76.0	74.0	408.590	11.0	48.59		
4.00	Total	Average	Average	Average	Total				
	13.00	84.0	75.0	74.0	13.060	11.81		0.9957	1.9004
		79.5	Tm			**Average**		**0.9973**	**1.8829**

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Routine Dry Gas Meter Calibration

Control Module:	C-10	Leak checks			Barometric Press. -- 28.90
Date:	01/20/17	Negative	0.0	>5 W.C.	Previous Y -- 0.9973
Technician:	BAW	Positive -	0.0	> in.Hg	Previous Delta H -- 1.8829

Orifice Diff Pressure H	Wet Test Volume, Ft^3	Dry Gas Meter Temp, F		Wet Test Meter Temp, F	Dry Gas Volume Ft^3	Elapsed Time of Cal. Point		Meter Coefficient Y	Orifice Coefficient dH@
		Inlet	Outlet						
Nominal	Initial	Initial	Initial	Initial	Initial				
0.500	2675.00	79.0	77.0	73.0	902.860				
Actual	Final	Final	Final	Final	Final	Minutes	SEC		
	2680.00	80.0	77.0	73.0	907.900	12	40.2		
0.50	Total	Average	Average	Average	Total	Minutes			
	5.00	79.5	77.0	73.0	5.040	12.67		1.0006	1.8631
		78.3							
Nominal	Initial	Initial	Initial	Initial	Initial				
1.000	2681.00	80.0	77.0	73.0	908.500				
Actual	Final	Final	Final	Final	Final	Minutes	SEC		
	2686.00	80.0	78.0	73.0	913.480	8.0	58.15		
1.00	Total	Average	Average	Average	Total				
	5.00	80.0	77.5	73.0	4.980	8.97		1.0123	1.8655
		78.8	Tm						
Nominal	Initial	Initial	Initial	Initial	Initial				
2.000	2687.00	79.0	78.0	73.0	914.230				
Actual	Final	Final	Final	Final	Final	Minutes	SEC		
	2692.00	80.0	78.0	73.0	919.270	6	19.8		
2.00	Total	Average	Average	Average	Total				
	5.00	79.5	78.0	73.0	5.040	6.33		0.9977	1.8567
		78.8	Tm						
Nominal	Initial	Initial	Initial	Initial	Initial				
3.000	2695.00	80.0	78.0	73.0	921.800				
Actual	Final	Final	Final	Final	Final	Minutes	SEC		
	2705.00	81.0	79.0	73.0	931.830	10.0	31.2		
3.00	.	Average	Average	Average	Total				
	10.00	80.5	78.5	73.0	10.030	10.52		1.0015	1.9212
		79.5	Tm						
Nominal	Initial	Initial	Initial	Initial	Initial				
4.000	2707.00	81.0	79.0	73.0	933.750				
Actual	Final	Final	Final	Final	Final	Minutes	SEC		
	2717.00	81.0	79.0	73.0	943.710	9.0	5.23		
4.00	Total	Average	Average	Average	Total				
	10.00	81.0	79.0	73.0	9.960	9.09		1.0070	1.9096
		80.0	Tm	**Average**				**1.0038**	**1.8832**

Routine Dry Gas Meter Calibration

Control Module:	C-12	Leak checks			Barometric Press. --	28.22
Date:	01/31/17	Negative	0.0	>5 W.C.	Previous Y --	0.9961
Technician:	DJK	Positive -	0.0	> in.Hg	Previous Delta H --	1.9139

Orifice Diff Pressure H	Wet Test Volume, Ft^3	Dry Gas Meter Temp, F		Wet Test Meter Temp, F	Dry Gas Volume Ft^3	Elapsed Time of Cal. Point		Meter Coefficient Y	Orifice Coefficient dH@
		Inlet	Outlet						
Nominal	Initial	Initial	Initial	Initial	Initial				
0.500	4218.00	74.0	70.0	71.0	126.260				
Actual	Final	Final	Final	Final	Final	Minutes	SEC		
	4225.00	74.0	71.0	71.0	133.240	17	53		
0.50	Total	Average	Average	Average	Total	Minutes			
	7.00	74.0	70.5	71.0	6.980	17.88		1.0039	1.9484
		72.3							
Nominal	Initial	Initial	Initial	Initial	Initial				
1.000	4226.00	74.0	71.0	71.0	134.250				
Actual	Final	Final	Final	Final	Final	Minutes	SEC		
	4235.00	75.0	72.0	70.5	143.220	16.0	11		
1.00	Total	Average	Average	Average	Total				
	9.00	74.5	71.5	70.8	8.970	16.18		1.0050	1.9250
		73.0	Tm						
Nominal	Initial	Initial	Initial	Initial	Initial				
2.000	4195.00	71.0	69.0	71.0	103.270				
Actual	Final	Final	Final	Final	Final	Minutes	SEC		
	4217.00	74.0	70.0	71.0	125.270	28	57		
2.00	Total	Average	Average	Average	Total				
	22.00	72.5	69.5	71.0	22.000	28.95		0.9948	2.0716
		71.0	Tm						
Nominal	Initial	Initial	Initial	Initial	Initial				
3.000	4236.00	75.0	72.0	70.5	144.220				
Actual	Final	Final	Final	Final	Final	Minutes	SEC		
	4248.00	76.0	72.0	70.0	156.330	12.0	42		
3.00	Total	Average	Average	Average	Total				
	12.00	75.5	72.0	70.3	12.110	12.70		0.9897	1.9949
		73.8	Tm						
Nominal	Initial	Initial	Initial	Initial	Initial				
4.000	4249.00	76.0	72.0	70.0	157.350				
Actual	Final	Final	Final	Final	Final	Minutes	SEC		
	4262.00	78.0	72.0	70.0	170.570	11.0	56		
4.00	Total	Average	Average	Average	Total				
	13.00	77.0	72.0	70.0	13.220	11.93		0.9815	1.9991
		74.5 Tm				**Average**		**0.9950**	**1.9878**

Routine Dry Gas Meter Calibration

Control Module:	AS-01	Leak checks		Barometric Press. --	28.39
Date:	12/12/16	Negative --	>5 W.C.	Previous Y --	0.9946
Technician:	MTP	Positive --	> in.Hg	Previous Delta H --	1.83

Orifice Diff Pressure H	Wet Test Volume, Ft^3	Dry Gas Meter Temp, F		Wet Test Meter Temp, F	Dry Gas Volume Ft^3	Elapsed Time of Cal. Point		Meter Coefficient Y	Orifice Coefficient dH@
		Inlet	Outlet						
Nominal	Initial	Initial	Initial	Initial	Initial				
0.500	3997.00	81.5	81.5	73.0	1.069				
Actual	Final	Final	Final	Final	Final	Minutes	SEC		
	4002.00	82.2	82.2	73.0	6.196	12	40.02		
0.50	Total	Average	Average	Average	Total	Minutes			
	5.00	81.9	81.9	73.0	5.127	12.67		0.9901	1.8787
		81.9							
Nominal	Initial	Initial	Initial	Initial	Initial				
1.000	4005.01	82.8	82.8	73.0	9.297				
Actual	Final	Final	Final	Final	Final	Minutes	SEC		
	4010.01	84.0	84.0	73.0	14.445	9.0	2.49		
1.00	Total	Average	Average	Average	Total				
	5.00	83.4	83.4	73.0	5.148	9.04		0.9876	1.9088
		83.4	Tm						
Nominal	Initial	Initial	Initial	Initial	Initial				
2.000	3961.10	72.7	72.7	73.0	35.347				
Actual	Final	Final	Final	70	Final	Minutes	SEC		
	3966.30	75.0	75.0	73.0	40.546	6	33.63		
2.00	Total	Average	Average	Average	Total				
	5.20	73.9	73.9	73.0	5.199	6.56		0.9966	1.8916
		73.9	Tm						
Nominal	Initial	Initial	Initial	Initial	Initial				
3.000	3969.00	76.8	76.8	73.0	2.245				
Actual	Final	Final	Final	Final	Final	Minutes	SEC		
	3974.00	78.1	78.1	73.0	7.284	5.0	6.76		
3.00	Total	Average	Average	Average	Total				
	5.00	77.5	77.5	73.0	5.039	5.11		0.9928	1.8513
		77.5	Tm						
Nominal	Initial	Initial	Initial	Initial	Initial				
4.000	3976.00	78.6	78.6	73.0	9.298				
Actual	Final	Final	Final	Final	Final	Minutes	SEC		
	3981.00	78.6	78.6	73.0	14.338	4.0	24.03		
4.00	Total	Average	Average	Average	Total				
	5.00	78.6	78.6	73.0	5.040	4.40		0.9922	1.8248
		78.6	Tm			**Average**		**0.9919**	**1.87**

Routine Dry Gas Meter Calibration

Control Module:	AS-01	Leak checks			Barometric Press. --	29.38
Date:	01/06/17	Negative	0.0	>5 W.C.	Previous Y --	0.9919
Technician:	MTP	Positive -	0.0	> in.Hg	Previous Delta H --	1.8700

Orifice Diff Pressure H	Wet Test Volume, Ft^3	Dry Gas Meter Temp, F		Wet Test Meter Temp, F	Dry Gas Volume Ft^3	Elapsed Time of Cal. Point		Meter Coefficient Y	Orifice Coefficient dH@
		Inlet	Outlet						
Nominal	Initial	Initial	Initial	Initial	Initial				
0.500	2629.00	81.9	81.9	72.0	27.734				
Actual	Final	Final	Final	Final	Final	Minutes	SEC		
	2634.00	82.9	82.9	71.5	32.879	13	8.9		
0.50	Total	Average	Average	Average	Total	Minutes			
	5.00	82.4	82.4	71.8	5.145	13.15		0.9900	1.9448
		82.4							
Nominal	Initial	Initial	Initial	Initial	Initial				
1.000	2623.00	80.1	80.1	72.0	21.560				
Actual	Final	Final	Final	Final	Final	Minutes	SEC		
	2628.00	81.9	81.9	72.0	26.702	9.0	7.79		
1.00	Total	Average	Average	Average	Total				
	5.00	81.0	81.0	72.0	5.142	9.13		0.9864	1.8820
		81.0	Tm						
Nominal	Initial	Initial	Initial	Initial	Initial				
2.000	2613.00	77.5	77.5	72.0	11.328				
Actual	Final	Final	Final	Final	Final	Minutes	SEC		
	2619.00	78.8	78.8	72.0	17.463	7	37.18		
2.00	Total	Average	Average	Average	Total				
	6.00	78.2	78.2	72.0	6.135	7.62		0.9844	1.8303
		78.2	Tm						
Nominal	Initial	Initial	Initial	Initial	Initial				
3.000	2637.00	82.9	82.9	71.5	2.464				
Actual	Final	Final	Final	Final	Final	Minutes	SEC		
	2642.00	84.2	84.2	71.5	7.629	5.0	10.14		
3.00	Total	Average	Average	Average	Total				
	5.00	83.6	83.6	71.5	5.165	5.17		0.9826	1.7979
		83.6	Tm						
Nominal	Initial	Initial	Initial	Initial	Initial				
1.500	2644.00	84.2	84.2	71.5	9.704				
Actual	Final	Final	Final	Final	Final	Minutes	SEC		
	2649.00	84.2	84.2	71.0	14.898	7.0	26.78		
1.50	Total	Average	Average	Average	Total				
	5.00	84.2	84.2	71.3	5.194	7.45		0.9824	1.8616
		84.2	Tm				**Average**	**0.9852**	**1.86**

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Vost Module Calibration Data Sheet

VOST Module	Dual Vost A - 1	Leak checks:		Barometric Pressure:	29.22
Date:	12/7/2016	Negative --	Pass	Previous Y:	0.9905
Technician:	DAH	@8 inHg.		Previous Rate, l/min:	0.400

Rotometer Setting, LPM	Wet Test Volume, Cubic Feet	Dry Gas Meter Temp, °F	Wet Test Meter Temp, °F	Dry Gas Volume, Liters	Elapsed Time, Minutes		Meter Coefficient, Y	Sample Rate, LPM
Nominal 0.50	Initial 2334.950	Initial 67.0	Initial 73.0	Total Final				
	Final 2335.950	Final 71.0	Final 73.0	Volume 28.36	Min 54.0	Sec 47.0		
	1.000	Average 69.0	Average 73.0		Total 54.783		0.9914	0.52
Nominal 0.50	Initial 2335.960	Initial 71.0	Initial 73.0	Total Final				
	Final 2337.590	Final 74.0	Final 73.0	Volume 46.63	Min 91.0	Sec 30.0		
	Total 1.630	Average 72.5	Average 73.0		Total 91.500		0.9893	0.51
					Average		**0.9904**	**0.51**

Vost Module Calibration Data Sheet

VOST Module	Dual Vost A - 1	Leak checks:		Barometric Pressure:	29.62
Date:	3/3/2017	Negative --	Pass	Previous Y:	0.9904
Technician:	MTP	@10 inHg.		Previous Rate, l/min:	0.510

Rotometer Setting, LPM	Wet Test Volume, Cubic Feet	Dry Gas Meter Temp, °F	Wet Test Meter Temp, °F	Dry Gas Volume, Liters	Elapsed Time, Minutes		Meter Coefficient, Y	Sample Rate, LPM
Nominal 0.40	Initial 3342.750	Initial 54.0	Initial 71.5	Total Final				
	Final 3344.230	Final 68.0	Final 71.0	Volume 40.286	Min 82.0	Sec 58.0		
	1.480	Average 61.0	Average 71.3		Total 82.967		1.0206	0.49
Nominal 0.40	Initial 3344.250	Initial 68.0	Initial 71.0	Total Final				
	Final 3345.250	Final 73.0	Final 71.5	Volume 27.88	Min 60.0	Sec 27.0		
	Total 1.000	Average 70.5	Average 71.3		Total 60.450		1.0147	0.46
					Average		**1.0176**	**0.47**

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Vost Module Calibration Data Sheet

VOST Module	Dual Vost A - 2	Leak checks:		Barometric Pressure:	29.22
Date:	12/7/2016	Negative --	Pass	Previous Y:	0.9801
Technician:	DAH	@8 inHg.		Previous Rate, l/min:	0.400

Rotometer Setting, LPM	Wet Test Volume, Cubic Feet	Dry Gas Meter Temp, °F	Wet Test Meter Temp, °F	Dry Gas Volume, Liters	Elapsed Time, Minutes		Meter Coefficient, Y	Sample Rate, LPM
Nominal 0.50	Initial 2341.550	Initial 76.0	Initial 73.0	Total Final Volume 31.75				
	Final 2342.650	Final 76.0	Final 73.0		Min 61.0	Sec 34.0		
	1.100	Average 76.0	Average 73.0		Total 61.567		0.9870	0.52
Nominal 0.50	Initial 2340.230	Initial 77.0	Initial 73.0	Total Final Volume 37.74				
	Final 2341.530	Final 76.0	Final 73.0		Min 74.0	Sec 30.0		
	Total 1.300	Average 76.5	Average 73.0		Total 74.500		0.9822	0.51
				Average			**0.9846**	**0.51**

Vost Module Calibration Data Sheet

VOST Module	Dual Vost A - 2	Leak checks:		Barometric Pressure:	29.62
Date:	3/3/2017	Negative --	Pass	Previous Y:	0.9735
Technician:	rmp	@8 inHg.		Previous Rate, l/min:	0.400

Rotometer Setting, LPM	Wet Test Volume, Cubic Feet	Dry Gas Meter Temp, °F	Wet Test Meter Temp, °F	Dry Gas Volume, Liters	Elapsed Time, Minutes		Meter Coefficient, Y	Sample Rate, LPM
Nominal 0.40	Initial 3345.500	Initial 73.0	Initial 71.5	Total Final Volume 28.79				
	Final 3346.500	Final 74.0	Final 71.5		Min 76.0	Sec 28.0		
	1.000	Average 73.5	Average 71.5		Total 76.467		0.9877	0.38
Nominal 0.40	Initial 3346.700	Initial 74.0	Initial 71.5	Total Final Volume 28.93				
	Final 3347.700	Final 74.0	Final 71.5		Min 74.0	Sec 34.0		
	Total 1.000	Average 74.0	Average 71.5		Total 74.567		0.9838	0.39
Nominal 0.40	Initial	Initial	Initial	Total Final Volume				
	Final	Final	Final		Min	Sec		
	Total 0.000	Average #DIV/0!	Average #DIV/0!		Total 0.000		#DIV/0!	#DIV/0!
					Average		**0.9857**	**0.38**

Vost Module Calibration Data Sheet

VOST Module	Dual Vost B - 1	Leak checks:		Barometric Pressure:	29.33
Date:	12/8/2016	Negative --	Pass	Previous Y:	1.0073
Technician:	DAH	@8 inHg.		Previous Rate, l/min:	2.000

Rotometer Setting, LPM	Wet Test Volume, Cubic Feet	Dry Gas Meter Temp, °F	Wet Test Meter Temp, °F	Dry Gas Volume, Liters	Elapsed Time, Minutes		Meter Coefficient, Y	Sample Rate, LPM
Nominal 0.50	Initial 2342.680	Initial 51.0	Initial 73.0	Total Final				
	Final 2343.880	Final 63.0	Final 73.0	Volume 32.73	Min 62.0	Sec 33.0		
	1.200	Average 57.0	Average 73.0		Total 62.550		1.0075	0.52
Nominal 0.50	Initial 2343.920	Initial 64.0	Initial 73.0	Total Final				
	Final 2345.570	Final 72.0	Final 73.0	Volume 46.01	Min 87.0	Sec 57.0		
	Total 1.650	Average 68.0	Average 73.0		Total 87.950		1.0064	0.52
				Average			**1.0069**	**0.52**

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Vost Module Calibration Data Sheet

VOST Module	Dual Vost B - 1	Leak checks:		Barometric Pressure:	28.80
Date:	3/2/2017	Negative --	Pass	Previous Y:	0.9970
Technician:	DAH	@10 inHg.		Previous Rate, l/min:	0.400

Rotometer Setting, LPM	Wet Test Volume, Cubic Feet	Dry Gas Meter Temp, °F	Wet Test Meter Temp, °F	Dry Gas Volume, Liters	Elapsed Time, Minutes		Meter Coefficient, Y	Sample Rate, LPM
Nominal 0.40	Initial 3323.200	Initial 59.0	Initial 72.0	Total Final				
	Final 3324.200	Final 71.0	Final 72.0	Volume 27.552	Min 66.0	Sec 58.0		
	1.000	Average 65.0	Average 72.0		Total 66.967		1.0147	0.41
Nominal 0.40	Initial 3324.250	Initial 71.0	Initial 72.0	Total Final				
	Final 3325.320	Final 72.0	Final 72.0	Volume 29.88	Min 69.0	Sec 4.0		
	Total 1.070	Average 71.5	Average 72.0		Total 69.067		1.0135	0.43
				Average			**1.0141**	**0.42**

Vost Module Calibration Data Sheet

VOST Module	Dual Vost B - 2	Leak checks:		Barometric Pressure:	29.50
Date:	12/8/2016	Negative --	Pass	Previous Y:	1.0096
Technician:	DAH	@8 inHg.		Previous Rate, l/min:	2.000

Rotometer Setting, LPM	Wet Test Volume, Cubic Feet	Dry Gas Meter Temp, °F	Wet Test Meter Temp, °F	Dry Gas Volume, Liters	Elapsed Time, Minutes		Meter Coefficient, Y	Sample Rate, LPM
Nominal 0.50	Initial 2345.650	Initial 72.0	Initial 73.0	Total Final Volume 30.92				
	Final 2346.740	Final 74.0	Final 73.0		Min 61.0	Sec 2.0		
	1.090	Average 73.0	Average 73.0		Total 61.033		0.9986	0.51
Nominal 0.50	Initial 2346.800	Initial 74.0	Initial 73.0	Total Final Volume 31.730				
	Final 2347.920	Final 74.0	Final 73.0		Min 60.0	Sec 31.0		
	Total 1.120	Average 74.0	Average 73.0		Total 60.517		1.0018	0.52
					Average		**1.0002**	**0.52**

Vost Module Calibration Data Sheet

VOST Module	Dual Vost B - 2	Leak checks:		Barometric Pressure:	29.00
Date:	3/2/2017	Negative --	Pass	Previous Y:	1.0002
Technician:	DAH	@8 inHg.		Previous Rate, l/min:	0.500

Rotometer Setting, LPM	Wet Test Volume, Cubic Feet	Dry Gas Meter Temp, °F	Wet Test Meter Temp, °F	Dry Gas Volume, Liters	Elapsed Time, Minutes		Meter Coefficient, Y	Sample Rate, LPM
Nominal	Initial	Initial	Initial	Total				
0.40	3325.390	70.0	72.0	Final				
	Final	Final	Final	Volume	Min	Sec		
	3326.460	70.0	72.0	30	74.0	3.0		
		Average	Average		Total			
	1.070	70.0	72.0		74.050		1.0066	0.41
Nominal	Initial	Initial	Initial	Total				
0.40	3326.490	70.0	72.0	Final				
	Final	Final	Final	Volume	Min	Sec		
	3342.450	73.0	71.5	449.168	1046.0	6.0		
	Total	Average	Average		Total			
	15.960	71.5	71.8		1046.100		1.0061	0.43
					Average		**1.0063**	**0.42**

Meter Pyrometer Calibration

	Meter I.D.			C-8		
Temperature Calibrator Used	**CL-300-100F**	X	X	X	X	X
	CL-3512-A					
	DATE	3/3/2017	3/3/2017	3/3/2017	3/3/2017	3/3/2017
	TECHNICIAN	RMP	RMP	RMP	RMP	RMP
	Thermocouple I.D.	T.C. 1	T.C. 2	T.C. 3	T.C. 4	T.C. 5
Reference °F	**Acceptable Range**	** If not within Acceptable Range, unit not to be used within range at which failure occurred.				
1950	1932 to 1968	1958				1956
1800	1784 to 1816	1805				1804
1600	1585 to 1615	1605				1605
1400	1387 to 1413	1404				1402
1200	1188 to 1212	1205				1205
1000	990 to 1010	1005				1004
900	890 to 910	904				903
800	791 to 809	804				803
700	692 to 708	704				703
600	593 to 607	601				601
500	493 to 507	499	500	499		498
400	394 to 406	400	400	399		399
300	295 to 305	301	300	300		299
200	196 to 204	200	200	199		198
150	146 to 154	149	149	148	147	147
100	96 to 104	98	98	97	97	97
50	47 to 53	48	48	47	47	47
0	-3 to 3	0			-1	0
-50	-53 to -47	-51			-53	-52

Pass/Fail based on +/- 0.75% of Rankine value

Meter Pyrometer Calibration

	Meter I.D.			C-9		
	Pyrometer Used, I.D.					
Temperature	**CL-300-100F**					
Calibrator Used	**CL-3512-A**	X				
	DATE	1/5/2017				
	TECHNICIAN	LDP2				
	Thermocouple I.D.	T.C. 1	T.C. 2	T.C. 3	T.C. 4	T.C. 5
Reference °F	**Acceptable Range**	** If not within Acceptable Range, unit not to be used within range at which failure occurred.				
1950	1932 to 1968	1959				1957
1800	1784 to 1816	1806				1805
1600	1585 to 1615	1606				1605
1400	1387 to 1413	1401				1400
1200	1188 to 1212	1204				1202
1000	990 to 1010	1004				1003
900	890 to 910	902				901
800	791 to 809	800				800
700	692 to 708	700				699
600	593 to 607	598				597
500	493 to 507	495	495	493		493
400	394 to 406	397	396	397		397
300	295 to 305	298	298	298		298
200	196 to 204	197	197	197		197
150	146 to 154	146	146	146	146	146
100	96 to 104	96	96	96	96	96
50	47 to 53	47	47	47	47	47
0	-3 to 3	-2			-2	-2
-50	-53 to -47	-53			-53	-53

Pass/Fail based on +/- 0.75% of Rankine value

▨ Fail indicated by cell highliting

Reviewd by:

Meter Pyrometer Calibration

	Meter I.D.		C-10			
	Pyrometer Used, I.D.	D-15				
Temperature	**CL-300-100F**					
Calibrator Used	**CL-3512-A**	X				
	DATE	4/10/2017				
	TECHNICIAN	DAH				
	Thermocouple I.D.	T.C. 1	T.C. 2	T.C. 3	T.C. 4	T.C. 5

Reference °F	**Acceptable Range**	** If not within Acceptable Range, unit not to be used within range at which failure occurred.				
1950	1932 to 1968	1960				1959
1800	1784 to 1816	1807				1806
1600	1585 to 1615	1607				1606
1400	1387 to 1413	1404				1403
1200	1188 to 1212	1204				1202
1000	990 to 1010	1004				1003
900	890 to 910	903				902
800	791 to 809	802				802
700	692 to 708	702				699
600	593 to 607	601				598
500	493 to 507	498	496	493		494
400	394 to 406	398	397	397		397
300	295 to 305	297	298	298		298
200	196 to 204	197	197	197		197
150	146 to 154	147	146	146	146	147
100	96 to 104	97	97	96	96	96
50	47 to 53	47	47	47	47	47
0	-3 to 3	-2			-2	-2
-50	-53 to -47	-52			-53	-53

Pass/Fail based on +/- 0.75% of Rankine value

▨ Fail indicated by cell highlighting

Reviewed by:

Meter Pyrometer Calibration

	Meter I.D.		C-12			
Temperature Calibrator Used	**CL-300-100F**	X	X	X	X	X
	CL-3512-A					
	DATE	1/23/2017	1/23/2017	1/23/2017	1/23/2017	1/23/2017
	TECHNICIAN	LTR	LTR	LTR	LTR	LTR
	Thermocouple I.D.	T.C. 1	T.C. 2	T.C. 3	T.C. 4	T.C. 5

Reference °F	**Acceptable Range**	** If not within Acceptable Range, unit not to be used within range at which failure occurred.				
1000	990 to 1010	999				998
900	890 to 910	899				898
800	791 to 809	799				798
700	692 to 708	700				699
600	593 to 607	599				598
500	493 to 507	497	498	499		496
400	394 to 406	399	399	401		397
300	295 to 305	300	301	301		299
200	196 to 204	200	200	200		199
150	146 to 154	150	151	150	149	149
100	96 to 104	99	99	100	97	98
50	47 to 53	49	50	49	48	48
0	-3 to 3	1			0	0
-50	-53 to -47	-49			-51	-50

Pass/Fail based on +/- 0.75% of Rankine value

Fail indicated by cell highliting

Reviewd By:

Meter Pyrometer Calibration

	Meter I.D.			DV-A		
	Pyrometer Used, I.D.	D-15				
Temperature	**CL-300-100F**					
Calibrator Used	**CL-3512-A**	X				
	DATE	1/5/2017				
	TECHNICIAN	LDP2				
	Thermocouple I.D.	T.C. 1	T.C. 2	T.C. 3	T.C. 4	T.C. 5

Reference °F	**Acceptable Range**	** If not within Acceptable Range, unit not to be used within range at which failure occurred.				
1950	1932 to 1968	1950				1950
1800	1784 to 1816	1797				1798
1600	1585 to 1615	1600				1600
1400	1387 to 1413	1397				1397
1200	1188 to 1212	1200				1200
1000	990 to 1010	999				999
900	890 to 910	899				898
800	791 to 809	799				799
700	692 to 708	700				700
600	593 to 607	597				598
500	493 to 507	496	496	495		496
400	394 to 406	395	396	396		396
300	295 to 305	297	296	296		297
200	196 to 204	196	196	196		196
150	146 to 154	146	146	146	146	146
100	96 to 104	96	96	96	96	96
50	47 to 53	47	47	47	47	47
0	-3 to 3	-3			-3	-3
-50	-53 to -47	-53			▨ -54	▨ -54

Pass/Fail based on +/- 0.75% of Rankine value

▨ Fail indicated by cell highliting

Reviewd by:

Meter Pyrometer Calibration

	Meter I.D.			DV-B		
	Pyrometer Used, I.D.	D-15				
Temperature Calibrator Used	**CL-300-100F**					
	CL-3512-A	X				
	DATE	1/10/2017				
	TECHNICIAN	LDP2				
	Thermocouple I.D.	T.C. 1	T.C. 2	T.C. 3	T.C. 4	T.C. 5

** If not within Acceptable Range,
unit not to be used within range at which failure occurred.

Reference °F	**Acceptable Range**	T.C. 1	T.C. 2	T.C. 3	T.C. 4	T.C. 5
1950	1932 to 1968	1953				1953
1800	1784 to 1816	1802				1802
1600	1585 to 1615	1604				1603
1400	1387 to 1413	1401				1401
1200	1188 to 1212	1204				1204
1000	990 to 1010	1003				1004
900	890 to 910	903				903
800	791 to 809	802				803
700	692 to 708	702				702
600	593 to 607	600				600
500	493 to 507	498	498	498		498
400	394 to 406	398	398	398		398
300	295 to 305	299	299	299		299
200	196 to 204	198	199	198		198
150	146 to 154	148	147	147	147	147
100	96 to 104	96	96	96	96	97
50	47 to 53	47	47	47	47	47
0	-3 to 3	-1			-1	0
-50	-53 to -47	-52			-52	-52

Pass/Fail based on +/- 0.75% of Rankine value

Fail indicated by cell highlighting

Reviewed by:

Meter Pyrometer Calibration

Meter I.D.			AS-01				
Pyrometer Used, I.D.		D-15					D-15
Temperature Calibrator Used	**CL-300-100F**						
	CL-3512-A	X					
DATE		1/6/2017					1/6/2017
TECHNICIAN		LDP2					MTP
Thermocouple I.D.		T.C. 1	T.C. 2	T.C. 3	T.C. 4	T.C. 5	T.C. 6
Reference °F	**Acceptable Range**	** If not within Acceptable Range, unit not to be used within range at which failure occurred.					
1750	1734 to 1766	1750				1751	1751
1600	1585 to 1615	1603				1602	1602
1400	1387 to 1413	1401				1401	1401
1200	1188 to 1212	1200				1200	1201
1000	990 to 1010	1000				1000	1000
900	890 to 910	900				900	900
800	791 to 809	800				800	800
700	692 to 708	699				699	700
600	593 to 607	599				599	598
500	493 to 507	499	498	499		498	498
400	394 to 406	400	400	400		400	400
300	295 to 305	302	302	301		301	302
200	196 to 204	200	200	200		200	200
150	146 to 154	150	150	150	149	150	150
100	96 to 104	100	100	100	99	99	100
50	47 to 53	51	51	49	49	50	50
0	-2 to 3	0			-2	-1	-1
-30	-33 to -26	-30			-31	-31	-30

Pass/Fail based on +/- 0.75% of Rankine value

Fail indicated by cell highliting

Reviewd by:

PYROMETER CALIBRATION

Pyrometer Number: D-14 Date: 12/27/2016

Temperature Calibrator: CL-3512-A Technician: HLP

		Pyrometer ° F	
Reference (°F)	Rankine	Reading	Pass/Fail
1950	2410	1952	Pass
1800	2260	1802	Pass
1700	2160	1701	Pass
1600	2060	1601	Pass
1500	1960	1502	Pass
1400	1860	1401	Pass
1300	1760	1302	Pass
1200	1660	1201	Pass
1100	1560	1101	Pass
1000	1460	1001	Pass
950	1410	951	Pass
900	1360	902	Pass
850	1310	851	Pass
800	1260	802	Pass
750	1210	751	Pass
700	1160	701	Pass
650	1110	651	Pass
600	1060	601	Pass
550	1010	551	Pass
500	960	500	Pass
450	910	450	Pass
400	860	400	Pass
350	810	350	Pass
300	760	300	Pass
250	710	250	Pass
200	660	200	Pass
150	610	149	Pass
100	560	100	Pass
50	510	50	Pass
0	460	-0.3	Pass
-50	410	-51	Pass

Pass/Fail based on +/- 0.75% of Rankine value

Reviewd by:

BARR

S-Type Pitot Tube
Geometry Check

Pitot Tube Number: 20

Length: 8 ft

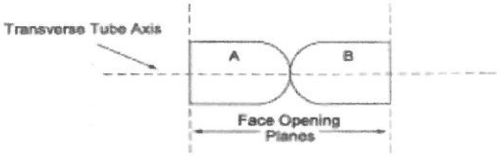
Function: M-5 Probe / [✓ Free]

Inspection Date: 1/4/16

Technician: BAW

1. Are face openings perpendicular to tube axis?

☑ YES (go to 2) ☐ NO (go to 1a)

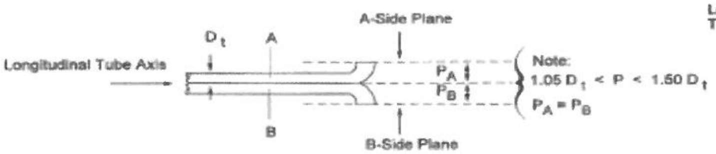


1a. If NO, is angle less than 10°?

☐ YES (go to 2) ☐ NO (discontinue use)

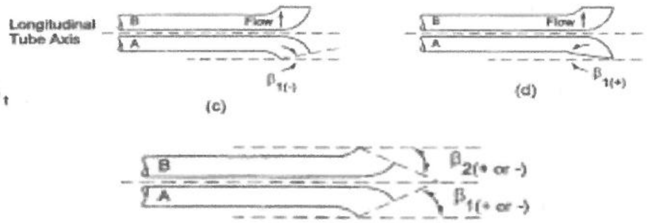
2. Are face openings parallel to longitudinal axis?

☑ YES (go to 3) ☐ NO (go to 2a)



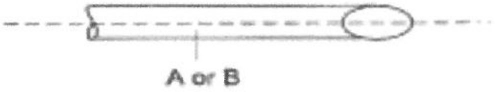
2a. If NO, is angle less than 5°?

☐ YES (go to 3) ☐ NO (discontinue use)



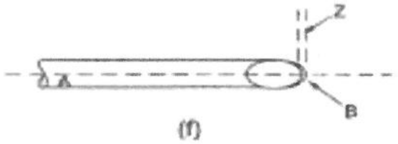
3. Are legs of equal length?

☑ YES (go to 4) ☐ NO (go to 3a)



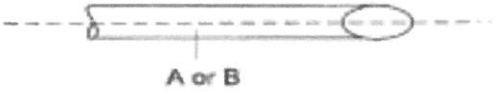
3a. If NO, is difference less than 1/8 inch?

☐ YES (go to 4) ☐ NO (discontinue use)



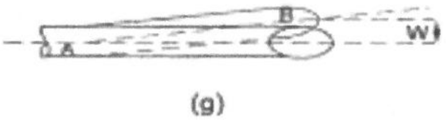
4. Are center-lines of legs coincident?

☑ YES (go to 5) ☐ NO (go to 4a)



4a. If NO, are center-lines of face openings less than 1/32 inch?

☐ YES (go to 5) ☐ NO (discontinue use)



5. Does this pitot tube pass all of the above criteria? ☑ YES ☐ NO

I certify that the pitot tube meets or exceeds all specifications and criteria listed in 40 CFR Part 60, Appendix A, EPA Method 2, and is assigned a pitot tube certification factor of 0.84.

Technician Signature:

Reviewed by:

BARR

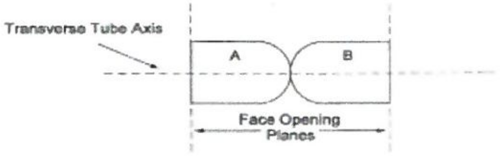
S-Type Pitot Tube
Geometry Check

Pitot Tube Number: S-2
Length: 5'
Function: [✓ M-5 Probe] / Free

Inspection Date: 1-3-17
Technician: RMP

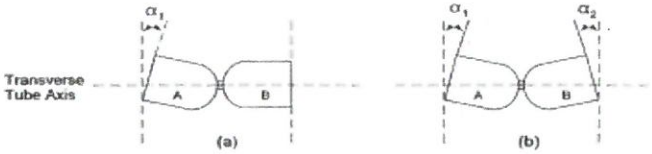
1. Are face openings perpendicular to tube axis?

☑ YES (go to 2) ☐ NO (go to 1a)



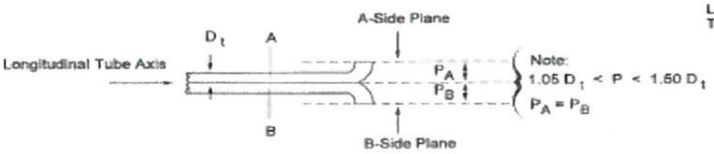
1a. If NO, is angle less than 10°?

☐ YES (go to 2) ☐ NO (discontinue use)



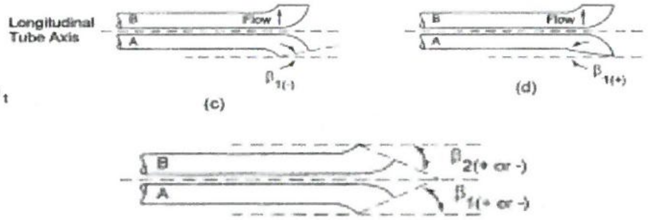
2. Are face openings parallel to longitudinal axis?

☑ YES (go to 3) ☐ NO (go to 2a)



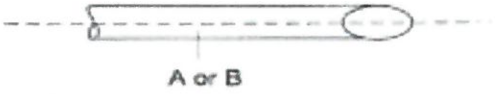
2a. If NO, is angle less than 5°?

☐ YES (go to 3) ☐ NO (discontinue use)



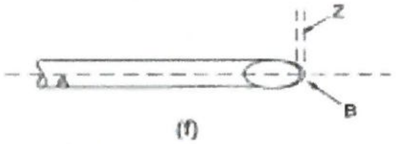
3. Are legs of equal length?

☑ YES (go to 4) ☐ NO (go to 3a)



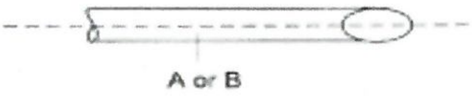
3a. If NO, is difference less than 1/8 inch?

☐ YES (go to 4) ☐ NO (discontinue use)



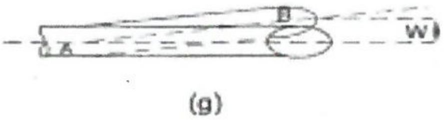
4. Are center-lines of legs coincident?

☑ YES (go to 5) ☐ NO (go to 4a)



4a. If NO, are center-lines of face openings less than 1/32 inch?

☐ YES (go to 5) ☐ NO (discontinue use)



5. Does this pitot tube pass all of the above criteria? ☑ YES ☐ NO

I certify that the pitot tube meets or exceeds all specifications and criteria listed in 40 CFR Part 60, Appendix A, EPA Method 2, and is assigned a pitot tube certification factor of 0.84.

Technician Signature:

Reviewed by:

BARR

S-Type Pitot Tube
Geometry Check

Pitot Tube Number: S-3

Length: 5'

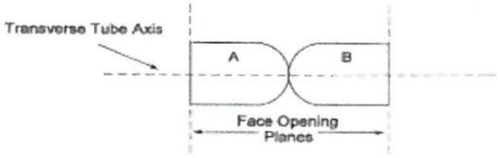
Function: [✓ M-5 Probe] / Free

Inspection Date: 1-3-17

Technician: RMP

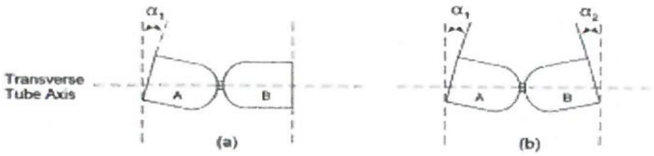
1. Are face openings perpendicular to tube axis?

☑ YES (go to 2) ☐ NO (go to 1a)



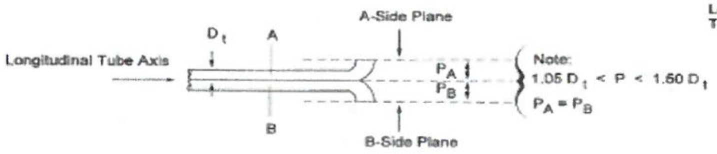
1a. If NO, is angle less than 10°?

☐ YES (go to 2) ☐ NO (discontinue use)



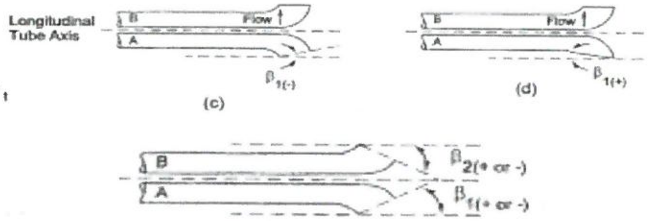
2. Are face openings parallel to longitudinal axis?

☑ YES (go to 3) ☐ NO (go to 2a)



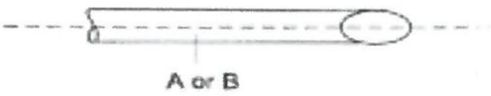
2a. If NO, is angle less than 5°?

☐ YES (go to 3) ☐ NO (discontinue use)



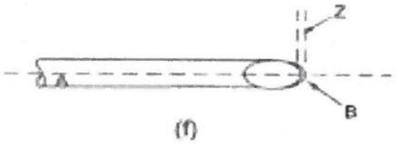
3. Are legs of equal length?

☑ YES (go to 4) ☐ NO (go to 3a)



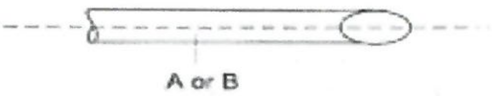
3a. If NO, is difference less than 1/8 inch?

☐ YES (go to 4) ☐ NO (discontinue use)



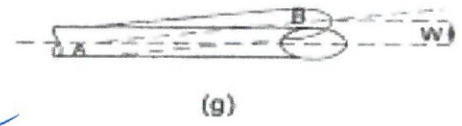
4. Are center-lines of legs coincident?

☑ YES (go to 5) ☐ NO (go to 4a)



4a. If NO, are center-lines of face openings less than 1/32 inch?

☐ YES (go to 5) ☐ NO (discontinue use)



5. Does this pitot tube pass all of the above criteria? ☑ YES ☐ NO

I certify that the pitot tube meets or exceeds all specifications and criteria listed in 40 CFR Part 60, Appendix A, EPA Method 2, and is assigned a pitot tube certification factor of 0.84.

Technician Signature:

Reviewed by:

BARR

S-Type Pitot Tube
Geometry Check

Pitot Tube Number: 5-5

Length: 5'

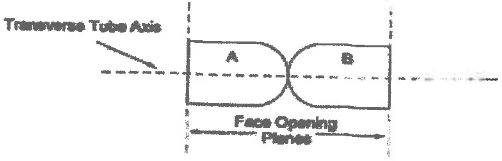
Function: [✓ M-5 Probe] / Free

Inspection Date: 2/1/17

Technician: LTR

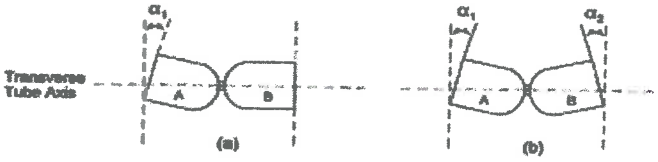
1. Are face openings perpendicular to tube axis?

☑ YES (go to 2) ☐ NO (go to 1a)



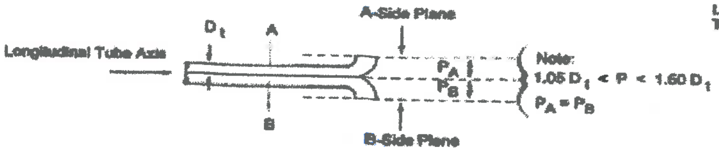
1a. If NO, is angle less than 10°?

☐ YES (go to 2) ☐ NO (discontinue use)



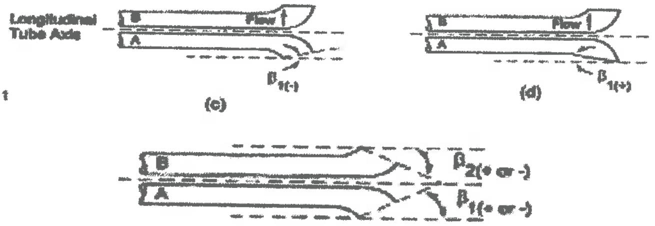
2. Are face openings parallel to longitudinal axis?

☑ YES (go to 3) ☐ NO (go to 2a)



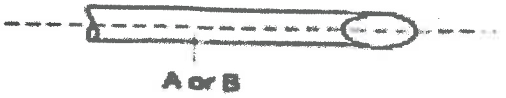
2a. If NO, is angle less than 5°?

☐ YES (go to 3) ☐ NO (discontinue use)



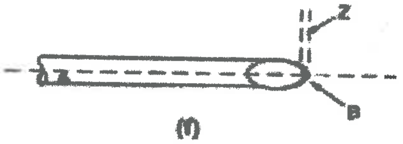
3. Are legs of equal length?

☑ YES (go to 4) ☐ NO (go to 3a)



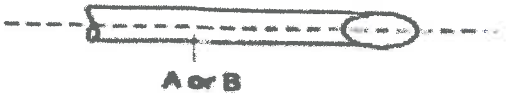
3a. If NO, is difference less than 1/8 inch?

☐ YES (go to 4) ☐ NO (discontinue use)



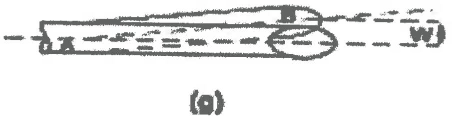
4. Are center-lines of legs coincident?

☑ YES (go to 5) ☐ NO (go to 4a)



4a. If NO, are center-lines of face openings less than 1/32 inch?

☐ YES (go to 5) ☐ NO (discontinue use)



5. Does this pitot tube pass all of the above criteria? ☑ YES ☐ NO

I certify that the pitot tube meets or exceeds all specifications and criteria listed in 40 CFR Part 60, Appendix A, EPA Method 2, and is assigned a pitot tube certification factor of 0.84.

Technician Signature: Lee Pavlak

Reviewed by:

BARR

S-Type Pitot Tube
Geometry Check

Pitot Tube Number: 37

Length: 10'

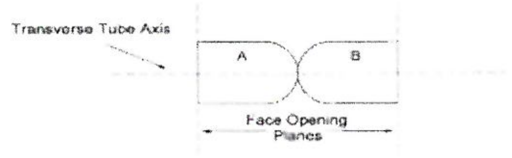
Function: M-5 Probe / [✓ Free]

Inspection Date: 12-28-16

Technician: RMP

1. Are face openings perpendicular to tube axis?

☑ YES (go to 2) ☐ NO (go to 1a)

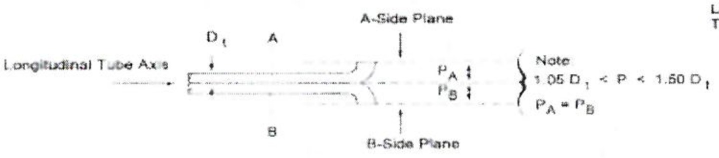


1a. If NO, is angle less than 10°?

☐ YES (go to 2) ☐ NO (discontinue use)

2. Are face openings parallel to longitudinal axis?

☑ YES (go to 3) ☐ NO (go to 2a)

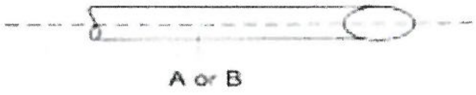


2a. If NO, is angle less than 5°?

☐ YES (go to 3) ☐ NO (discontinue use)

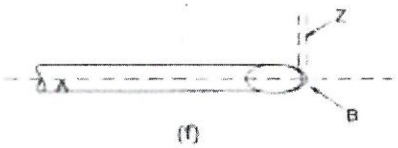
3. Are legs of equal length?

☑ YES (go to 4) ☐ NO (go to 3a)



3a. If NO, is difference less than 1/8 inch?

☐ YES (go to 4) ☐ NO (discontinue use)



(f)

4. Are center-lines of legs coincident?

☑ YES (go to 5) ☐ NO (go to 4a)

4a. If NO, are center-lines of face openings less than 1/32 inch?

☐ YES (go to 5) ☐ NO (discontinue use)

(g)

5. Does this pitot tube pass all of the above criteria? ☑ YES ☐ NO

I certify that the pitot tube meets or exceeds all specifications and criteria listed in 40 CFR Part 60, Appendix A, EPA Method 2, and is assigned a pitot tube certification factor of 0.84.

Technician Signature:

Reviewed by:

BARR

Manometer Calibration Sheet

Manometer Number	Alnor M-11	Leak Check:	
Date of Calibration	1/21/2016	Negative	0.0 @3"
Technician	JAR2	Positive	0.0 @3"

	Oil Manometer	Digital Manometer	Pass/Fail
Positive	**0.06**	0.06	Pass
	0.2	0.20	Pass
	0.5	0.50	Pass
	0.8	0.80	Pass
	1	1.00	Pass
	1.5	1.45	Pass
	2	1.95	Pass
	2.5	2.50	Pass
	3	2.99	Pass
	3.5	3.49	Pass
Negative	**0.06**	0.06	Pass
	0.2	0.20	Pass
	0.5	0.51	Pass
	0.8	0.80	Pass
	1	1.00	Pass
	1.5	1.46	Pass
	2	1.95	Pass
	2.5	2.49	Pass
	3	2.99	Pass
	3.5	3.48	Pass

Pass/Fail based on +/- 5% of set value

Technician signature:

QA signature:

Manometer Calibration Sheet

Manometer Number	Alnor M-13	Leak Check:	
Date of Calibration	1/4/2017	Negative	0.0 @3"
Technician	DAH	Positive	0.0 @3"

	Oil Manometer	Digital Manometer	Pass/Fail
Positive	**0.06**	0.06	Pass
	0.2	0.19	Pass
	0.5	0.48	Pass
	0.8	0.78	Pass
	1	0.98	Pass
	1.5	1.49	Pass
	2	1.95	Pass
	2.5	2.42	Pass
	3	2.95	Pass
	3.5	3.46	Pass
Negative	**0.06**	0.06	Pass
	0.2	0.19	Pass
	0.5	0.48	Pass
	0.8	0.79	Pass
	1	0.98	Pass
	1.5	1.47	Pass
	2	1.96	Pass
	2.5	2.50	Pass
	3	3.00	Pass
	3.5	3.47	Pass

Pass/Fail based on +/- 5% of set value

Reviewed by:

THERMOCOUPLE CALIBRATION

Meter Out **THERMOCOUPLE ID** **AS-01**

Cal Date: **1/5/2017**

CALIBRATION TECHNICIAN: **HLP**

REFERENCE STANDARDS	**TRACEABILITY**	**DATE**	**LABORATORY**
Hart Scientific 9103-A s/n A1B289	**Report No. T15-1116-JC-2**	**11/16/2015**	**NBS Calibrations**
Fluke 9144 s/n B5A077	**Report No. 7060.00-205700-001**	**1/20/2016**	**JM Test Systems**

Temperature Calibration Points	**20**	**70**	**150**
Reference Deg F (To)	20	70	150
Probe Temp (deg F)	21.0	70.0	151.0
Difference (degrees)	1.0	0.0	1.0
TC Meets Method 5 Specifications: (± 2.0 °F)	YES	YES	YES

Reviewed by:

THERMOCOUPLE CALIBRATION

Meter **THERMOCOUPLE ID** **DVA-1**

Cal Date: **1/6/2017**

CALIBRATION TECHNICIAN: **HLP**

REFERENCE STANDARDS	**TRACEABILITY**	**DATE**	**LABORATORY**
Hart Scientific 9103-A s/n A1B289	**Report No. T15-1116-JC-2**	**11/16/2015**	**NBS Calibrations**
Fluke 9144 s/n B5A077	**Report No. 7060.00-205700-001**	**1/20/2016**	**JM Test Systems**

Temperature Calibration Points	**20**	**70**	**150**
Reference Deg F (To)	20	70	150
Probe Temp (deg F)	20.0	70.0	150.0
Difference (degrees)	0.0	0.0	0.0
TC Meets Method 5 Specifications: (± 2.0 °F)	YES	YES	YES

Reviewed by:

THERMOCOUPLE CALIBRATION

Meter **THERMOCOUPLE ID** **DVA-2**

Cal Date: **1/6/2017**

CALIBRATION TECHNICIAN: **HLP**

REFERENCE STANDARDS	TRACEABILITY	DATE	LABORATORY
Hart Scientific 9103-A s/n A1B289	Report No. T15-1116-JC-2	11/16/2015	NBS Calibrations
Fluke 9144 s/n B5A077	Report No. 7060.00-205700-001	1/20/2016	JM Test Systems

Temperature Calibration Points	20	70	150
Reference Deg F (To)	20	70	150
Probe Temp (deg F)	20.0	71.0	150.0
Difference (degrees)	0.0	1.0	0.0
TC Meets Method 5 Specifications: (± 2.0 °F)	YES	YES	YES

Reviewed by:

THERMOCOUPLE CALIBRATION

Meter **THERMOCOUPLE ID** **DVB-1**

Cal Date: **1/10/2017**

CALIBRATION TECHNICIAN: **LDP2**

REFERENCE STANDARDS	**TRACEABILITY**	**DATE**	**LABORATORY**
Hart Scientific 9103-A s/n A1B289	**Report No. T15-1116-JC-2**	**11/16/2015**	**NBS Calibrations**
Fluke 9144 s/n B5A077	**Report No. 7060.00-205700-001**	**1/20/2016**	**JM Test Systems**

Temperature Calibration Points	**20**	**70**	**150**
Reference Deg F (To)	20	70	150
Probe Temp (deg F)	21.0	69.0	150.0
Difference (degrees)	1.0	1.0	0.0
TC Meets Method 5 Specifications: (± 2.0 °F)	YES	YES	YES

Reviewed by:

THERMOCOUPLE CALIBRATION

Meter		**THERMOCOUPLE ID**	**DVB-2**
Cal Date:	**1/10/2017**		
		CALIBRATION TECHNICIAN:	**LDP2**

REFERENCE STANDARDS	**TRACEABILITY**	**DATE**	**LABORATORY**
Hart Scientific 9103-A s/n A1B289	**Report No. T15-1116-JC-2**	**11/16/2015**	**NBS Calibrations**
Fluke 9144 s/n B5A077	**Report No. 7060.00-205700-001**	**1/20/2016**	**JM Test Systems**

Temperature Calibration Points	**20**	**70**	**150**
Reference Deg F (To)	20	70	150
Probe Temp (deg F)	20.0	70.0	149.0
Difference (degrees)	0.0	0.0	1.0
TC Meets Method 5 Specifications: (± 2.0 °F)	YES	YES	YES

Reviewed by:

BARR

THERMOCOUPLE CALIBRATION

Meter In **THERMOCOUPLE ID** **C8-I**

Cal Date: **2/27/2017**

CALIBRATION TECHNICIAN: **RMP**

REFERENCE STANDARDS	**TRACEABILITY**	**DATE**	**LABORATORY**
Hart Scientific 9103-A s/n A1B289	**Report No. T15-1116-JC-2**	**11/16/2015**	**NBS Calibrations**
Fluke 9144 s/n B5A077	**Report No. 7060.00-205700-001**	**1/20/2016**	**JM Test Systems**

Temperature Calibration Points	**20**	**70**	**150**
Reference Deg F (To)	20	70	150
Probe Temp (deg F)	22.0	70.0	148.0
Difference (degrees)	2.0	0.0	2.0
TC Meets Method 5 Specifications: (± 2.0 °F)	YES	YES	YES

Reviewed by: Mark Peters

BARR

THERMOCOUPLE CALIBRATION

Meter Out **THERMOCOUPLE ID** **C8-O**

Cal Date: **2/27/2017**

CALIBRATION TECHNICIAN: **RMP**

REFERENCE STANDARDS	TRACEABILITY	DATE	LABORATORY
Hart Scientific 9103-A s/n A1B289	Report No. T15-1116-JC-2	11/16/2015	NBS Calibrations
Fluke 9144 s/n B5A077	Report No. 7060.00-205700-001	1/20/2016	JM Test Systems

Temperature Calibration Points	20	70	150
Reference Deg F (To)	20	70	150
Probe Temp (deg F)	22.0	70.0	148.0
Difference (degrees)	2.0	0.0	2.0
TC Meets Method 5 Specifications: (± 2.0 °F)	YES	YES	YES

Reviewed by: Mark Pete

THERMOCOUPLE CALIBRATION

Meter In **THERMOCOUPLE ID** **C9-I**

Cal Date: **1/6/2017**

CALIBRATION TECHNICIAN: **HLP**

REFERENCE STANDARDS	TRACEABILITY	DATE	LABORATORY
Hart Scientific 9103-A s/n A1B289	**Report No. T15-1116-JC-2**	**11/16/2015**	**NBS Calibrations**
Fluke 9144 s/n B5A077	**Report No. 7060.00-205700-001**	**1/20/2016**	**JM Test Systems**

Temperature Calibration Points	**20**	**70**	**150**
Reference Deg F (To)	20	70	150
Probe Temp (deg F)	22.0	70.0	148.0
Difference (degrees)	2.0	0.0	2.0
TC Meets Method 5 Specifications: (± 2.0 °F)	YES	YES	YES

Reviewed by:

THERMOCOUPLE CALIBRATION

Meter Out **THERMOCOUPLE ID** **C9-O**

Cal Date: **1/5/2017**

CALIBRATION TECHNICIAN: **HLP**

REFERENCE STANDARDS	TRACEABILITY	DATE	LABORATORY
Hart Scientific 9103-A s/n A1B289	Report No. T15-1116-JC-2	11/16/2015	NBS Calibrations
Fluke 9144 s/n B5A077	Report No. 7060.00-205700-001	1/20/2016	JM Test Systems

Temperature Calibration Points	20	70	150
Reference Deg F (To)	20	70	150
Probe Temp (deg F)	22.0	71.0	148.0
Difference (degrees)	2.0	1.0	2.0
TC Meets Method 5 Specifications: (± 2.0 °F)	YES	YES	YES

Reviewed by:

BARR

THERMOCOUPLE CALIBRATION

Meter In **THERMOCOUPLE ID** **C10-I**

Cal Date: **4/10/2017**

CALIBRATION TECHNICIAN: **DAH**

REFERENCE STANDARDS	TRACEABILITY	DATE	LABORATORY
Hart Scientific 9103-A s/n A1B289	Report No. T15-1116-JC-2	11/16/2015	NBS Calibrations
Fluke 9144 s/n B5A077	Report No. 7060.00-205700-001	1/20/2016	JM Test Systems

Temperature Calibration Points	20	70	150
Reference Deg F (To)	20	70	150
Probe Temp (deg F)	22.0	71.0	149.0
Difference (degrees)	2.0	1.0	1.0
TC Meets Method 5 Specifications: (± 2.0 °F)	YES	YES	YES

Reviewed by:

THERMOCOUPLE CALIBRATION

Meter In **THERMOCOUPLE ID** **C10-O**

Cal Date: **4/10/2017**

CALIBRATION TECHNICIAN: **DAH**

REFERENCE STANDARDS	TRACEABILITY	DATE	LABORATORY
Hart Scientific 9103-A s/n A1B289	Report No. T15-1116-JC-2	11/16/2015	NBS Calibrations
Fluke 9144 s/n B5A077	Report No. 7060.00-205700-001	1/20/2016	JM Test Systems

Temperature Calibration Points	20	70	150
Reference Deg F (To)	20	70	150
Probe Temp (deg F)	22.0	70.0	148.0
Difference (degrees)	2.0	0.0	2.0
TC Meets Method 5 Specifications: (± 2.0 °F)	YES	YES	YES

Reviewed by:

THERMOCOUPLE CALIBRATION

Meter In **THERMOCOUPLE ID** **C12-I**

Cal Date: **1/31/2017** **DGM Inlet TC**

CALIBRATION TECHNICIAN: **LTR**

REFERENCE STANDARDS	TRACEABILITY	DATE	LABORATORY
Hart Scientific 9103-A s/n A1B289	Report No. T15-1116-JC-2	11/16/2015	NBS Calibrations
Fluke 9144 s/n B5A077	Report No. 7060.00-205700-001	1/20/2016	JM Test Systems

Temperature Calibration Points	20	70	150
Reference Deg F (To)	20	70	150
Probe Temp (deg F)	22.0	70.0	148.0
Difference (degrees)	2.0	0.0	2.0
TC Meets Method 5 Specifications: (± 2.0 °F)	YES	YES	YES

Reviewed by:

BARR

THERMOCOUPLE CALIBRATION

Meter Out **THERMOCOUPLE ID** **C12-O**

Cal Date: **1/31/2017** **DGM Outlet TC**

CALIBRATION TECHNICIAN: **LTR**

REFERENCE STANDARDS	**TRACEABILITY**	**DATE**	**LABORATORY**
Hart Scientific 9103-A s/n A1B289	**Report No. T15-1116-JC-2**	**11/16/2015**	**NBS Calibrations**
Fluke 9144 s/n B5A077	**Report No. 7060.00-205700-001**	**1/20/2016**	**JM Test Systems**

Temperature Calibration Points	**20**	**70**	**150**
Reference Deg F (To)	20	70	150
Probe Temp (deg F)	22.0	70.0	148.0
Difference (degrees)	2.0	0.0	2.0
TC Meets Method 5 Specifications: (± 2.0 °F)	YES	YES	YES

Reviewed by:

BARR

THERMOCOUPLE CALIBRATION

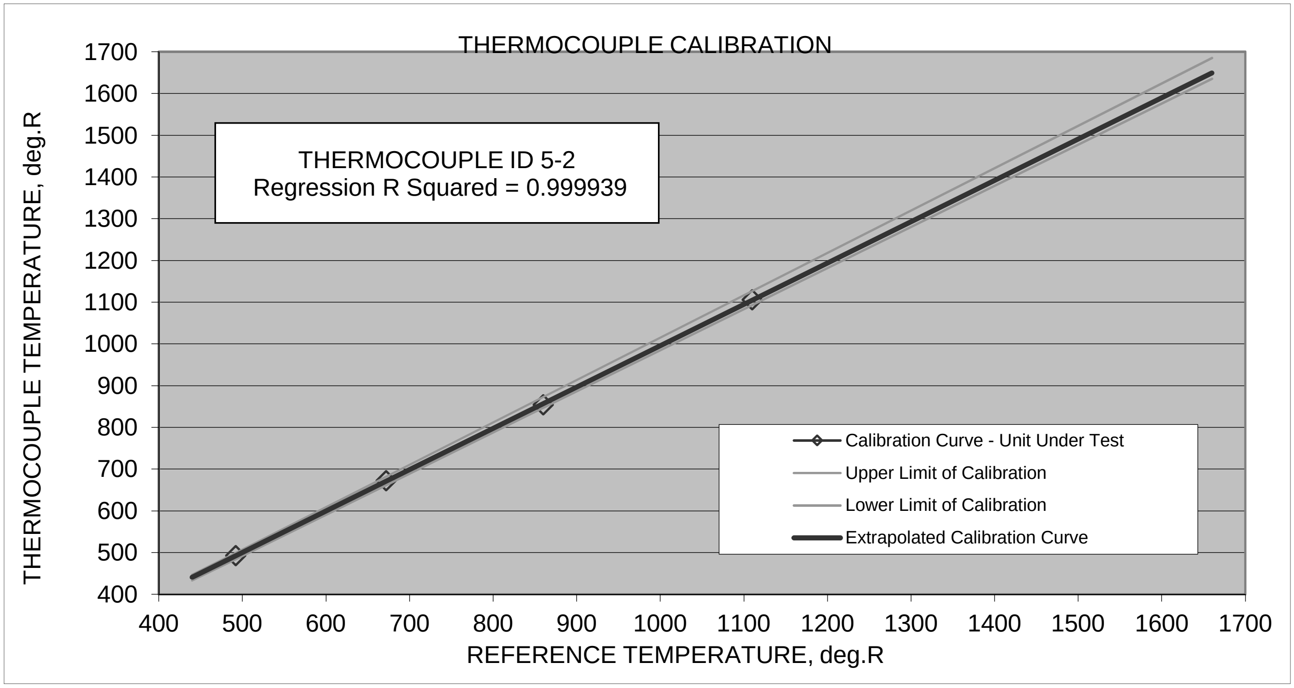
THERMOCOUPLE ID **5-2**

Cal Date: **12/30/2016** **Probe**

CALIBRATION TECHNICIAN: **HLP**

REFERENCE STANDARDS	**TRACEABILITY**	**DATE**	**LABORATORY**
Hart Scientific 9103-A s/n A1B289	**Report No. T15-1116-JC-2**	**11/16/2015**	**NBS Calibrations**
Fluke 9144 s/n B5A077	**Report No. 7060.00-205700-001**	**1/20/2016**	**JM Test Systems**

Temperature Calibration Points	**32**	**212**	**400**	**650**	**Ambient**
Reference Deg F (To)	32	212	400	650	70
Probe Temp (deg F)	33	212	394	646	70
Reference Temp (deg R) deg F + 460	492	672	860	1110	530
Probe Temp (deg R), deg F + 460	493	672	854	1106	530
Difference (degrees)	-1	0	6	4	0
% Diff Abs. T	0.2%	0.0%	0.7%	0.4%	0.0%
Is difference less than 1.5% at all measured points?	YES				



Are extrapolated limits less than 1.5%? YES

FAHRENHEIT
CALIBRATION RANGE
-20 1200

If not acceptable, describe corrective action:

Reviewed by:

BARR

THERMOCOUPLE CALIBRATION

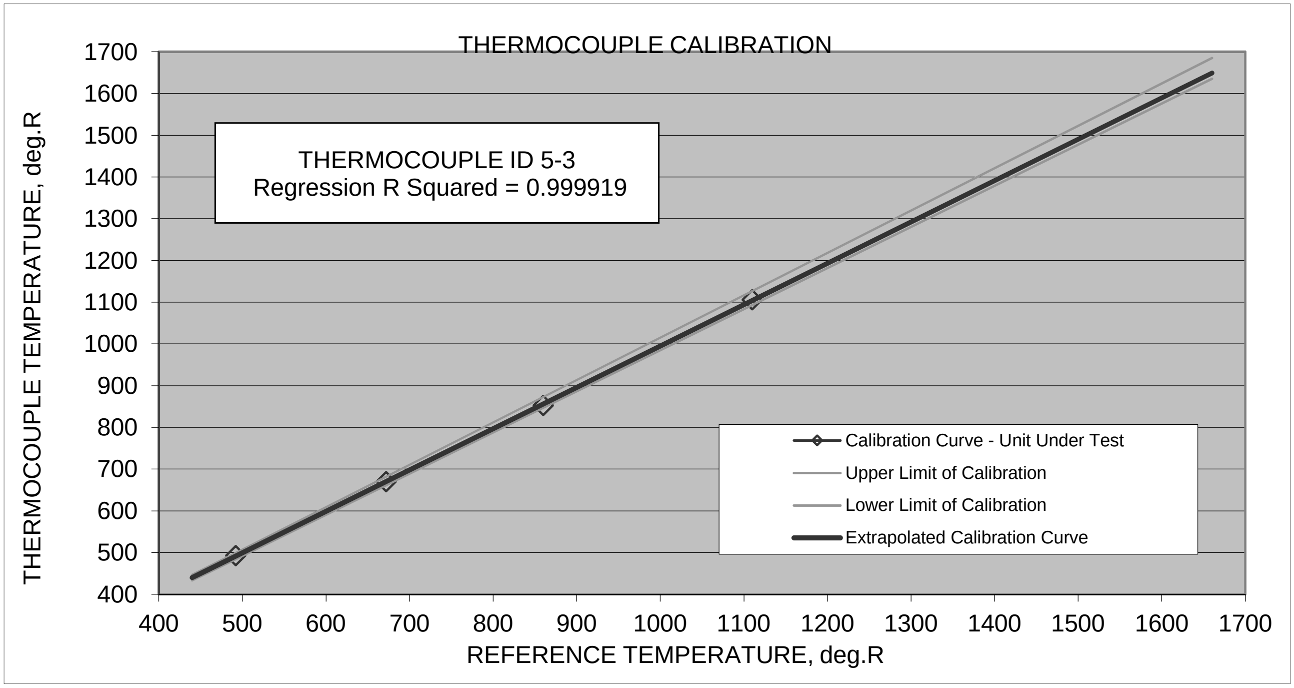
THERMOCOUPLE ID **5-3**

Cal Date: **1/2/2017** **Probe**

CALIBRATION TECHNICIAN: **HLP**

REFERENCE STANDARDS	**TRACEABILITY**	**DATE**	**LABORATORY**
Hart Scientific 9103-A s/n A1B289	**Report No. T15-1116-JC-2**	**11/16/2015**	**NBS Calibrations**
Fluke 9144 s/n B5A077	**Report No. 7060.00-205700-001**	**1/20/2016**	**JM Test Systems**

Temperature Calibration Points	**32**	**212**	**400**	**650**	**Ambient**
Reference Deg F (To)	32	212	400	650	70
Probe Temp (deg F)	33	210	393	646	70
Reference Temp (deg R) deg F + 460	492	672	860	1110	530
Probe Temp (deg R), deg F + 460	493	670	853	1106	530
Difference (degrees)	-1	2	7	4	0
% Diff Abs. T	0.2%	0.3%	0.8%	0.4%	0.0%
Is difference less than 1.5% at all measured points?	YES				



Are extrapolated limits less than 1.5%? YES

FAHRENHEIT
CALIBRATION RANGE
-20 1200

If not acceptable, describe corrective action:

Reviewed by:

BARR

THERMOCOUPLE CALIBRATION

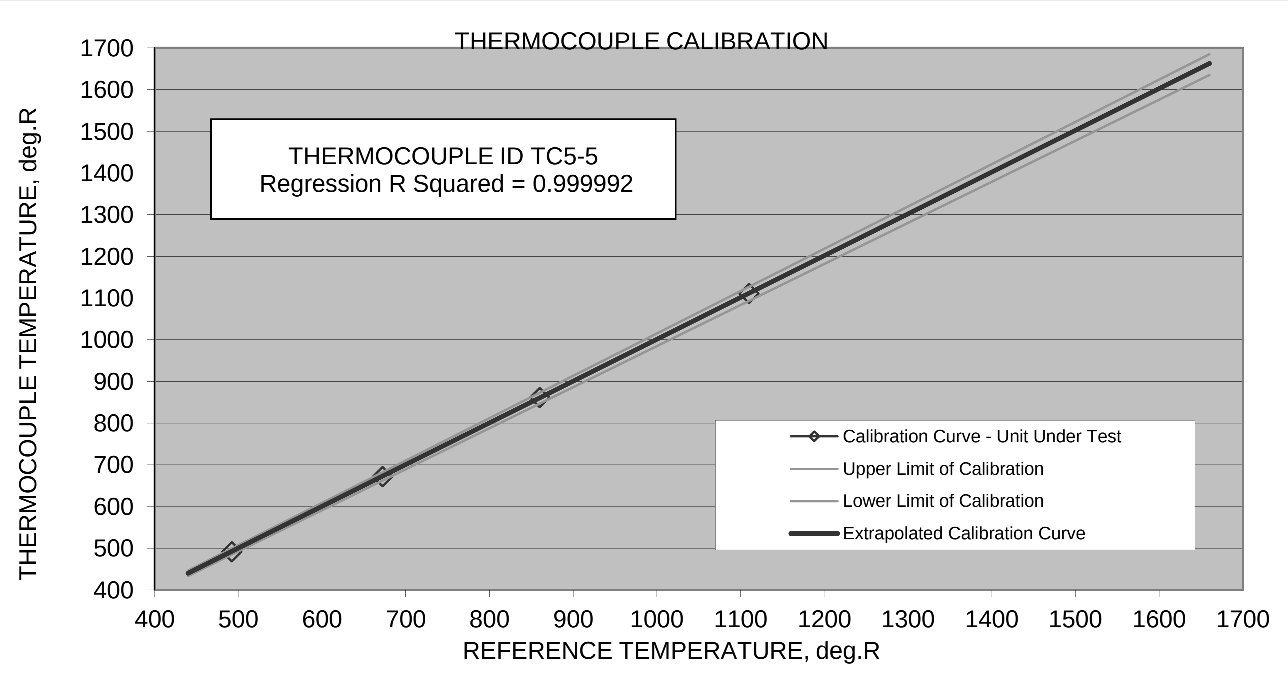
THERMOCOUPLE ID **TC5-5**

Cal Date: **1/30/2017** **Method 5 Probe**

CALIBRATION TECHNICIAN: **LTR**

REFERENCE STANDARDS	TRACEABILITY	DATE	LABORATORY
Hart Scientific 9103-A s/n A1B289	Report No. T15-1116-JC-2	11/16/2015	NBS Calibrations
Fluke 9144 s/n B5A077	Report No. 7060.00-205700-001	1/20/2016	JM Test Systems

Temperature Calibration Points	**32**	**212**	**400**	**650**	**Ambient**
Reference Deg F (To)	32	212	400	650	70
Probe Temp (deg F)	32	212	402	651	70
Reference Temp (deg R) deg F + 460	492	672	860	1110	530
Probe Temp (deg R), deg F + 460	492	672	862	1111	530
Difference (degrees)	0	0	-2	-1	0
% Diff Abs. T	0.0%	0.0%	0.2%	0.1%	0.0%
Is difference less than 1.5% at all measured points?	YES				



Are extrapolated limits less than 1.5%? YES

FAHRENHEIT
CALIBRATION RANGE
-20 1200

If not acceptable, describe corrective action:

Reviewed by:

THERMOCOUPLE CALIBRATION

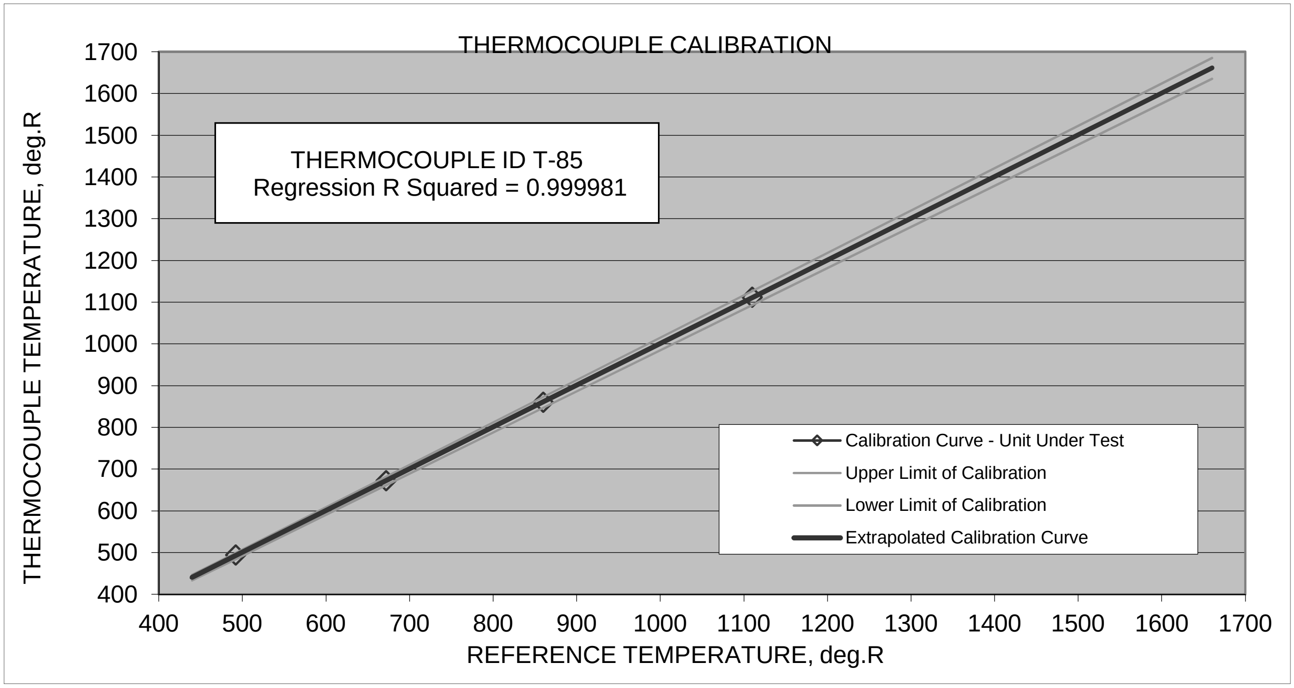
THERMOCOUPLE ID **T-85**

Cal Date: **12/28/2016** **Handheld**

CALIBRATION TECHNICIAN: **HLP**

REFERENCE STANDARDS	TRACEABILITY	DATE	LABORATORY
Hart Scientific 9103-A s/n A1B289	**Report No. T15-1116-JC-2**	**11/16/2015**	**NBS Calibrations**
Fluke 9144 s/n B5A077	**Report No. 7060.00-205700-001**	**1/20/2016**	**JM Test Systems**

Temperature Calibration Points	32	212	400	650	Ambient
Reference Deg F (To)	32	212	400	650	70
Probe Temp (deg F)	34	212	400	652	70
Reference Temp (deg R) deg F + 460	492	672	860	1110	530
Probe Temp (deg R), deg F + 460	494	672	860	1112	530
Difference (degrees)	-2	0	0	-2	0
% Diff Abs. T	0.4%	0.0%	0.0%	0.2%	0.0%
Is difference less than 1.5% at all measured points?	YES				



Are extrapolated limits less than 1.5%? YES

FAHRENHEIT
CALIBRATION RANGE
-20 1200

If not acceptable, describe corrective action:

Reviewed by:

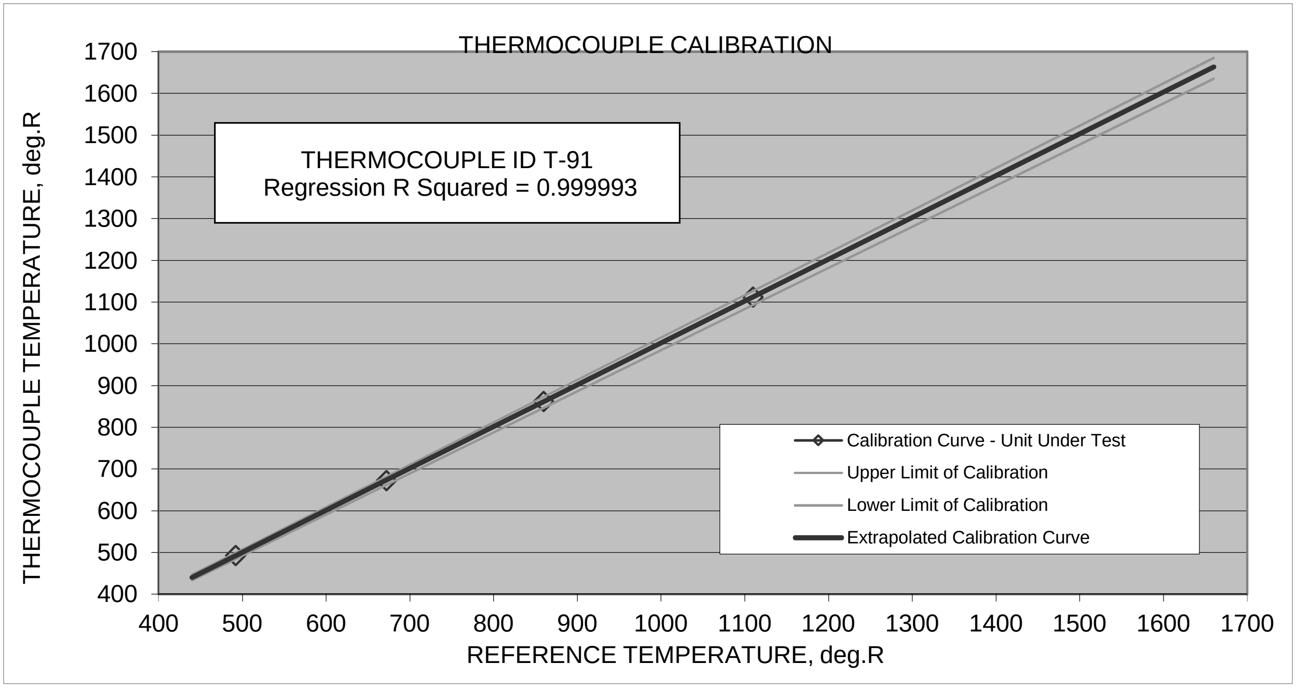
BARR

THERMOCOUPLE CALIBRATION

		THERMOCOUPLE ID	**T-91**
Cal Date:	**12/28/2016**		**Handheld**
		CALIBRATION TECHNICIAN:	**HLP**

REFERENCE STANDARDS	**TRACEABILITY**	**DATE**	**LABORATORY**
Hart Scientific 9103-A s/n A1B289	**Report No. T15-1116-JC-2**	**11/16/2015**	**NBS Calibrations**
Fluke 9144 s/n B5A077	**Report No. 7060.00-205700-001**	**1/20/2016**	**JM Test Systems**
Pyrometer Reference	**D-18**		

Temperature Calibration Points	**32**	**212**	**400**	**650**	**Ambient**
Reference Deg F (To)	32	212	400	650	70
Probe Temp (deg F)	33	212	402	652	70
Reference Temp (deg R) deg F + 460	492	672	860	1110	530
Probe Temp (deg R), deg F + 460	493	672	862	1112	530
Difference (degrees)	-1	0	-2	-2	0
% Diff Abs. T	0.2%	0.0%	0.2%	0.2%	0.0%
Is difference less than 1.5% at all measured points?	YES				



		FAHRENHEIT CALIBRATION RANGE	
Are extrapolated limits less than 1.5%?	YES	-20	1200

If not acceptable, describe corrective action:

Reviewed by:

BARR

THERMOCOUPLE CALIBRATION

Impinger Outlet **THERMOCOUPLE ID TIO-6000**

Cal Date: **4/10/2017** **Umbilical 200-4**

CALIBRATION TECHNICIAN: **DAH**

REFERENCE STANDARDS	TRACEABILITY	DATE	LABORATORY
Hart Scientific 9103-A s/n A1B289	Report No. T15-1116-JC-2	11/16/2015	NBS Calibrations
Fluke 9144 s/n B5A077	Report No. 7060.00-205700-001	1/20/2016	JM Test Systems

Temperature Calibration Points	20	70	150
Reference Deg F (To)	20	70	150
Probe Temp (deg F)	22.0	70.0	149.0
Difference (degrees)	2.0	0.0	1.0
TC Meets Method 5 Specifications: (± 2.0 °F)	YES	YES	YES

Reviewed by:

THERMOCOUPLE CALIBRATION

Impinger Outlet TC **THERMOCOUPLE ID** **TIO-6268**

Cal Date: **1/25/2017** **Umbilical** **200-2**

CALIBRATION TECHNICIAN: **LTR**

REFERENCE STANDARDS	**TRACEABILITY**	**DATE**	**LABORATORY**
Hart Scientific 9103-A s/n A1B289	**Report No. T15-1116-JC-2**	**11/16/2015**	**NBS Calibrations**
Fluke 9144 s/n B5A077	**Report No. 7060.00-205700-001**	**1/20/2016**	**JM Test Systems**

Temperature Calibration Points	**20**	**70**	**150**
Reference Deg F (To)	20	70	150
Probe Temp (deg F)	22.0	70.0	148.0
Difference (degrees)	2.0	0.0	2.0
TC Meets Method 5 Specifications: (± 2.0 °F)	YES	YES	YES

Reviewed by:

BARR

THERMOCOUPLE CALIBRATION

Impinger Outlet **THERMOCOUPLE ID** **TIO-1**

Cal Date: **1/5/2017** **Umbilical** **300-1**

CALIBRATION TECHNICIAN: **HLP**

REFERENCE STANDARDS	**TRACEABILITY**	**DATE**	**LABORATORY**
Hart Scientific 9103-A s/n A1B289	**Report No. T15-1116-JC-2**	**11/16/2015**	**NBS Calibrations**
Fluke 9144 s/n B5A077	**Report No. 7060.00-205700-001**	**1/20/2016**	**JM Test Systems**

Temperature Calibration Points	**20**	**70**	**150**
Reference Deg F (To)	21	70	150
Probe Temp (deg F)	21.0	71.0	149.0
Difference (degrees)	0.0	1.0	1.0
TC Meets Method 5 Specifications: (± 2.0 °F)	YES	YES	YES

Reviewed by:

THERMOCOUPLE CALIBRATION

Impinger Outlet **THERMOCOUPLE ID** **TIO-1253**

Cal Date: **1/5/2017** **Umbilical** **200-5**

CALIBRATION TECHNICIAN: **HLP**

REFERENCE STANDARDS	**TRACEABILITY**	**DATE**	**LABORATORY**
Hart Scientific 9103-A s/n A1B289	**Report No. T15-1116-JC-2**	**11/16/2015**	**NBS Calibrations**
Fluke 9144 s/n B5A077	**Report No. 7060.00-205700-001**	**1/20/2016**	**JM Test Systems**

Temperature Calibration Points	**20**	**70**	**150**
Reference Deg F (To)	20	70	150
Probe Temp (deg F)	21.0	71.0	150.0
Difference (degrees)	1.0	1.0	0.0
TC Meets Method 5 Specifications: (± 2.0 °F)	YES	YES	YES

Reviewed by:

THERMOCOUPLE CALIBRATION

Impinger Outlet		**THERMOCOUPLE ID**	**TIO-2162**
Cal Date:	**1/5/2017**	**Umbilical**	**200-1**
		CALIBRATION TECHNICIAN:	**HLP**

REFERENCE STANDARDS	**TRACEABILITY**	**DATE**	**LABORATORY**
Hart Scientific 9103-A s/n A1B289	**Report No. T15-1116-JC-2**	**11/16/2015**	**NBS Calibrations**
Fluke 9144 s/n B5A077	**Report No. 7060.00-205700-001**	**1/20/2016**	**JM Test Systems**

Temperature Calibration Points	**20**	**70**	**150**
Reference Deg F (To)	20	70	150
Probe Temp (deg F)	21.0	71.0	148.0
Difference (degrees)	1.0	1.0	2.0
TC Meets Method 5 Specifications: (± 2.0 °F)	YES	YES	YES

Reviewed by:

BARR

THERMOCOUPLE CALIBRATION

Impinger Outlet **THERMOCOUPLE ID TIO-5843**
Cal Date: **1/5/2017** **Umbilical 200-3**
CALIBRATION TECHNICIAN:

REFERENCE STANDARDS	**TRACEABILITY**	**DATE**	**LABORATORY**
Hart Scientific 9103-A s/n A1B289	**Report No. T15-1116-JC-2**	**11/16/2015**	**NBS Calibrations**
Fluke 9144 s/n B5A077	**Report No. 7060.00-205700-001**	**1/20/2016**	**JM Test Systems**

Temperature Calibration Points	**20**	**70**	**150**
Reference Deg F (To)	20	70	150
Probe Temp (deg F)	22.0	70.0	148.0
Difference (degrees)	2.0	0.0	2.0
TC Meets Method 5 Specifications: (± 2.0 °F)	YES	YES	YES

Reviewed by:

Nozzle Calibration
Indurating Furnace Stack C (SV016)

BPAC/HPAC Screening

Nozzle Calibration

Nozzle No. 2-7

Used for Runs: 1 - 3

Point	Measurement, inches
1	0.213
2	0.214
3	0.215
Average	0.214

Test Date 1/17-18/2017
Date Measured: 1/17/2017
Technician: Mark Petersen

Nozzle Calibration
Indurating Furnace Stack D (SV017)

BPAC/HPAC Screening

Nozzle Calibration

Nozzle No. 5-7

Used for Runs: 1 - 3

Point	Measurement, inches
1	0.217
2	0.217
3	0.217
Average	0.217

Test Date 1/17-18/2017

Date Measured: 1/17/2017

Technician: Mark Petersen

Nozzle Calibration
Indurating Furnace Stack A (SV014)

Longterm 1

Nozzle Calibration

Nozzle No. A-1

Used for Runs: 1 - 3

Point	Measurement, inches
1	0.215
2	0.214
3	0.215
Average	0.215

Test Date 2/8/2017

Date Measured: 2/7/2017

Technician: RMP

Nozzle Calibration
Indurating Furnace Stack B (SV015)

Longterm 1

Nozzle Calibration

Nozzle No. B-1

Used for Runs: 1 - 3

Point	Measurement, inches
1	0.214
2	0.215
3	0.215
Average	0.215

Test Date 2/9/2017

Date Measured: 2/9/2017

Technician: MJN

Nozzle Calibration
Indurating Furnace Stack C (SV016)

Longterm 1

Nozzle Calibration

Nozzle No. C-1

Used for Runs: 1 - 3

Point	Measurement, inches
1	0.214
2	0.215
3	0.214
Average	0.214

Test Date 2/8/2017

Date Measured: 2/7/2017

Technician: RMP

Nozzle Calibration
Indurating Furnace Stack D (SV017)

Longterm 1

Nozzle Calibration

Nozzle No. D-1

Used for Runs: 1 - 3

Point	Measurement, inches
1	0.215
2	0.214
3	0.214
Average	0.214

Test Date 2/9/2017

Date Measured: 2/9/2017

Technician: MJN

Nozzle Calibration
Indurating Furnace Stack A (SV014)

Longterm 2

Nozzle Calibration

Nozzle No. A-1

Used for Runs: 1 - 3

Point	Measurement, inches
1	0.213
2	0.212
3	0.213
Average	0.213

Test Date 3/28/2017

Date Measured: 3/27/2017

Technician: R. Pantzke

Nozzle Calibration
Indurating Furnace Stack B (SV015)

Longterm 2

Nozzle Calibration

Nozzle No. B-1

Used for Runs: 1 - 3

Point	Measurement, inches
1	0.213
2	0.214
3	0.213
Average	0.213

Test Date 3/29/2017

Date Measured: 3/28/2017

Technician: R. Pantzke

Nozzle Calibration
Indurating Furnace Stack C (SV016)

Longterm 2

Nozzle Calibration

Nozzle No. C-1

Used for Runs: 1 - 3

Point	Measurement, inches
1	0.210
2	0.209
3	0.210
Average	0.210

Test Date 3/28/2017

Date Measured: 3/27/2017

Technician: R. Pantzke

Nozzle Calibration
Indurating Furnace Stack D (SV017)

Longterm 2

Nozzle Calibration

Nozzle No. D-1

Used for Runs: 1 - 3

Point	Measurement, inches
1	0.209
2	0.210
3	0.210
Average	0.210

Test Date 3/29/2027

Date Measured: 3/28/2017

Technician: R. Pantzke

Field Barometer Calibration

Calibration to PRINCO Mercury Barometer

Barr Engineering Company Edina Field Office

		Reference PRINCO		Field Barometer					
Date	Technician	Observation Time	Station Pressure	ID	Time	Barometric Pressure	Condition	Remarks	Offset tolerance +/- 0.10
2/3/2017	BAW	1000	29.34	BA-19	1000	29.34	In Calibration	As Found	0.00
5/1/17	BAW	1000	29.15	BA-19	1000	29.20	In Calibration	As Found	0.05

Appendix E

Cylinder Gas Certifications

PRAXAIR

Praxair Distribution, Inc.
6055 Brent Drive
Toledo, OH 43611
Tel: +1 (419) 729-7732
Fax: +1 (419) 729-2411

10/26/2016

PRAXAIR PKG ROSEVILLE MN P
2455 ROSEGATE
ROSEVILLE, MN 55113

Work Order No. **70134884**
Customer Reference No. **78130854**

Product Lot/Batch No. **0920VC16**
Product Part No. **NI 5.5CE-AS**

CERTIFICATE OF ANALYSIS

Nitrogen, 5.5 Continuous Emission Monitoring Zero

Analytes	Specification	Analytical Results	Analytical Principle	Analytical Accuracy
Nitrogen	**99.9995%**	**99.9995%**	**N**	**N/A**
Oxygen	**< 0.5 ppm**	**< 0.1 ppm**	**W**	**± 15%**
Water	**< 2 ppm**	**< 0.5 ppm**	**P**	**± 10%**
Carbon Dioxide	**< 1 ppm**	**ND**	**L**	**± 10%**
Carbon Monoxide	**< 0.5 ppm**	**ND**	**L**	**± 15%**
Total Hydrocarbons	**< 0.1 ppm**	**ND**	**L**	**± 15%**
Oxides of Nitrogen	**< 0.1 ppm**	**< 0.1 ppm**	**L**	**± 15%**
Sulfur Dioxide	**< 0.1 ppm**	**ND**	**L**	**± 15%**

Analytical Instruments: **Delta F~SF30555S~~**
Panametrics~MISPE~~
MKS~2031 FTIR~~

Cylinder Style: **AS**
Cylinder Pressure @70F: **2000 psig**
Cylinder Volume: **142 ft3**
Valve Outlet Connection: **580**
Cylinder No(s). **EB0013783**
Comments: **Batch: CC167620, CC402300, CC101995, EB0025782, CC155530, CC218156, CC77464, SA22291, CC254034, SA9939, EB0022486**

Filling Method: **Temperature/Pressure**
Date of Fill: **09/20/2016**

QA Reviewer: **Rolonda Kaywood**

Tera Thomas

Approved Signer: **Tera Thomas**

This analysis of the product described herein was prepared by Praxair Distribution, Inc. using instruments whose calibration is certified using Praxair Distribution, Inc. Reference Materials. Praxair Distribution, Inc. Reference Materials are prepared either by weights traceable to the National Institute of Standards and Technology (NIST), Measurement Canada or by using NIST Standard Reference Materials where available.

Note: All expressions for concentration (e.g., % or ppm) are for gas phase, by volume (e.g., ppmv) unless otherwise noted.

Key to Analytical Techniques:

A	Flame Ionization with Methanizer
E	Gas Chromatography with Flame Photometric Detector
I	Gas Chromatography with Reduction Gas Analyzer
M	Mass Spectrometry - MS or GC/MS
Q	Total Hydrocarbon Analyzer
U	Chemiluminescence
Y	Vendor Analysis
B	Gas Chromatography with Discharge Ionization Detector
F	Gas Chromatography with Helium Ionization Detector
J	Gas Chromatography with Thermal Conductivity Detector
N	By Difference of Typical Impurities
R	Wet Chemical
V	Gravimetric
C	Gas Chromatography with Electrolytic Conductivity Detector
G	Gas Chromatography with Methanizer Carbonizer
K	Binary Gas Analyzer with Thermal Conductivity Detector
O	Paramagnetic
S	Detector Tube
W	Electrolytic Cell/Electrochemical
D	Gas Chromatography with Flame Ionization Detector
H	Gas Chromatography with Photoionization Detector
L	Infrared - FTIR or NDIR
P	Specific Water Analyzer
T	Odor
X	UV Spectrometry

IMPORTANT
The information contained herein has been prepared at your request by personnel within Praxair Distribution, Inc. While we believe the information is accurate within the limits of the analytical methods employed and is complete to the extent of the specific analyses performed, we make no warranty or representation as to the suitability of the use of the information for any particular purpose. The information is offered with the understanding that any use of the information is at the sole discretion and risk of the user. In no event shall liability of Praxair Distribution, Inc. arising out of the use of the

AMERICAN GAS GROUP

Specialty Gases of America, Inc.
6055 Brent Drive
Toledo, OH 43611
Tel: +1 (419) 729-7732
Fax: +1 (419) 729-2411

12/08/2016

TOLL GAS & WELDING SUPPLY
3005 NIAGARA LANE NORTH
PLYMOUTH, MN 55447

Work Order No. **86510011**
Customer Reference No. **78159132**
Product Lot/Batch No. **N70001633603**
Product Part No. **NI 5.5CE-AS**

CERTIFICATE OF ANALYSIS

Nitrogen, 5.5 Continuous Emission Monitoring Zero

Analytes	Specification	Analytical Results	Analytical Principle	Analytical Accuracy
Nitrogen	**99.9995%**	**99.9995%**	**N**	**N/A**
Oxygen	**< 0.5 ppm**	**< 0.2 ppm**	**W**	**± 15%**
Water	**< 2 ppm**	**< 0.4 ppm**	**P**	**± 10%**
Carbon Dioxide	**< 1 ppm**	**ND**	**L**	**± 10%**
Carbon Monoxide	**< 0.5 ppm**	**ND**	**L**	**± 15%**
Total Hydrocarbons	**< 0.1 ppm**	**ND**	**L**	**± 15%**
Oxides of Nitrogen	**< 0.1 ppm**	**ND**	**L**	**± 15%**
Sulfur Dioxide	**< 0.1 ppm**	**< 0.1 ppm**	**L**	**± 15%**

Analytical Instruments: **Delta F~SF30555S~~**
Panametrics~MISPE~~
MKS~2031 FTIR~~

Cylinder Style: **AS**
Cylinder Pressure @70F: **2000 psig**
Cylinder Volume: **142 ft3**
Valve Outlet Connection: **580**
Cylinder No(s): **CC276219**
Comments: **Batch: CC244717, CC240978, CC249664, CC263620**

Filling Method: **Temperature/Pressure**
Date of Fill: **12/01/2016**

Tera Thomas

QA Reviewer: **Rolonda Kaywood**

Approved Signer: **Tera Thomas**

This analysis of the product described herein was prepared by Specialty Gases of America, Inc. using instruments whose calibration is certified using Specialty Gases of America, Inc. Reference Materials. Specialty Gases of America, Inc. Reference Materials are prepared either by weights traceable to the National Institute of Standards and Technology (NIST), Measurement Canada or by using NIST Standard Reference Materials where available.

Note: All expressions for concentration (e.g., % or ppm) are for gas phase, by volume (e.g., ppmv) unless otherwise noted.

Key to Analytical Techniques:

A	Flame Ionization with Methanizer	B	Gas Chromatography with Discharge Ionization Detector	C	Gas Chromatography with Electrolytic Conductivity Detector	D	Gas Chromatography with Flame Ionization Detector
E	Gas Chromatography with Flame Photometric Detector	F	Gas Chromatography with Helium Ionization Detector	G	Gas Chromatography with Methanizer Carbonizer	H	Gas Chromatography with Photoionization Detector
I	Gas Chromatography with Reduction Gas Analyzer	J	Gas Chromatography with Thermal Conductivity Detector	K	Binary Gas Analyzer with Thermal Conductivity Detector	L	Infrared - FTIR or NDIR
M	Mass Spectrometry - MS or GC/MS	N	By Difference of Typical Impurities	O	Paramagnetic	P	Specific Water Analyzer
Q	Total Hydrocarbon Analyzer	R	Wet Chemical	S	Detector Tube	T	Odor
U	Chemiluminescence	V	Gravimetric	W	Electrolytic Cell/Electrochemical	X	UV Spectrometry
Y	Vendor Analysis						

IMPORTANT
The information contained herein has been prepared at your request by personnel within Specialty Gases of America, Inc.. While we believe the information is accurate within the limits of the analytical methods employed and is complete to the extent of the specific analyses performed, we make no warranty or representation as to the suitability of the use of the information for any particular purpose. The information is offered with the understanding that any use of the information is at the sole discretion and risk of the user. In no event shall liability of Specialty Gases of America, Inc. arising out of the use of the information contained herein exceed the fee established for providing such information.

SCOTT-MARRIN, INC. PGVP Vendor ID: H12015
6531 Box Springs Blvd • Riverside, CA 92507-0725
Phone: +1(951)653-6780 • Fax: +1(951)653-2430 • www.scottmarrin.com

Report Of Analysis
EPA Protocol Gas Mixtures

TO: BARR01
Barr Engineering Co
Attn: Benjamin Wiltse
5150 West 76th Street
Edina, MN 55439-2900
(952) 832-2885

REPORT NO: 67349-01
REPORT DATE: December 15, 2015
CUSTOMER PO NO: BAW11102015

CYLINDER SIZE: 150A (141 std cu ft)
CYLINDER NUMBER: **CC116801**
CYLINDER PRESSURE: 2000 psig

COMPONENT	MOLAR CONCENTRATION ± EXPANDED UNCERTAINTY	REFERENCE STANDARD		ANALYZER MAKE, MODEL, S/N, DETECTION		REPLICATE ANALYSIS DATA
Carbon dioxide	9.51 ± 0.1 %	GMIS	SRM 1674b	Varian Model 3400		12/7/2015
			Samp#: 7-H-39	Serial # 10680		9.51 %
		Cyl#: CC116770	Cyl#: FF10598	Thermal Conductivity		9.51 %
		7.99 ± 0.08 %	6.944 ± 0.013 %	Gas Chromotography		9.50 %
		Exp: 3/18/2022	Exp: 6/17/2019	**LAST CAL DATE:** 12/7/2015	x̄ :	9.51 %
Oxygen	9.46 ± 0.05 %	GMIS	SRM 2658a	Varian Model 3800		12/4/2015
			Samp#: 72-D-37	Serial # None		9.46 %
		Cyl#: CC51181	Cyl#: CAL016820	Thermal Conductivity		9.46 %
		10.06 ± 0.05 %	9.918 ± 0.022 %	Gas Chromotography		9.46 %
		Exp: 5/6/2021	Exp: 6/1/2017	**LAST CAL DATE:** 12/4/2015	x̄ :	9.46 %
Nitrogen	Balance					

CERTIFICATION DATE: December 4, 2015 **EPA EXPIRATION DATE:** December 5, 2023

ppm = µmole/mole **% = mole-%** **x̄ = EPA weighted mean**

The above analyses were performed in accordance with Procedure G1 of the EPA Traceability Protocol, Report Number EPA600/R-12/531, dated May 2012.

The above analyses should not be used if the cylinder pressure is less than 100 psig.

ANALYST: ______________________ **APPROVED:** ______________________
M.S.Calhoun J. T. Marrin

The only liability of this company for gas which fails to comply with this analysis shall be replacement or reanalysis thereof by the company without extra cost.

SCOTT-MARRIN, INC. PGVP Vendor ID: H12013
6531 Box Springs Blvd • Riverside, CA 92507-0725
Phone: +1(951)653-6780 • Fax: +1(951)653-2430 • www.scottmarrin.com

Report Of Analysis
EPA Protocol Gas Mixtures

TO: BARR01
Barr Engineering Co
Attn: Benjamin Wiltse
5150 West 76th Street
Edina, MN 55439-2900
(952) 832-2885

REPORT NO: 64614-01
REPORT DATE: March 24, 2014
CUSTOMER PO NO: BAW02142014

CYLINDER SIZE: 150A (141 std cu ft)
CYLINDER NUMBER: **CC115022**
CYLINDER PRESSURE: 2000 psig

COMPONENT	CONCENTRATION (v/v) ± EPA UNCERTAINTY	REFERENCE STANDARD		ANALYZER MAKE, MODEL, S/N, DETECTION		REPLICATE ANALYSIS DATA
Carbon dioxide	18.94 ± 0.03 %	GMIS	SRM 1675b	Varian Model 3400		3/18/2014
			Samp#: 6-34-E	Serial # 10680		18.94 %
		Cyl#: CC51172	Cyl#: CLM006499	Thermal Conductivity		18.93 %
		18.00 ± 0.03 %	14.01 ± 0.02 %	Gas Chromotography		18.94 %
		Exp: 8/2/2020	Exp: 6/16/2012	**LAST CAL DATE:** 3/17/2014	$\bar{x}$:	18.94 %
Oxygen	5.02 ± 0.04 %	GMIS	SRM 2658a	Varian Model 3800		3/19/2014
			Samp#: 72-D-37	Serial # None		5.01 %
		Cyl#: ALM026741	Cyl#: CAL016820	Thermal Conductivity		5.01 %
		5.05 ± 0.03 %	9.918 ± 0.022 %	Gas Chromotography		5.03 %
		Exp: 5/6/2021	Exp: 6/1/2017	**LAST CAL DATE:** 3/19/2014	$\bar{x}$:	5.02 %
Nitrogen	Balance					

CERTIFICATION DATE: March 18, 2014 **EPA EXPIRATION DATE:** March 19, 2022

ppm = µmole/mole **% = mole-%** **$\bar{x}$ = EPA weighted mean**

The above analyses were performed in accordance with Procedure G1 of the EPA Traceability Protocol, Report Number EPA600/R-12/531, dated May 2012.

The above analyses should not be used if the cylinder pressure is less than 100 psig.

ANALYST: ____________________ **APPROVED:** ____________________

M.S.Calhoun J. T. Marrin

The only liability of this company for gas which fails to comply with this analysis shall be replacement or reanalysis thereof by the company without extra cost.

SCOTT-MARRIN, INC. PGVP Vendor ID: H12015

6531 Box Springs Blvd • Riverside, CA 92507-0725
Phone: +1(951)653-6780 • Fax: +1(951)653-2430 • www.scottmarrin.com

Report Of Analysis
EPA Protocol Gas Mixtures

BARR01
TO: Barr Engineering Co
Attn: Benjamin Wiltse
5150 West 76th Street
Edina, MN 55439-2900
(952) 832-2885

REPORT NO: 67349-02
REPORT DATE: December 15, 2015
CUSTOMER PO NO: BAW11102015

CYLINDER SIZE: 150A (141 std cu ft)
CYLINDER PRESSURE: 2000 psig

CYLINDER NUMBER: **CA06643**

COMPONENT	MOLAR CONCENTRATION ± EXPANDED UNCERTAINTY	REFERENCE STANDARD		ANALYZER MAKE, MODEL, S/N, DETECTION	REPLICATE ANALYSIS DATA
Oxygen	21.16 ± 0.05 %	GMIS	SRM 2659a	Varian Model 3800	12/4/2015
			Samp#: 71-D-23	Serial # None	21.20 %
		Cyl#: CC106787	Cyl#: CAL015788	Thermal Conductivity	21.15 %
		24.04 ± 0.05 %	20.72 ± 0.043 %	Gas Chromotography	21.14 %
		Exp: 9/3/2023	Exp: 1/1/2016	**LAST CAL DATE:** 12/4/2015	$\bar{x}$: 21.16 %
Nitrogen	Balance				

CERTIFICATION DATE: December 4, 2015 **EPA EXPIRATION DATE:** December 5, 2023

ppm = µmole/mole **% = mole-%** **$\bar{x}$ = EPA weighted mean**

The above analyses were performed in accordance with Procedure G1 of the EPA Traceability Protocol, Report Number EPA600/R-12/531, dated May 2012.

The above analyses should not be used if the cylinder pressure is less than 100 psig.

ANALYST: ____________________ **APPROVED:** ____________________

M.S.Calhoun J. T. Marrin

The only liability of this company for gas which fails to comply with this analysis shall be replacement or reanalysis thereof by the company without extra cost.

SCOTT-MARRIN, INC. PGVP Vendor ID: H12014

6531 Box Springs Blvd • Riverside, CA 92507-0725
Phone: +1(951)653-6780 • Fax: +1(951)653-2430 • www.scottmarrin.com

Report Of Analysis
EPA Protocol Gas Mixtures

TO: BARR01
Barr Engineering Co
Attn: Benjamin Wiltse
5150 West 76th Street
Edina, MN 55439-2900
(952) 832-2885

REPORT NO: 66125-03
REPORT DATE: March 2, 2015
CUSTOMER PO NO: BAW01272015

CYLINDER SIZE: 150A (141 std cu ft)
CYLINDER PRESSURE: 2000 psig
CYLINDER NUMBER: **CA03203**

COMPONENT	CONCENTRATION (v/v) ± EPA UNCERTAINTY	REFERENCE STANDARD		ANALYZER MAKE, MODEL, S/N, DETECTION	REPLICATE ANALYSIS DATA
Oxygen	21.57 ± 0.25 %	GMIS	SRM 2659a	Varian Model 3800	2/17/2015
			Samp#: 71-D-23	Serial # None	21.54 %
		Cyl#: CC88824	Cyl#: CAL015788	Thermal Conductivity	21.60 %
		24.92 ± 0.25 %	20.72 ± 0.043 %	Gas Chromotography	21.58 %
		Exp: 2/25/2021	Exp: 1/1/2016	**LAST CAL DATE:** 2/16/2015	$\bar{x}$: 21.57 %
Nitrogen	Balance				

CERTIFICATION DATE: February 17, 2015 **EPA EXPIRATION DATE:** February 18, 2023

ppm = µmole/mole **% = mole-%** **$\bar{x}$ = EPA weighted mean**

The above analyses were performed in accordance with Procedure G1 of the EPA Traceability Protocol, Report Number EPA600/R-12/531, dated May 2012.

The above analyses should not be used if the cylinder pressure is less than 100 psig.

ANALYST: ______________________ **APPROVED:** ______________________

M.S.Calhoun J. T. Marrin

The only liability of this company for gas which fails to comply with this analysis shall be replacement or reanalysis thereof by the company without extra cost.

Appendix F

Project Participants

Project Participants

ArcelorMittal Minorca Mine, Inc.

Jaime Johnson – Manager - Environmental
Nate Holmes – Process Engineer

Barr Engineering Company

Tim Russell – Vice President/Chemical Engineer
Tom Kuchinski – Stack Test Group Supervisor
Ben Wiltse – Project Manager
Dan Koschak – Senior Air Quality Technician
Mark Petersen – Senior Air Quality Technician
Tom Leier – Senior Air Quality Technician
Mike Norstrem – Air Quality Technician
John Rooney – Air Quality Technician
Ryan Pantzke – Air Quality Technician

Attachment N

Post ACI Testing Process Equipment Inspection Summary

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engineering and environmental consultants
BARR

Technical Memorandum

To: ArcelorMittal Minorca Mine
From: Barr Engineering Co.
Subject: Post ACI Testing Process Equipment Inspection Summary
Date: 11/9/2017
Project: ArcelorMittal Minorca Mine – 23691905.00

1.0 Introduction

ArcelorMittal Minorca Mine (Minorca) completed a long-term activated carbon injection (ACI) test to determine the feasibility of ACI for control of Hg emissions from the facility's furnace exhaust stacks. The carbon injected into the system is known as brominated powdered activated carbon (BPAC). The long-term ACI testing was started on January 20, 2017 and ended on April 7, 2017 (77 days). The BPAC was injected at an average rate of 1 lb BPAC / MMACF using ports at the inlet to the multiclones. The locations of the activated carbon injection ports are identified in Attachment A. Following the long-term ACI testing, Barr Engineering Co. (Barr) and Minorca performed a visual inspection of the equipment in contact with the injected carbon to identify any abnormal erosion, corrosion, material buildup or equipment issues resulting from the ACI. The inspection was performed April 25 – May 1, 2017 following a plan developed by Barr and provided to Minorca on April 24, 2017. The plan outlined the inspection points, documentation of the inspections, sample collection and the proposed sample analysis to be performed. A copy of the plan is attached to this memo (Attachment B). There are five figures attached to the plan which are referenced as Figures 1 – 5 of the plan within this document.

2.0 Inspection and Laboratory Results

The results of the inspections are summarized in the following sections based on inspection point location. Photos were taken to document any material buildup at each of the inspection points and notes were taken that included a description of each inspection point. The photos are attached to this memo (Attachment C). Each inspection point was visually inspected for any unusual signs of wear or corrosion following the ACI testing. The phrase 'good condition' is used to describe several inspection points and indicates the inspection point did not show any signs of wear or corrosion different than what is typically seen per the facility representative that escorted the inspectors. The amount of material buildup in the inspected area is described using the terms light, moderate and heavy. Light buildup is defined as areas with up to ½ inch of material; moderate buildup is ½ - 2 inches of material; heavy is 2 – 4+ inches of material with the exception of the continuous emissions monitoring system (CEMS) probes. Light buildup on the CEMS probes is defined as a visible dusting of material; moderate buildup is up to ⅛ inch of material; heavy is ⅛– ¼ inch of material. A single composite sample was collected at each sampling point by combining multiple samples spaced appropriately across the plant equipment being inspected. The samples were analyzed for carbon content using the Walkley-Black method and for bromide content using ion chromatography. The inspection plan originally called for the samples to be analyzed for bromine using a bomb calorimeter; however, most samples were unable to be combusted in the bomb calorimeter. A complete summary of the results and inspection notes is attached as Table 1.

2.1 Furnace Stacks A-D

Four inspection points were identified that were associated with the furnace stacks: at the base of the stack, at the transition area from the scrubbers to stacks, on the CEMS probe, and the CEMS particulate matter filter. The inspection points (A1, B1, C1, and D1) are identified in Figure 4 of the attached inspection plan. Buildup of material was noted in all four stacks at each inspection point and the amount of buildup is detailed in Table 1.

The areas of the stacks inspected were noted as being in good condition. The maximum percent by mass of organic carbon was 0.87% by weight for all stack inspection point samples. The organic carbon content in the material increased generally from Stack A to Stack D; however, the bromide content was quite variable from 25 mg Br / Kg of material to 1,900 mg Br / Kg of material.

The CEMS probes were in good condition upon inspection. The probes were noted as having light to moderate buildup of material in Stack A increasing to heavy buildup (1/4 inch) on the probe in Stack D. The CEMS probes in Stacks B and C had slightly less organic carbon content than those in Stacks A and D, but all results were on the same order of magnitude. The bromide content in the material on the probes in Stacks C and D were 10-15% of what was analyzed in the material on the probes in Stacks A and B. The highest bromide content analyzed was in the material on the CEMS probe in Stack B at 4,300 mg Br / Kg of material. The four CEMS particulate matter filters were analyzed using the bomb calorimeter ion analysis and all results for bromine and organic carbon were non-detect.

Table 2-1 Furnace Stack Material Analysis Results

Equipment	Inspection Point	Bromide, mg/Kg – dry	Organic Carbon, % by weight
Stack A	Base of stack (1 point)	25	0.052
	Transition area from scrubbers to stacks (1 point)	ND	0.091
	CEMS Probe	2900	1
	CEMS Filter	ND	ND
Stack B	Base of stack (1 point)	1900	0.66
	Transition area from scrubbers to stacks (1 point)	ND	0.12
	CEMS Probe	4300	0.85
	CEMS Filter	ND	ND
Stack C	Base of stack (1 point)	570	0.62
	Transition area from scrubbers to stacks (1 point)	ND	0.13
	CEMS Probe	450	0.74
	CEMS Filter	ND	ND
Stack D	Base of stack (1 point)	160	0.87
	Transition area from scrubbers to stacks (1 point)	ND	0.14
	CEMS Probe	390	1.2
	CEMS Filter	ND	ND

2.2 Furnace Stacks A-D Scrubbers

The mid-body and the lower-body of each of the four scrubbers were identified as the inspection points within the scrubbers. The inspection points (A2-A3, B2-B3, C2-C3, and D2-D3) are identified in Figure 4 of the attached inspection plan. The inspection points were in good condition upon inspection. The mid-body on the scrubbers exhausting through Stacks A-C had a light buildup of material and the Stack D scrubber was noted as having moderate buildup. The lower-body of all scrubbers had moderate buildup. A single composite sample from two sample points, one at both the front and back access doors, was collected to represent the lower-body of each scrubber. The bromide content of the material in the mid-body of the scrubber increased from 29 mg Br / Kg material in the Stack A scrubber to 2,300 mg Br / Kg material in the Stack D scrubber. The bromide content of the material in the lower-body of the scrubber ranged variably from 7 mg Br / Kg material to 200 mg Br / Kg material. The organic carbon content in the material at any scrubber inspection point did not exceed 0.5%.

Table 2-2 Furnace Stack Scrubber Material Analysis Results

Equipment	Inspection Point	Bromide, mg/Kg – dry	Organic Carbon, % by weight
Scrubber A	Mid-body (1 point)	29	0.035
	Lower-body (2 points)[1]	130	0.25
Scrubber B	Mid-body (1 point)	75	0.14
	Lower-body (2 points)[1]	200	0.21
Scrubber C	Mid-body (1 point)	490	0.24
	Lower-body (2 points)[1]	7.3	0.041
Scrubber D	Mid-body (1 point)	2300	0.5
	Lower-body (2 points)[1]	160	0.34

1 - A single composite sample from two sample points, one at both the front and back access doors, was collected to represent the lower-body of each scrubber.

2.3 Scrubber Recirculating Tank

The scrubber recirculating tank does not have access to inspect the interior of the tank, though a sample was collected from the tank drain pipe. The location of the scrubber recirculating tank (E1) is shown in Figure 2 of the attached inspection plan. The bromide analysis results were non-detect and the organic carbon content was less than 0.1%.

Table 2-3 Scrubber Recirculating Tank Material Analysis Results

Equipment	Inspection Point	Bromide, mg/Kg – dry	Organic Carbon, % by weight
Scrubber recirculating tank	Scrubber recirculating tank (1 point)	ND	0.063

2.4 Windbox Exhaust Fan

The inspection points at the inlet and outlet side of the windbox exhaust fan and the windbox belly were found to be in good condition with normal wear according to Minorca staff. The duct to fan transition at the inlet and outlet were the inspection points; the ductwork around the fan was not inspected. The locations of the inspection points (G1-G3) are identified in Figures 2 and 3 of the attached inspection plan. The windbox exhaust fan was found to have zero buildup of material for sample collection. A sample was not collected from the belly of the windbox exhaust fan because there was no buildup of material. The inlet and outlet sides of the windbox exhaust fan were inspected and found to be clean; however, samples were collected from material found on the ground outside the access doors to the windbox fan believed to represent material from the fan compartments.

Table 2-4 Windbox Exhaust Fan Material Analysis Results

Equipment	Inspection Point	Bromide, mg/Kg – dry	Organic Carbon, % by weight
Windbox Exhaust Fan	Wind box belly (1 point)[1]	N/A	N/A
	Outlet side (1 point)[2]	450	0.14
	Inlet side (2 points)[2]	290	0.78

1 - A sample was not collected from the belly of the windbox exhaust fan because there was no buildup of material.
2 - Samples were collected from material found outside the access door to the windbox fan believed to represent material from the fan compartments.

2.5 Multiclones

The multiclones included four inspection points: the sump, the cones discharge at ground level, the cones at the second level, and the top of the multiclone. The locations of the inspection points (H1-H4) are identified in Figures 2-4 of the attached inspection plan. All areas inspected were noted to be in good condition with a light buildup of material. Composite samples were collected at both the cones discharge at ground level and the cones at the second level. Each of these were comprised of material collected from three separate sampling points at the inspection point. The samples collected from cones at the ground level and the top of the multiclone had a bromide content more than an order of magnitude higher than in the material collected from the sump and the cones at the second level. The organic carbon varied between the samples collected, but was highest in the material collected from the inspection point at the top at 0.7% carbon by weight.

Table 2-5 Multiclones Material Analysis Results

Equipment	Inspection Point	Bromide, mg/Kg – dry	Organic Carbon, % by weight
Multiclone	Sump (1 point)	18	0.17
	Cones discharge at ground level (3 points)[1]	2400	0.092
	Cones at second level (3 points)[1]	150	0.077
	Top (1 point)	3300	0.68

1 - Each of these were comprised of material collected from three separate sampling points at the inspection point.

2.6 Denver Sump

The Denver Sump was inspected and found to be in good condition. The location of the Denver Sump (I1) is shown in Figure 1 of the attached inspection plan. It was noted that there was water and mud / sludge in the sump. A sample was collected and the bromide content was non-detect. The organic carbon was analyzed at 0.1% by weight.

Table 2-6 Denver Sump Material Analysis Results

Equipment	Inspection Point	Bromide, mg/Kg – dry	Organic Carbon, % by weight
Denver Sump	Denver Sump (1 point)	ND	0.098

2.7 Ducting Prior to Scrubbers

The ducting prior to the scrubbers and the access of the process gas header were inspected. The inspection points (J1 and J2) are shown in Figure 5 of the attached inspection plan. The ducting had a light buildup of material which consisted of mostly pellets with a light amount of carbon mixed in. The duct header access area had moderate to heavy buildup consisting of mostly pellets with a light amount of carbon mixed in. All areas inspected in the ducting were noted to be in good condition. There are three ducts off the process gas header. A composite sample was collected from the three ducts and a single sample was collected at the access to the process gas header. The bromide content of the sample collected from the duct work was non-detect and the sample collected from the duct header was 5.3 mg Br / Kg. The organic carbon content of both samples was less than 0.1% by weight.

Table 2-7 Scrubber Ducting Material Analysis Results

Equipment	Inspection Point	Bromide, mg/Kg – dry	Organic Carbon, % by weight
Ducting prior to scrubber	Ducting off process gas header (3 points per duct)[1]	ND	0.074
	Access of process gas header (1 point)	5.3	0.057

1 – This sample was comprised of material collected from each of the three ducts off the process gas header.

3.0 Conclusions

The post ACI injection testing inspection shows that the areas inspected were overall in good condition. There was light to moderate wear indicated on the windbox exhaust fan; however, this is not specifically due to the ACI or the bromide in the BPAC as plant personnel noted the wear was normal compared to conditions seen during previous plant outages. There is no indication that any additional wear occurred due to the ACI. The results of the bromide and organic carbon content analyses of the material samples are summarized in Table 1 attached to this memo. The maximum organic carbon content in a sample was 1.2% by weight and the bromide content of the samples varied from 0 to 4,300 mg Br / Kg material. There were no consistent elevated bromide contents with regard to specific locations in the process or equipment type. Any corrosion specifically due to the addition of bromine to the stack gases may not be evident by visual inspection after such a short test period[1].

---

[1] Investigations on bromine corrosion associated with mercury control technologies in coal flue gasYe Zhuang, Chuanmin Chen, Ron Timpe, John Pavlish; Energy and Environmental Research Center, University of North Dakota, 15 North 23rd Street, Grand Forks, ND 58203, USA and School of Environmental Science and Engineering, North China Electric Power University, Baoding 071003, Hebei Province, PR China [http://www.academia.edu/19899131/Investigations_on_bromine_corrosion_associated_with_mercury_control_technologies_in_coal_flue_gas]

Table 1

Post ACI Inspection Results Summary

TABLE 1

Post ACI Testing Inspection Results Summary

Equipment	Inspection Point ID	Inspection Point Description	Collection Date	Collection Time	Bromide, mg/Kg - dry	Organic Carbon, % by weight	Moisture, % of sample	Amount of Material Buildup	Inspection Notes
Stack “A”	A1-1	1 point - base of the stack	4/25/2017	6:05	25	0.052	18	Light to moderate	4/25/17 - 6:05 pm - Area good condition / Area not cleaned
	A1-2	1 point - transition area from the scrubbers to stacks	4/25/2017	6:03	ND	0.091	17	Light to moderate	4/25/17 - 6:03 pm - Area good condition / Area not cleaned
	A1-3	CEMS Probe	5/1/2017	11:40	2900	1	7.4	Light build-up on bottom of probe to moderate build-up on top of probe	5/1/17 - 11:40 am - Probe in good condition / Probe not cleaned
	A1-4	CEMS Filter	5/1/2017	11:50	ND	ND	ND	Amount of material buildup not documented	5/1/17 11:50 am - Filter was given as a sample
Scrubber “A”	A2	1 point at mid-body	4/25/2017	18:15	29	0.035	8.6	Light	4/25/17 - 6:15 pm - Area good condition / Area not cleaned
	A3	2 points at lower-body[1]	4/25/2017	17:59	130	0.25	26	Light to moderate	4/25/17 - 5:59 pm - Area good condition / Area not cleaned
Stack “B”	B1-1	1 point - base of the stack	4/25/2017	17:50	1900	0.66	20	Light to moderate	4/25/17 - 5:50 pm - Area good condition / Area not cleaned
	B1-2	1 point - transition area from the scrubbers to stacks	4/25/2017	17:46	ND	0.12	17	Moderate	4/25/17 - 5:46 pm - Area good condition / Area not cleaned
	B1-3	CEMS Probe	5/1/2017	11:21	4300	0.85	8.5	Light build-up on bottom of probe to moderate build-up on top of probe	5/1/17 - 11:21 am - Probe in good condition / Probe not cleaned
	B1-4	CEMS Filter	5/1/2017	11:50	ND	ND	ND	Amount of material buildup not documented	5/1/17 11:50 am - Filter was given as a sample
Scrubber “B”	B2	1 point at mid-body	4/25/2017	18:13	75	0.14	12	Light	4/25/17 - 6:13 pm - Area good condition / Area not cleaned
	B3	2 points at lower-body[1]	4/25/2017	17:40	200	0.21	18	Moderate	4/25/17 - 5:40 pm - Area good condition / Area not cleaned
Stack “C”	C1-1	1 point - base of the stack	4/25/2017	17:35	570	0.62	29	Moderate to Heavy	4/25/17 - 5:35 pm - Area good condition / Area not cleaned
	C1-2	1 point - transition area from the scrubbers to stacks	4/25/2017	17:30	ND	0.13	16	Light	4/25/17 - 5:30 pm - Area good condition / Area not cleaned
	C1-3	CEMS Probe	5/1/2017	11:02	450	0.74	7.7	Moderate to Heavy	5/1/17 - 11:02 am - Probe in good condition / Probe not cleaned
	C1-4	CEMS Filter	5/1/2017	11:50	ND	ND	ND	Amount of material buildup not documented	5/1/17 11:50 am - Filter was given as a sample
Scrubber “C”	C2	1 point at mid-body	4/25/2017	18:10	490	0.24	11	Light	4/25/17 - 6:10 pm - Area good condition / Area not cleaned
	C3	2 points at lower-body[1]	4/25/2017	17:25	7.3	0.041	16	Moderate	4/25/17 - 5:25 pm - Area good condition / Area not cleaned
Stack “D”	D1-1	1 point - base of the stack	4/25/2017	17:20	160	0.87	37	Moderate to Heavy	4/25/17 - 5:20 pm - Area good condition / Area not cleaned
	D1-2	1 point - transition area from the scrubbers to stacks	4/25/2017	17:15	ND	0.14	18	Light	4/25/17 - 5:15 pm - Area good condition / Area not cleaned
	D1-3	CEMS Probe	5/1/2017	10:00	390	1.2	2.5	Heavy	5/1/17 - 10:00 am - Probe in good condition / Probe not cleaned Note: Photo taken after probe was cleaned
	D1-4	CEMS Filter	5/1/2017	11:50	ND	ND	ND	Amount of material buildup not documented	5/1/17 11:50 am - Filter was given as a sample
Scrubber “D”	D2	1 point at mid-body	4/25/2017	16:30	2300	0.5	17	Moderate	4/25/17 - 4:30 pm - Area good condition / Area not cleaned
	D3	2 points at lower-body[1]	4/25/2017	17:03	160	0.34	21	Moderate	4/25/17 - 5:03 pm - Area good condition / Area not cleaned
Scrubber recirculating tank	E1	1 point	4/26/2017	9:25	ND	0.063	17	Amount of material buildup not documented	4/26/17 - 9:25 am - No access to tank interior / Sample from drain pipe
Windbox Exhaust Fan	G1	1 point at wind box belly[2]						None	4/26/17 - 9:30 am - Area in good condition/ Light to moderate wear / Area not cleaned
	G2	1 point at outlet side[3]	4/26/2017	9:40	450	0.14	1.2	None	4/26/17 - 9:40 am - Area in good condition/ Light to moderate wear / Area not cleaned
	G3	2 points at inlet side[3]	4/26/2017	9:38	290	0.78	0.94	None	4/26/17 - 9:38 am - Area in good condition/ Light to moderate wear / Area not cleaned
Multi Clone (3 lower discharge cones)	H1	1 point at sump	4/26/2017	9:55	18	0.17	21	Light	4/26/17 - 9:55 am - Area good condition / Area not cleaned
	H2	3 points at cones discharge at ground level[4]	4/26/2017	9:50	2400	0.092	0.92	Amount of material buildup not documented	4/26/17 - 9:50 am - Area good condition / Area not cleaned / Water and product in sump
	H3	3 points on cones at second level[4]	4/26/2017	9:58	150	0.077	0.58	Light	4/26/17 - 9:58 am - Area good condition / Area not cleaned
	H4	1 point at top	4/25/2017	18:25	3300	0.68	6.1	Light	4/25/17 - 6:25 pm - Area good condition / Area not cleaned
Denver sump	I1	1 point in the sump	4/26/2017	10:20	ND	0.098	23	Amount of material buildup not documented	4/26/17 - 10:20 am - Area good condition / Area not cleaned / Water and product in sump
Ducting Prior to Scrubber (3 injection points per duct)	J1	3 points in ducting off process gas header[5]	4/26/2017	10:09	ND	0.074	0.18	Light (mostly pellets)	4/26/17 - 10:09 am - Area good condition / Area not cleaned
	J2	1 point at access of process gas header	4/26/2017	10:04	5.3	0.057	ND	Moderate to Heavy (mostly pellets)	4/26/17 - 10:04 am - Area good condition / Area not cleaned

Notes:

1 - A single composite sample from two sample points, one at both the front and back access doors, was collected to represent the lower-body of each scrubber.

2 - A sample was not collected from the belly of the windbox exhaust fan because there was no buildup of material.

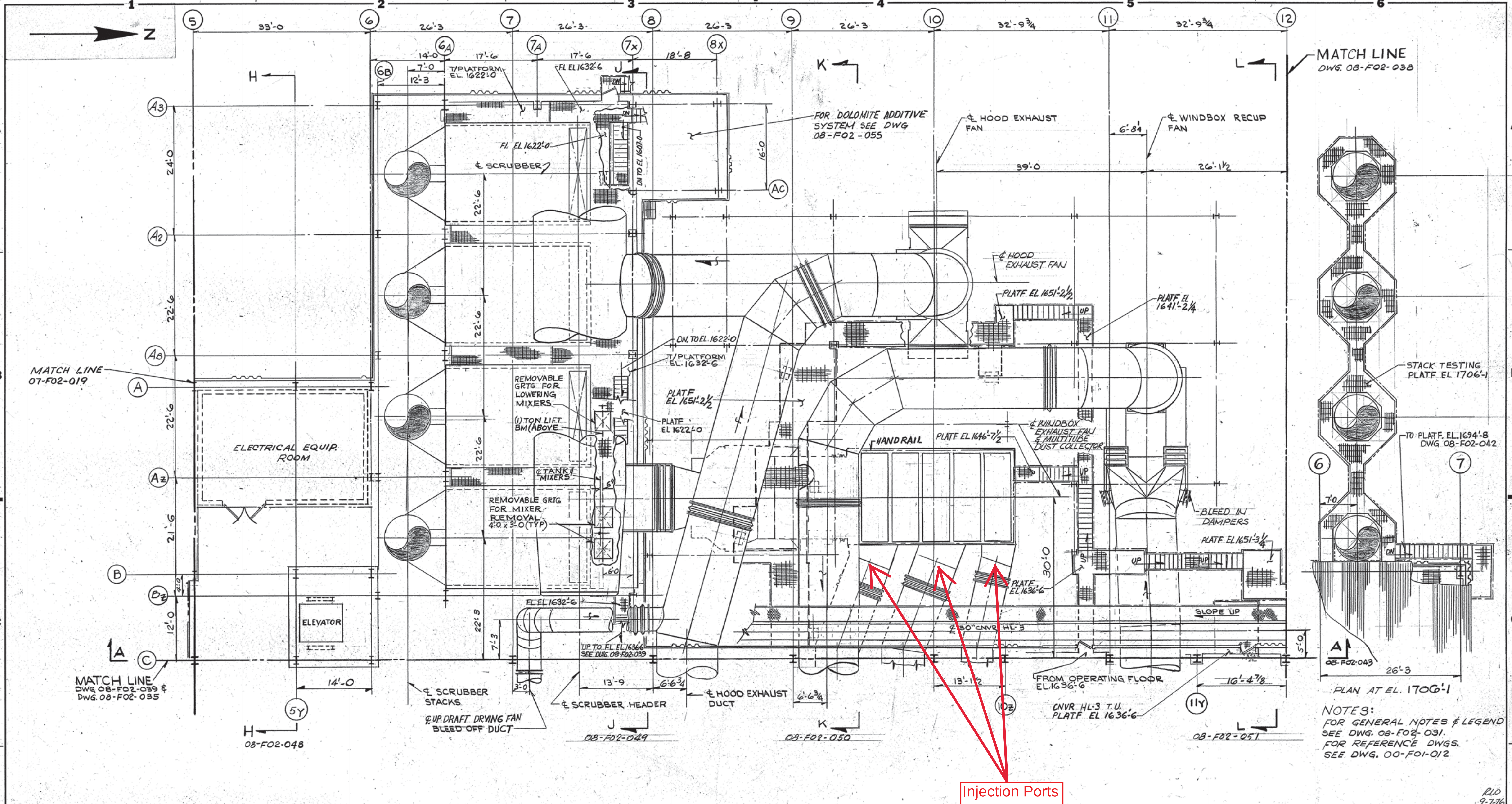
3 - Samples were collected from material found outside the access door to the windbox fan believed to represent material from the fan compartments.

4 - Each of these were comprised of material collected from three separate sampling points at the inspection point.

5 - This sample was comprised of material collected from each of the three ducts off the process gas header.

Attachment A

Injection Port Locations



NOTES:
FOR GENERAL NOTES & LEGEND SEE DWG. 08-F02-031.
FOR REFERENCE DWGS. SEE DWG. 00-F01-012

RLO
9-7-76

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ISSUE NO. 13 DATE PRINTED 9-13-76

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NO	BY	J. E.
3	SEW	9-3 WS
2	VM	9.12.75 WS
1	WS	5-14-75

REVISIONS

INLAND STEEL MINING CO.
MINORCA PROJECT
2,600,000 LTPY PELLET PLANT

PELLET PLANT
GEN. ARR. INDURATING AREA IV
PROCESS DUCT PLAN

DR JAW
CH WS
J. E. EC 3/13/75
SCALE ⅛"=1'-0
SECT. FP
CODE 502
CHF. S. [illegible] 3/14/75
APP'D
CONTRACT NO. M7090

Dravo
PITTSBURGH, PA. E & C DIV.

DRAWING NO.
08-F02-037

Attachment B

Post ACI Inspection Plan

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engineering and environmental consultants
BARR

To: ArcelorMittal Minorca Mine
From: Barr Engineering Co.
Subject: Inspection Plan for Post-Extended Testing of Activated Carbon Injection
Date: April 24, 2017
Project: 23691881.00

This document provides the inspection plan for inspecting plant equipment following the extended testing of activated carbon injection (ACI). This inspection plan has been developed specifically for ArcelorMittal Minorca Mine (Minorca).

1.0 Introduction

The purpose of this inspection plan is to document the possible effects on plant equipment resulting from extended ACI testing (approximately 76 days, from January 20th through April 6th, 2017) in which an activated carbon was injected at a rate of approximately 1 lb/MMacf. This testing was conducted to gather the necessary information to inform Minorca towards complying with state regulations. Minnesota regulations (Minn. R. 7007.0502) require Minorca to reduce mercury emissions by January 1, 2025 to no more than 28% of the mercury emitted in 2008 or 2010, whichever is greater. The state regulations also require Minorca to submit a mercury emissions reduction plan by December 30, 2018 to show how Minorca will achieve the 72% reduction, or propose an alternate plan if Minorca concludes that a 72% reduction is not technically or economically feasible, impairs pellet quality, and/or causes excessive corrosion to plant equipment.

Previous ACI testing in 2013 showed potential buildup of activated carbon in the multiclones, process gas scrubbers, and associated stacks. Therefore, this inspection plan is intended to identify:

1) locations in the plant process for physical inspection of any erosion/corrosion or activated carbon buildup due to the extended ACI testing,
2) procedures for safe inspection of the identified locations,
3) schedule for conducting inspections at each location,
4) procedures for documentation and sampling during the inspection, and
5) primary contacts for inspection locations.

2.0 Determine Potential Erosion/Corrosion Issues Associated with ACI

The activated carbon used during the extended ACI testing was a high temperature brominated powdered activated carbon (HPAC) supplied by Albemarle. This type of activated carbon was chosen based on screening tests conducted on January 17th and 18th, 2017, in which HPAC was found to provide greater mercury reduction compared to brominated powdered activated carbon (BPAC). However, previous testing of powdered activated carbon in 2013 lead to buildup of activated carbon on plant equipment. Therefore, this inspection plan is intended to document any erosion/corrosion or activated carbon buildup on plant equipment, which will then inform if ACI is a feasible potential technology for Minorca to implement in order to comply with the state regulations for mercury reduction.

3.0 Inspection Locations

Representatives from Barr Engineering Company (Barr) and Minorca met on Tuesday, March 14th, 2017, and identified the following list of inspection locations of plant equipment for erosion/corrosion or activated carbon buildup:

- ☐ Stack "A"
- ☐ Scrubber "A"
- ☐ Stack "B"
- ☐ Scrubber "B"
- ☐ Stack "C"
- ☐ Scrubber "C"
- ☐ Stack "D"
- ☐ Scrubber "D"
- ☐ Scrubber Recirculating Tank
- ☐ Exhaust Header
- ☐ Windbox Exhaust Fan
- ☐ Multiclones
- ☐ Denver Sump
- ☐ Duct Injection Point

This list is included in Attachment A to this document, with each location identified on the accompanying process flow diagrams. These locations were identified based on the ACI location with respect to the plant equipment and the potential for any erosion/corrosion or activated carbon buildup.

4.0 Safe Inspection

Given the main objectives and the overall activities to be accomplished during the inspection of the identified locations, the following protocol is set forth as a guide to the inspectors to perform safe inspection.

A. All inspectors shall:

   1. Be aware of the equipment and materials being used and the associated hazards of the materials and work areas.
   2. Be current on and have documentation available for their Mine Safety and Health Administration (MSHA) training, fall protection certification, and required site-specific training.
   3. Wear the appropriate personal protective equipment, including:

        a. hardhat,
        b. safety boots (metatarsals),
        c. long sleeves and long pants,
        d. hearing protection, and
        e. safety glasses with side shields.

B. Confined space entry:
    1. Inspectors are responsible for completing a confined space entry permit prior to conducting any confined space inspection.
    2. Inspectors are responsible for performing their own gas monitoring.
    3. Inspectors will follow Minorca's lockout/tagout procedures.

C. Emergency Procedures:
    1. Inspectors shall immediately report all accidents, injuries, or equipment damaged to the Minorca project manager (or the onsite shift manager during nights and weekends).
    2. When alarm sounds or an emergency is announced, inspectors shall follow announced directions
    3. To report an emergency, inspectors shall contact the Plant Control Room via:
        a. Gai-tronics,
        b. Phone at 218-305-3407
        c. Radio Channel 1 – Plant
    4. Inspectors shall provide emergency information to Control Room or Minorca contact.
    5. Inspectors shall secure the scene and respond as appropriate.
    6. Inspectors shall complete necessary forms with Minorca contact.

5.0 Inspection Schedule

To provide safe access to the inspection locations, adequate time must be allowed for proper cooling of plant equipment following the commencement of the plant outage. Therefore, inspections are to be carried out on Tuesday, April 25th, through Thursday, April 27th. Each inspection location has been assigned a tentative date and time to be inspected, subject to change, included in Attachment A.

6.0 Primary Contacts

The respective Minorca project contacts for the general plant locations are:

A. Multiclones – Willard Ario
B. Windbox Exhaust Fan – Adam Thompson
C. Scrubbers – Jason Craven

7.0 Inspection documentation and sampling

Each inspection location will be inspected initially by the inspection team and the designated Minorca project contact for the respective inspection location. The Minorca project contact will provide the inspection team with the knowledge of the inspection location's common condition as viewed during past plant outages. The inspection team will then:

1. Fill out the written documentation for the inspection location, including:
    a. Date and time of inspection
    b. Inspection location
    c. Condition of inspection location
    d. If the inspection location has been recently cleaned or not
    e. If material buildup is visible, and if so,
    f. If sampling of material is conducted,
2. Take photos of the inspection location with a digital camera (reviewing photos for clarity), and
3. Acquire samples of any material believed to be powdered activated carbon.

The recommended sample points for lab analysis are identified in Attachment A. Samples are to be collected and analyzed to determine carbon and bromine concentrations. Coordination of sampling will be completed by the inspection team with approval from the Minorca project contact. Minorca will be responsible for collection of the samples identified at the locations in Attachment A Inspection staff will be responsible for providing sample containers, coordination and scheduling of analytical analysis for these samples.

7.1 Sample collection method

The sampling method will consist of collecting multiple cross-cut samples, composited into one sample for that specific location. The multiple cross-cut samples should be spaced appropriately across the plant equipment being inspected, collecting a single sample at each location and then repeating this process to form the final composite sample for analysis. If an inspection location does not have enough buildup material to create a composite sample then the amount available will be placed in the sample container. The composite sample to be sent to the lab should fill a 4 oz. glass jar clearly labeled to show the inspection location. Samples should be capped and stored in sealed containers, not paper envelopes or paper boxes.

7.2 Sample analysis

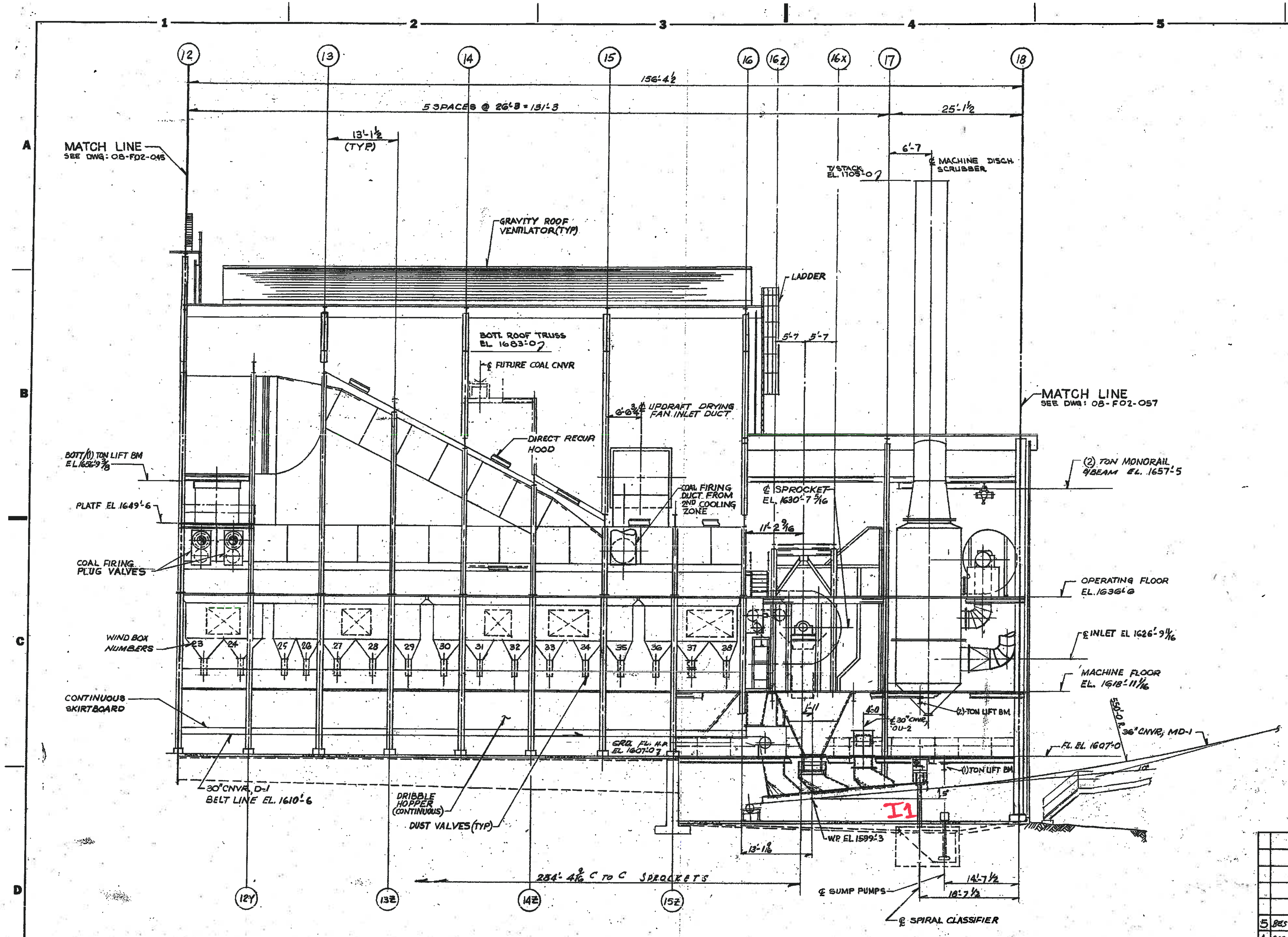
Samples are to be analyzed under the Walkley-Black method for carbon content, and EPA Method SW-846 5050/9056 (bomb/ion chromatography method) for bromine content. Barr will use ALS in Holland, Michigan for completing both analysis.

Attachment A

Inspection Locations and Schedule

ArcelorMittal Minorca Mine
Inspection Plan Following Testing of Activated Carbon Injection
Attachment A - Inspection Locations

Equipment	Number of Inspection Points	Drawing ID	Schedule For Inspection	Inspection Notes	Pictures Taken?	Samples Acquired?
Stack "A"	1 point	A1	April 25th, 2017 @ 4:00pm			
	CEMS	A1	April 25th, 2017 @ 4:00pm			
Scrubber "A"	1 point at mid-body	A2	April 25th, 2017 @ 4:00pm			
	2 points at lower-body	A3	April 25th, 2017 @ 4:00pm			
Stack "B"	1 point	B1	April 25th, 2017 @ 4:00pm			
	CEMS	B1	April 25th, 2017 @ 4:00pm			
Scrubber "B"	1 point at mid-body	B2	April 25th, 2017 @ 4:00pm			
	2 points at lower-body	B3	April 25th, 2017 @ 4:00pm			
Stack "C"	1 point	C1	April 25th, 2017 @ 4:00pm			
	CEMS	C1	April 25th, 2017 @ 4:00pm			
Scrubber "C"	1 point at mid-body	C2	April 25th, 2017 @ 4:00pm			
	2 points at lower-body	C3	April 25th, 2017 @ 4:00pm			
Stack "D"	1 point	D1	April 25th, 2017 @ 4:00pm			
	CEMS	D1	April 25th, 2017 @ 4:00pm			
Scrubber "D"	1 point at mid-body	D2	April 25th, 2017 @ 4:00pm			
	2 points at lower-body	D3	April 25th, 2017 @ 4:00pm			
Scrubber recirculating tank	1 point	E1	April 25th, 2017 @ 5:00-6:00pm			
Header	1 point **(bad roof at ladder- may have to forego inspection)**	**F1**	NOT AVAILABLE FOR INSPECTION			
Windbox Exhaust Fan	1 point at wind box belly	G1	April 26th, 2017 @ 7:00am			
	1 point at outlet side	G2	April 26th, 2017 @ 7:00am			
	2 points at inlet side	G3	April 26th, 2017 @ 7:00am			
Multi Clone (3 lower discharge cones)	1 point at sump	H1	April 26th, 2017 @ 7:00am			
	3 points at cones discharge at ground level	H2	April 26th, 2017 @ 7:00am			
	3 points on cones at second level	H3	April 26th, 2017 @ 7:00am			
	1 point at top	H4	April 26th, 2017 @ 7:00am			
Denver sump	1 point	I1	April 25th, 2017 5:00-6:00pm or April 26, 2017 @ 7:00am			
Ductwork (3 injection points per duct)	3 points	J1	April 27th, 2017 @ 7:00am			
	1 point at access of duct header	J2	April 27th, 2017 @ 7:00am			



NOTES:
FOR LEGEND AND GENERAL NOTES SEE DWG: 08-F02-031
FOR REFERENCE DWG SEE DWG: 00-F01-012

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ISSUE NO. 18 DATE PRINTED 8-2-76

NO	BY	J. E.
5	BES	WS 3/25
4	BES	WDS
3	vm	WS
2	WS	EC 3-7-75
1	WS	EC 1/16

REVISIONS

INLAND STEEL MINING CO.
MINORCA PROJECT
2,600,000 LTPY PELLET PLANT

PELLET PLANT
GEN. ARR. INDURATING AREA-III
SECTION C-C

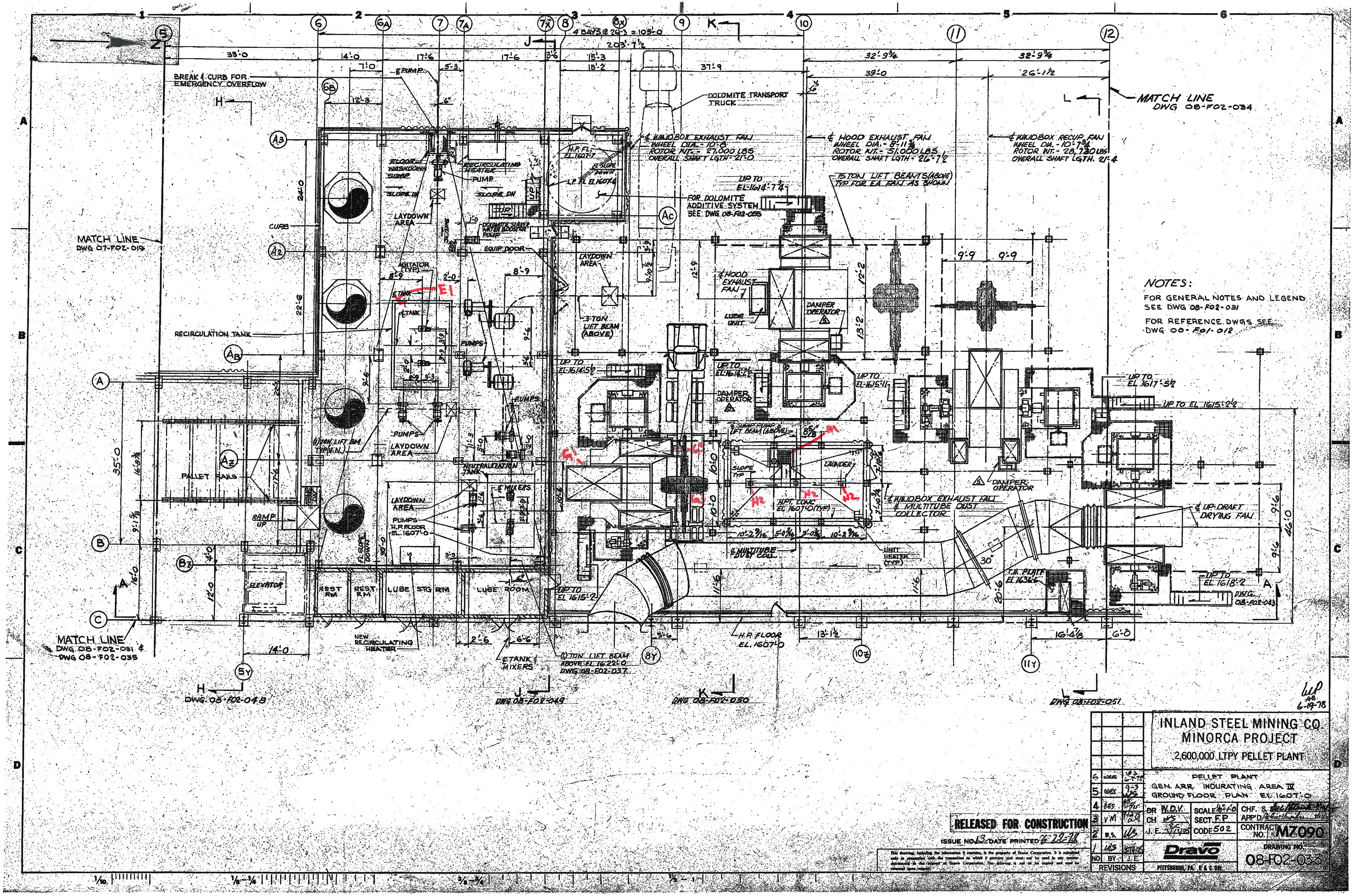
DR RZ
CH WS 12-19
J. E. EC 10/14
SCALE ⅛"=1'-0
SECT
CODE 502
CHF. S. E.
APP'D
CONTRACT NO. M7090

Dravo
PITTSBURGH, PA. E & C DIV.

DRAWING NO.
08-F02-046

1/10
⅛-¼
⅜-¾
½-1

Figure 1



wP
AB
6-19-78

INLAND STEEL MINING CO.
MINORCA PROJECT
2,600,000 LTPY PELLET PLANT

PELLET PLANT
GEN. ARR. INDURATING AREA IV
GROUND FLOOR PLAN EL. 1607'-0

NO	BY	J.E.
6	WES	WS 6-7-78
5	WES	9-3 WS
4	BEG	WS 3/25
3	VM	4/12/75 WS
2	B.S.	WS
1	WS	5-14-75

REVISIONS

DR W.D.V. SCALE 1/8"=1'-0 CHF. S.
CH WS SECT. F.P. APP'D
J.E. 3/13/75 CODE 502 CONTRACT NO. M7090

Dravo
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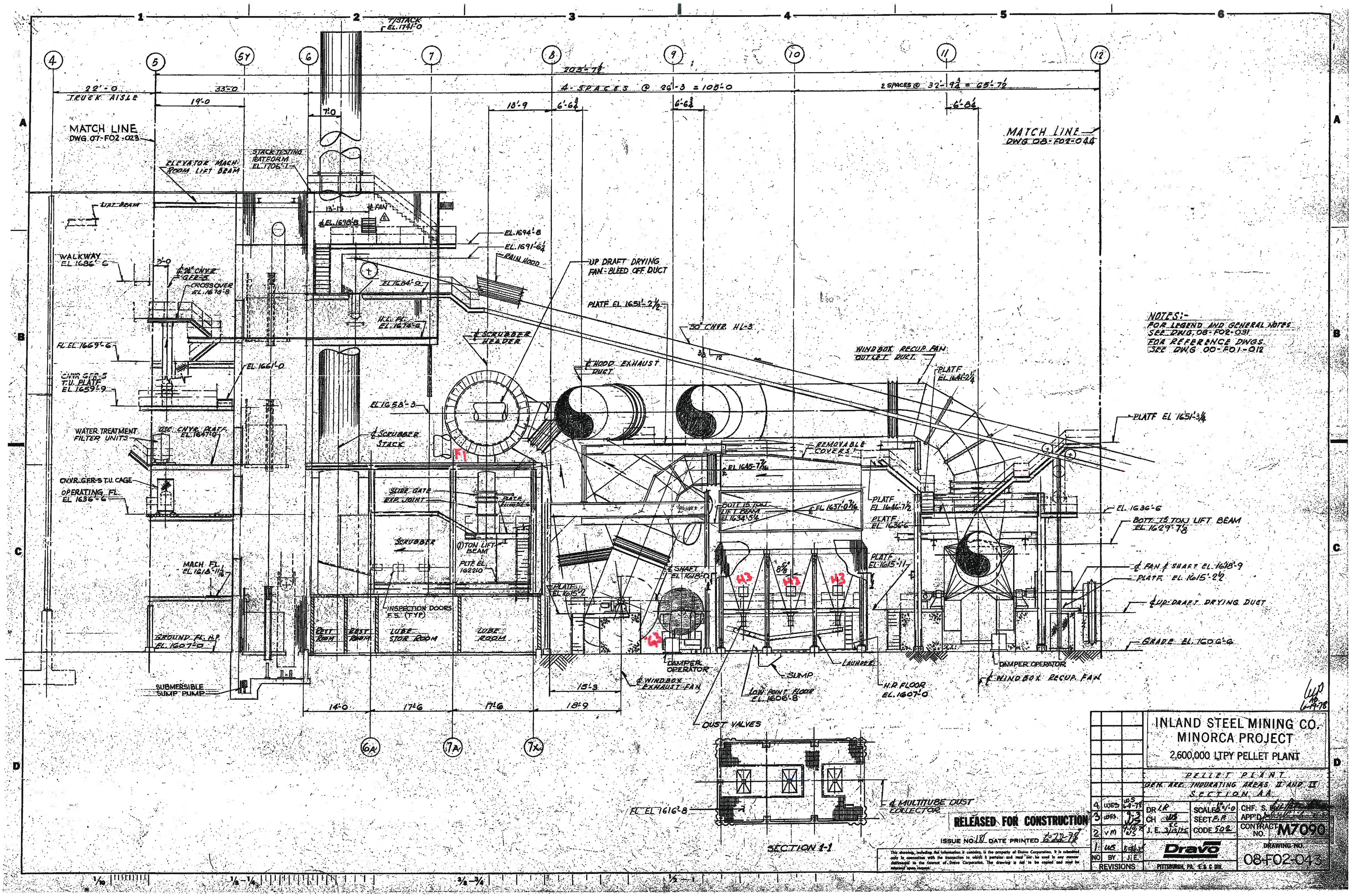
Figure 2


7'STACK EL.1741'-0
22'-0 TRUCK AISLE
33'-0
19'-0
7'-0
13'-9
6'-6¾
203'-7½
4-SPACES @ 26'-3 = 105'-0
6'-6¾
2 SPACES @ 32'-9¾ = 65'-7½
6'-8¼
MATCH LINE DWG 07-F02-023
MATCH LINE DWG 08-F02-044
ELEVATOR MACH. ROOM LIFT BEAM
STACK TESTING PLATFORM EL.1706'-1
LIFT BEAM
13'-13
FAN
EL.1698'-8
EL.1694'-8
EL.1691'-6¼
RAIN HOOD
WALKWAY EL.1686'-6
3'-0
CL 36" CNVR GER-5
CROSSOVER EL.1679'-8
EL.1684'-0
H.L. FL. EL.1676'-0
UP DRAFT DRYING FAN-BLEED OFF DUCT
PLATF EL.1651'-2½
30" CNVR HL-3
CL SCRUBBER HEADER
FL.EL.1669'-6
EL.1661'-0
CNVR GER-5 T.U. PLATF EL.1659'-9
CL HOOD EXHAUST DUCT
WIND BOX RECUP FAN OUTLET DUCT
PLATF EL.1641'-2¼
EL.1658'-3
PLATF EL 1651'-3¼
WATER TREATMENT FILTER UNITS
USC CNVR PLATF EL.1647'-0
CL SCRUBBER STACK
F1
REMOVABLE COVERS
EL.1645'-7/16
CNVR GER-5 T.U. CAGE
OPERATING FL. EL.1636'-6
SLIDE GATE EXP. JOINT
PLATF
BOTT 15 TON LIFT BEAM EL.1634'-5¼
FL.1637'-0/16
PLATF EL.1646'-1½
PLATF EL.1636'-6
EL.1636'-6
BOTT. 15 TON LIFT BEAM EL.1629'-7⅝
SCRUBBER
(1) TON LIFT BEAM
PLTF. EL.1622'10
PLATF EL.1615'-11
MACH. FL. EL.1618'-11½
PLATF EL.1615'
CL SHAFT EL.1618'-0
H3
H3
H3
CL FAN CL SHAFT EL.1618'-9
PLATF. EL.1615'-2½
CL UP-DRAFT DRYING DUCT
INSPECTION DOORS F.S. (TYP)
REST ROOM
REST ROOM
LUBE STOR ROOM
LUBE ROOM
GROUND FL. H.P. EL.1607'-0
H2
GRADE EL.1606'-6
DAMPER OPERATOR
SUMP
LAUNDER
DAMPER OPERATOR
CL WINDBOX RECUP FAN
SUBMERSIBLE SUMP PUMP
CL WINDBOX EXHAUST FAN
15'-3
LOW POINT FLOOR EL.1606'-8
H.P. FLOOR EL.1607'-0
14'-0
17'-6
17'-6
18'-9
DUST VALVES
NOTES:-
FOR LEGEND AND GENERAL NOTES SEE DWG. 08-F02-031
FOR REFERENCE DWGS. SEE DWG 00-F01-012
FL EL 1616'-8
CL MULTITUBE DUST COLLECTOR
SECTION 1-1
RELEASED FOR CONSTRUCTION
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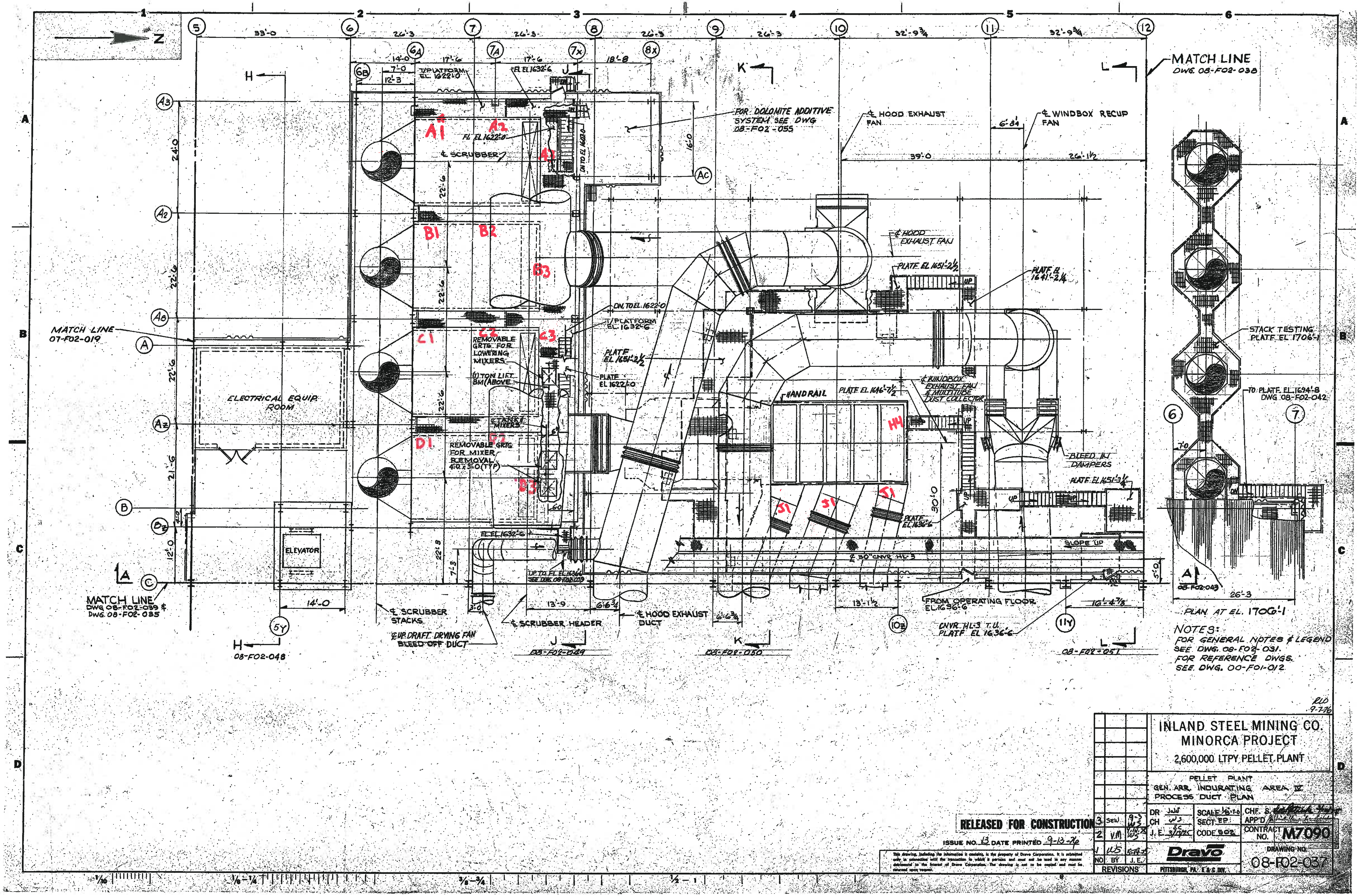
4
5
5Y
6
7
8
9
10
11
12
6A
7A
7X
1
2
3
4
5
6
A
B
C
D
INLAND STEEL MINING CO.
MINORCA PROJECT
2,600,000 LTPY PELLET PLANT
PELLET PLANT
GEN. ARR. INDURATING AREAS II AND II
SECTION AA
4 WSS WS 6-8-78
3 WSS 9-3 JJS
2 VM 9/10/74 WS
1 WS 5-14-75
NO BY J.E.
REVISIONS
DR LR
CH WS
J. E. 3/13/75
SCALE ⅛"=1'-0
SECT. F.R.
CODE 502
CHF. S.
APP'D
CONTRACT NO. M7090
Dravo
PITTSBURGH, PA. E & C DIV.
DRAWING NO.
08-F02-043
WP AB 6-19-78
1/16
1/8-1/4
3/8-3/4
1/2

Figure 3



NOTES:
FOR GENERAL NOTES & LEGEND SEE DWG. 08-F02-031.
FOR REFERENCE DWGS. SEE DWG. 00-F01-012

RLO
9-7-76

INLAND STEEL MINING CO.
MINORCA PROJECT
2,600,000 LTPY PELLET PLANT

PELLET PLANT
GEN. ARR. INDURATING AREA IV
PROCESS DUCT PLAN

NO	BY	J. E.
3	SEW	9-3 WS
2	VM	WS
1	WS	5-14-75

REVISIONS

DR JWW
CH WJ
J. E. 3/13/75
SCALE 1/8"=1'-0
SECT. EP
CODE 502
CHF. S.
APP'D
CONTRACT NO. M7090
DRAWING NO. 08-F02-037

Dravo
PITTSBURGH, PA. E & C DIV.

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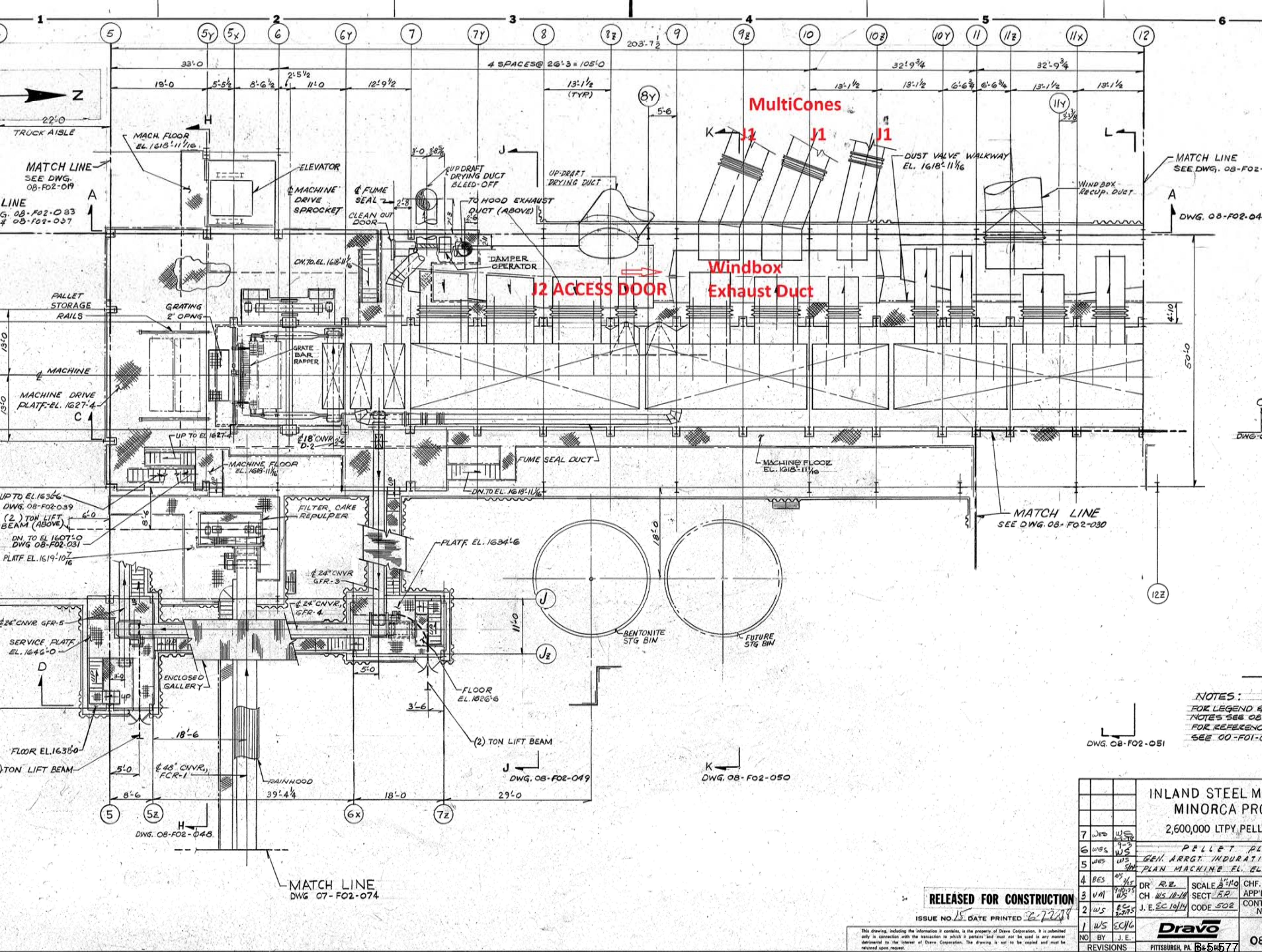
Figure 4



MultiCones
J1
J1
J1
Windbox
Exhaust Duct
J2 ACCESS DOOR
1
2
3
4
5
6
5
5Y
5X
6
6Y
7
7Y
8
8Z
9
9Z
10
10Z
10Y
11
11Z
11X
12
8Y
11Y
203'-7 1/2
33'-0
4 SPACES@ 26'-3 = 105'-0
32'-9 3/4
32'-9 3/4
19'-0
5'-5 1/2
8'-6 1/2
2'-5 1/2
11'-0
12'-9 1/2
13'-1 1/2 (TYP)
13'-1 1/2
13'-1 1/2
6'-6 3/4
6'-6 3/4
13'-1 1/2
13'-1 1/2
5'-6
3'-3 3/8
Z
22'-0
TRUCK AISLE
H
MACH. FLOOR EL. 1618'-11 1/16
MATCH LINE SEE DWG. 08-F02-019
LINE
G. 08-F02-083
& 08-F02-037
A
ELEVATOR
3'-0
3'-8 5/8
UP DRAFT DRYING DUCT BLEED-OFF
J
℄ MACHINE DRIVE SPROCKET
℄ FUME SEAL
2'-8
TO HOOD EXHAUST DUCT (ABOVE)
UP-DRAFT DRYING DUCT
K
DUST VALVE WALKWAY EL. 1618'-11 1/16
L
MATCH LINE SEE DWG. 08-F02-
WIND BOX RECUP. DUCT
A
DWG. 08-F02-04
CLEAN OUT DOOR
DN. TO EL. 1618'-11 1/16
DAMPER OPERATOR
PALLET STORAGE RAILS
GRATING 2" OPNG.
GRATE BAR RAPPER
4'-10
13'-0
13'-0
℄ MACHINE
MACHINE DRIVE PLATF.-EL. 1627'-4
C
50'-0
UP TO EL 1627'-4
℄ 18" CNVR D-2
2'-6
MACHINE FLOOR EL. 1618'-11 1/16
FUME SEAL DUCT
MACHINE FLOOR EL. 1618'-11 1/16
DN. TO EL. 1618'-11 1/16
UP TO EL. 1636'-6
DWG. 08-F02-039
(2) TON LIFT BEAM (ABOVE)
6'-0
8'-6
DN. TO EL 1607'-0 DWG 08-F02-031
PLATF EL. 1619'-10 7/16
FILTER CAKE REPULPER
MATCH LINE SEE DWG. 08-F02-030
PLATF. EL. 1634'-6
18'-0
℄ 24" CNVR GFR-3
℄ 24" CNVR GFR-4
℄ 24" CNVR GFR-5
J
11'-0
JZ
12Z
BENTONITE STG BIN
FUTURE STG BIN
SERVICE PLATF. EL. 1646'-0
D
3'-0
UP
ENCLOSED GALLERY
5'-0
FLOOR EL. 1626'-6
3'-6
FLOOR EL. 1638'-0
TON LIFT BEAM
18'-6
5'-0
℄ 48" CNVR. FCR-1
RAINHOOD
(2) TON LIFT BEAM
J
DWG. 08-F02-049
K
DWG. 08-F02-050
L
DWG. 08-F02-051
8'-6
39'-4 1/4
18'-0
29'-0
5
5Z
6X
7Z
H
DWG. 08-F02-048
MATCH LINE DWG 07-F02-074
NOTES:
FOR LEGEND &
NOTES SEE 08
FOR REFERENC
SEE 00-F01-
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7 WES WS 6-3-78
6 WES 9-3 WS
5 WES WS 5/14
4 BES WS 2/15
3 VM 9-10-75 WS
2 WS EC 3-7-75
1 WS EC 1/6
NO BY J.E.
REVISIONS
INLAND STEEL M
MINORCA PRO
2,600,000 LTPY PELL
PELLET PL
GEN. ARRGT. INDURATI
PLAN MACHINE FL. EL
DR R.Z.
CH WS 10-14
J.E. EC 10/14
SCALE 1/8"=1'-0
SECT. FP
CODE 502
CHF.
APP'D
CONT
N
Dravo
PITTSBURGH, PA.
08
1/8–1/4
3/8–3/4
1/2–1

Figure 5

Attachment C

Photo Documentation of Inspection Points

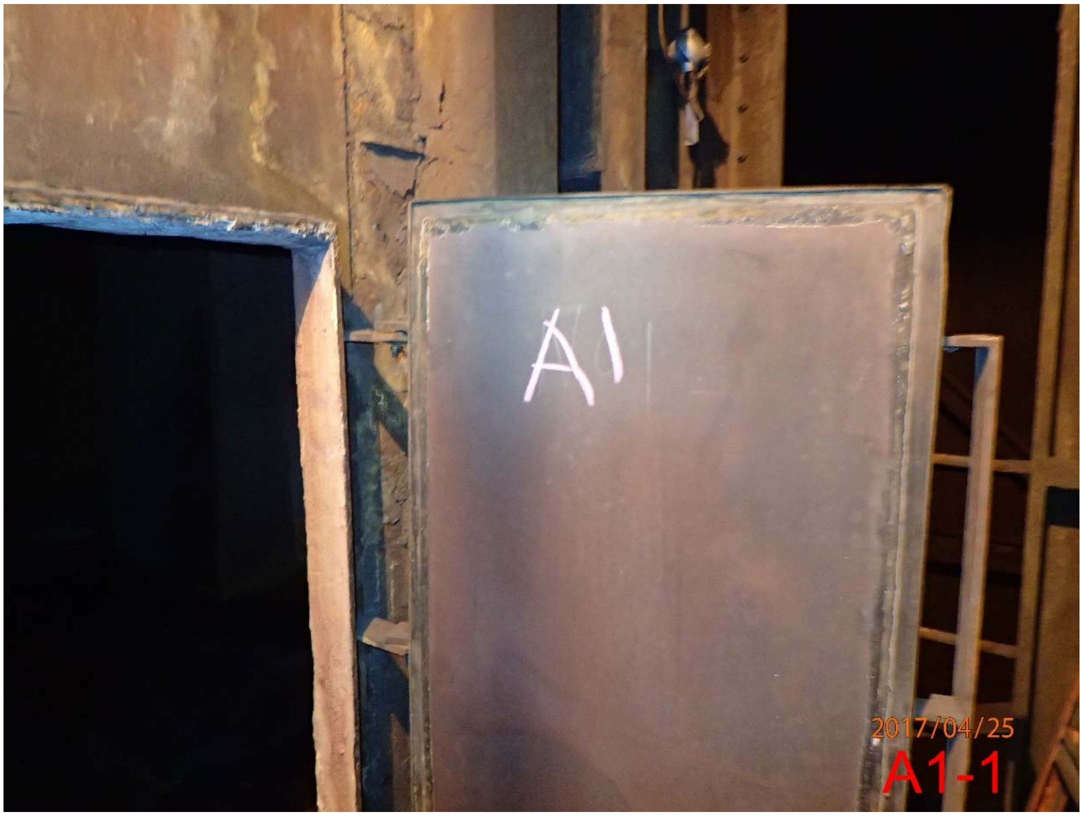

Photo 1 Base of Stack A (1)

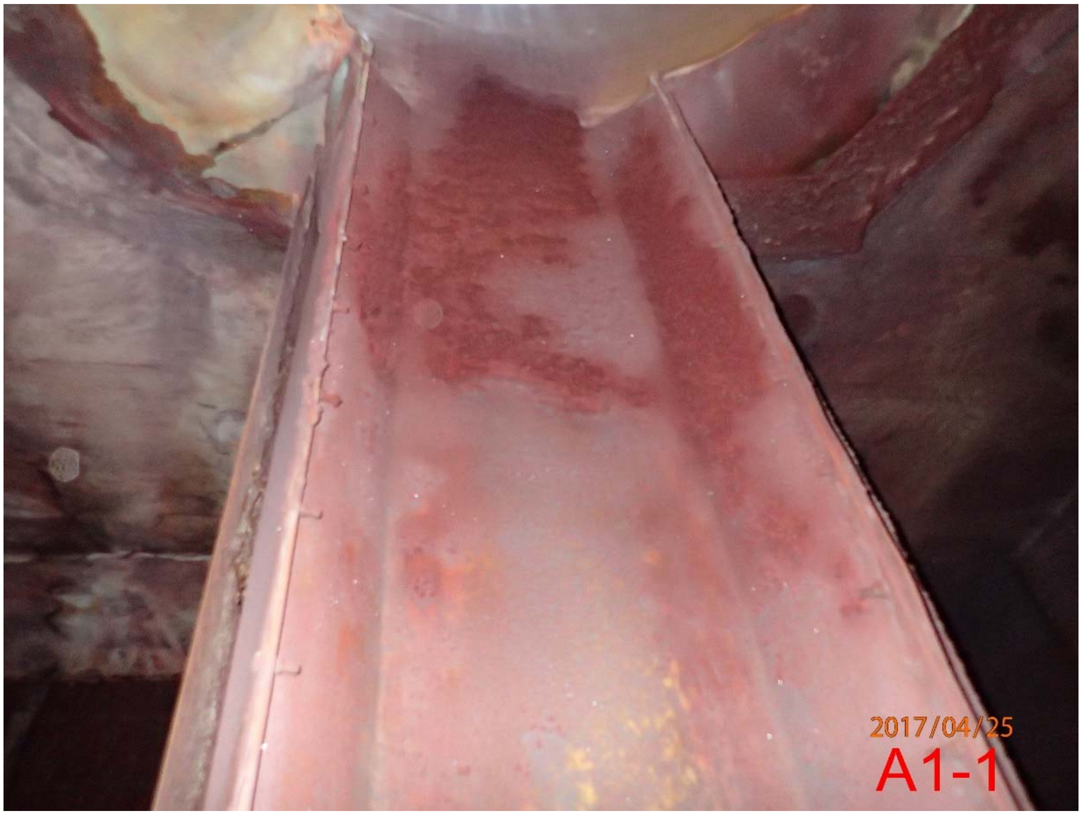

Photo 2 Base of Stack A (2)

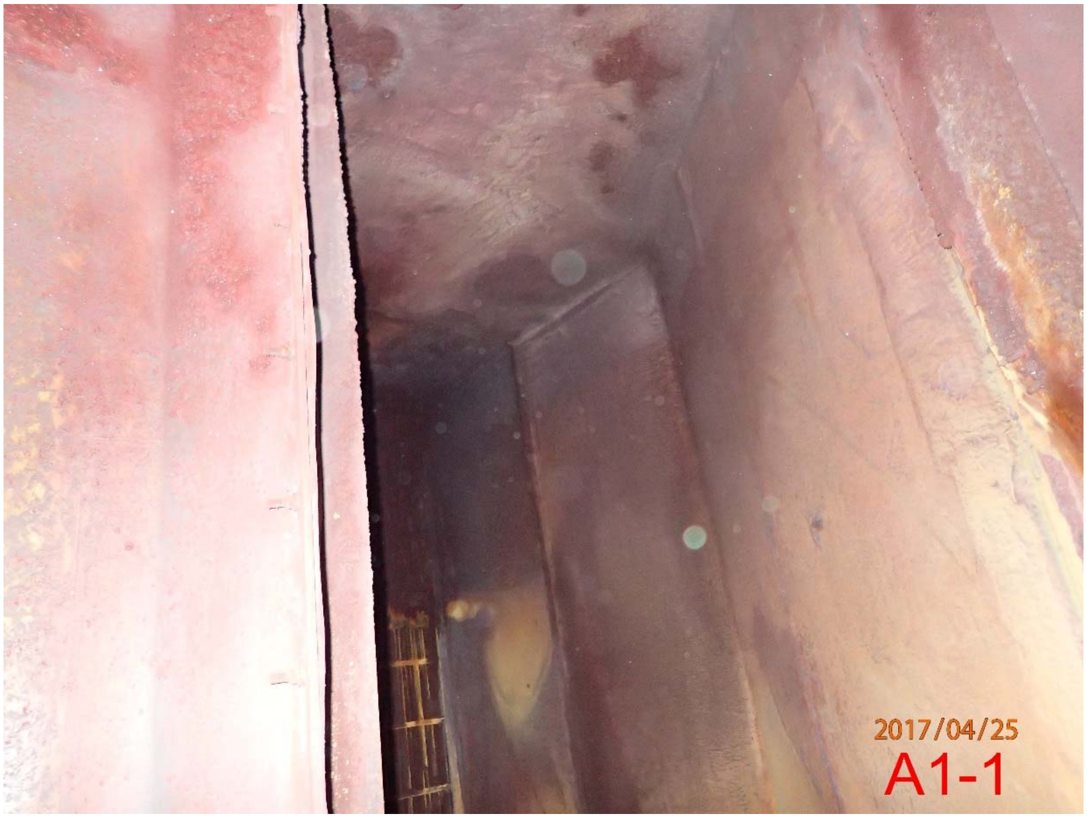

Photo 3 **Base of Stack A (3)**

Photo 4 **Base of Stack A (4)**

Photo 5 Base of Stack A (5)

Photo 6 Base of Stack A (6)

Photo 7 Base of Stack A (7)

Photo 8 Transition Area from Scrubbers to Stack A (1)

Photo 9 Transition Area from Scrubbers to Stack A (2)

Photo 10 Stack A CEMS Probe (1)

Photo 11 Stack A CEMS Probe (2)

Photo 12 Scrubber A Mid-body (1)

Photo 13 Scrubber A Mid-body (2)

Photo 14 Scrubber A Mid-body (3)

Photo 15 Scrubber A Mid-body (4)

Photo 16 Scrubber A Mid-body (5)

Photo 17 Scrubber A Mid-body (6)

Photo 18 Scrubber A Mid-body (7)

Photo 19 **Scrubber A Mid-body (8)**

Photo 20 **Scrubber A Lower-body (1)**

Photo 21 Scrubber A Lower-body (2)

Photo 22 Scrubber A Lower-body (3)

Photo 23 Scrubber A Lower-body (4)

Photo 24 Scrubber A Lower-body (5)

Photo 25 Scrubber A Lower-body (6)

Photo 26 Base of Stack B (1)

Photo 27 Base of Stack B (2)

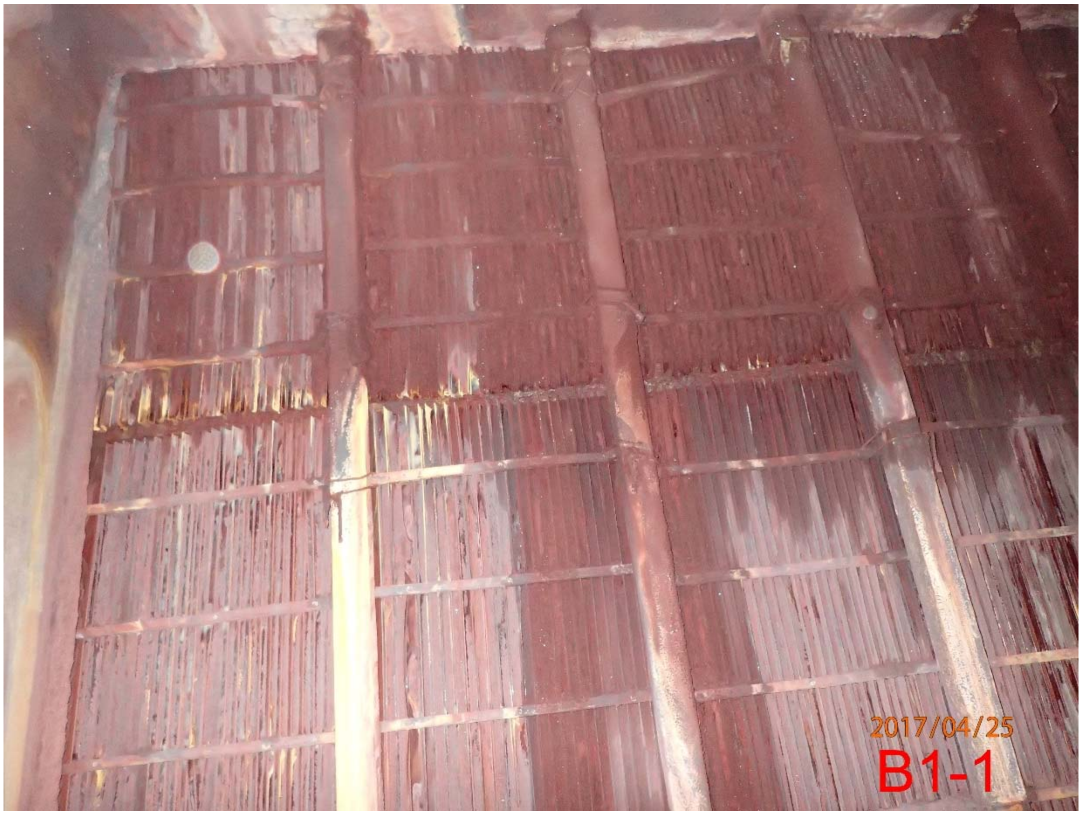

Photo 28 Base of Stack B (3)


2017/04/25
B1-1

Photo 29 **Base of Stack B (4)**


2017/04/25
B1-1

Photo 30 **Base of Stack B (5)**

Photo 31 **Base of Stack B (6)**

Photo 32 **Base of Stack B (7)**

Photo 33 Base of Stack B (8)

Photo 34 Transition Area from Scrubbers to Stack B (1)

Photo 35 Transition Area from Scrubbers to Stack B (2)

Photo 36 Transition Area from Scrubbers to Stack B (3)


2017/04/25
B1-2

Photo 37 Transition Area from Scrubbers to Stack B (4)

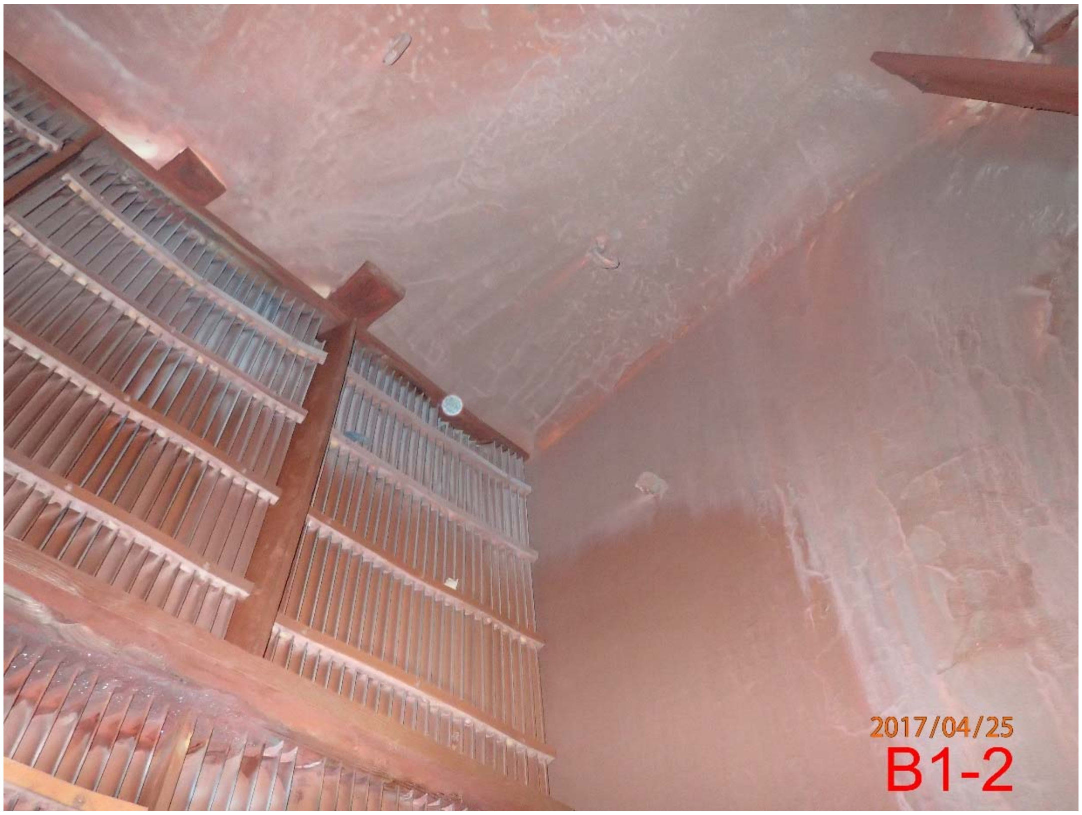
2017/04/25
B1-2

Photo 38 Transition Area from Scrubbers to Stack B (5)

Photo 39 Transition Area from Scrubbers to Stack B (6)

Photo 40 Stack B CEMS Probe (1)

Photo 41 Stack B CEMS Probe (2)

Photo 42 Scrubber B Mid-body (1)

Photo 43 Scrubber B Mid-body (2)

Photo 44 Scrubber B Mid-body (3)

Photo 45 Scrubber B Mid-body (4)

Photo 46 Scrubber B Lower-body (1)

Photo 47 **Scrubber B Lower-body (2)**

Photo 48 **Scrubber B Lower-body (3)**

Photo 49 Scrubber B Lower-body (4)

Photo 50 Scrubber B Lower-body (5)

Photo 51 Base of Stack C (1)

Photo 52 Base of Stack C (2)

Photo 53 Base of Stack C (3)

Photo 54 Base of Stack C (4)

Photo 55 Base of Stack C (5)

Photo 56 Base of Stack C (6)

Photo 57 Base of Stack C (7)

Photo 58 Base of Stack C (8)

Photo 59 Base of Stack C (9)

Photo 60 Base of Stack C (10)

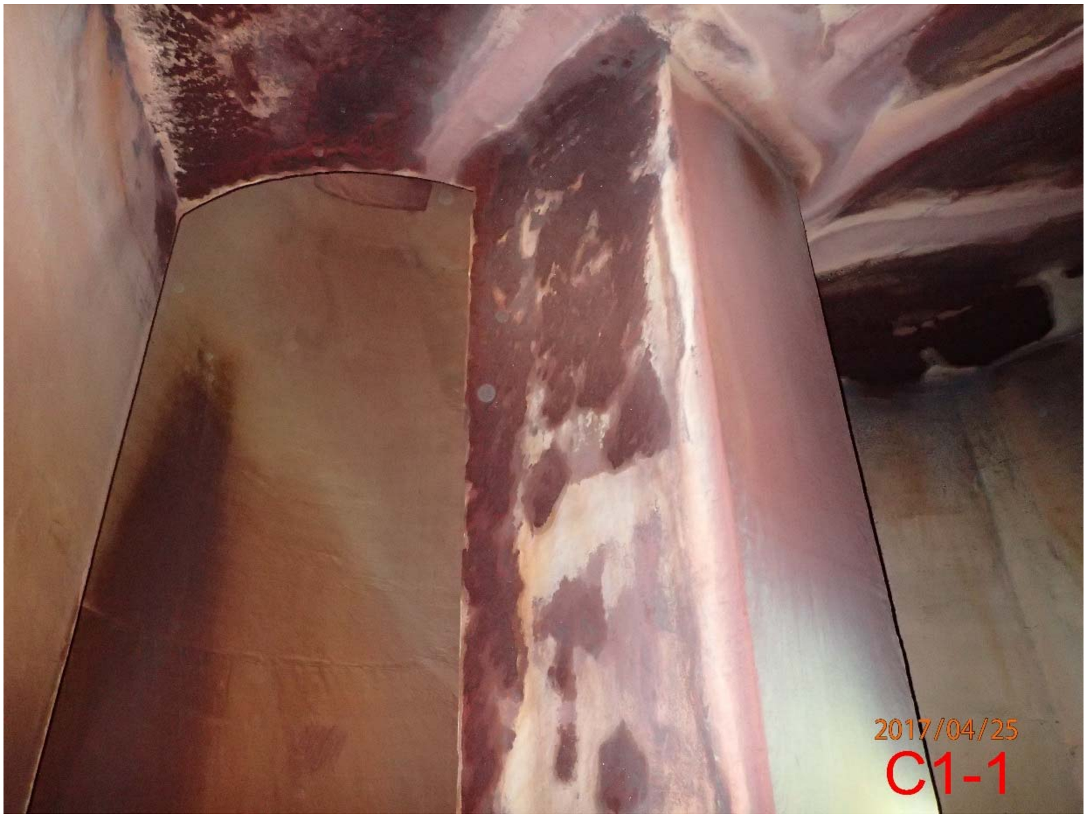

Photo 61 Base of Stack C (11)

Photo 62 Base of Stack C (12)

Photo 63 Transition Area from Scrubbers to Stack C (1)

Photo 64 Transition Area from Scrubbers to Stack C (2)

Photo 65 Transition Area from Scrubbers to Stack C (3)

Photo 66 Transition Area from Scrubbers to Stack C (4)

Photo 67 Transition Area from Scrubbers to Stack C (5)

Photo 68 Stack C CEMS Probe (1)

Photo 69 Stack C CEMS Probe (2)

Photo 70 Scrubber C Mid-body (1)

Photo 71 **Scrubber C Mid-body (2)**

Photo 72 **Scrubber C Mid-body (3)**

Photo 73 Scrubber C Mid-body (4)

Photo 74 Scrubber C Mid-body (5)

Photo 75 Scrubber C Mid-body (6)

Photo 76 Scrubber C Lower-body (1)

Photo 77 Scrubber C Lower-body (2)

Photo 78 Scrubber C Lower-body (3)

Photo 79 **Scrubber C Lower-body (4)**

Photo 80 **Scrubber C Lower-body (5)**

Photo 81 Base of Stack D (1)

Photo 82 Base of Stack D (2)

Photo 83 **Base of Stack D (3)**

Photo 84 **Base of Stack D (4)**

Photo 85 **Base of Stack D (5)**

Photo 86 **Base of Stack D (6)**

Photo 87 Base of Stack D (7)

Photo 88 Base of Stack D (8)

Photo 89 Transition Area from Scrubbers to Stack D (1)

Photo 90 Transition Area from Scrubbers to Stack D (2)

Photo 91 Transition Area from Scrubbers to Stack D (3)

Photo 92 Stack D CEMS Probe (1)

Photo 93 Stack D CEMS Probe (2)

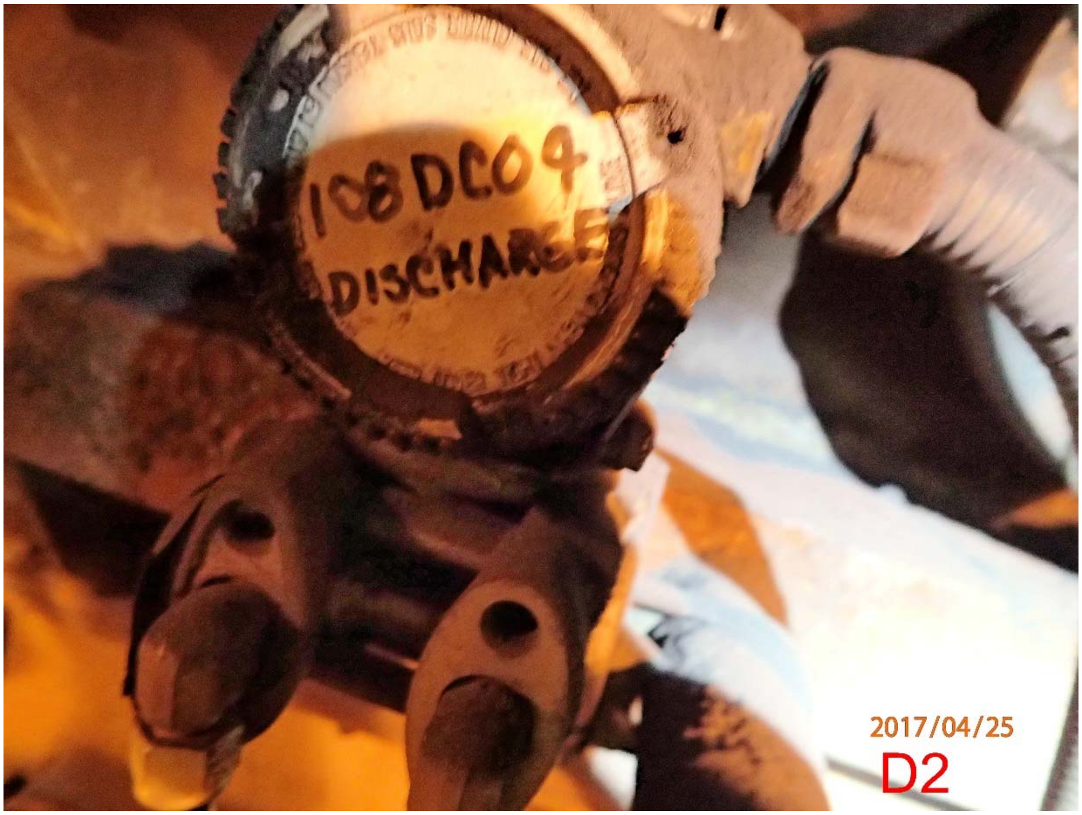

Photo 94 Scrubber D Mid-body (1)

Photo 95 Scrubber D Mid-body (2)

Photo 96 Scrubber D Mid-body (3)

Photo 97 Scrubber D Mid-body (4)

Photo 98 Scrubber D Mid-body (5)

Photo 99 **Scrubber D Mid-body (6)**

Photo 100 **Scrubber D Mid-body (7)**


2017/04/25
D2

Photo 101 **Scrubber D Mid-body (8)**


2017/04/25
D2

Photo 102 **Scrubber D Mid-body (9)**

Photo 103 Scrubber D Mid-body (10)

Photo 104 Scrubber D Lower-body (1)

Photo 105 **Scrubber D Lower-body (2)**

Photo 106 **Scrubber D Lower-body (3)**

Photo 107 Scrubber D Lower-body (4)

Photo 108 Scrubber D Lower-body (5)

Photo 109 **Scrubber D Lower-body (6)**

Photo 110 **Filters**


2017/04/26
E1

Photo 111 Scrubber Recirculating Tank


2017/04/26
G1

Photo 112 Windbox Belly (1)

Photo 113 **Windbox Belly (2)**

Photo 114 **Windbox Belly (3)**

Photo 115 **Windbox Outlet Side (1)**

Photo 116 **Windbox Outlet Side (2)**

Photo 117 Windbox Inlet Side (1)

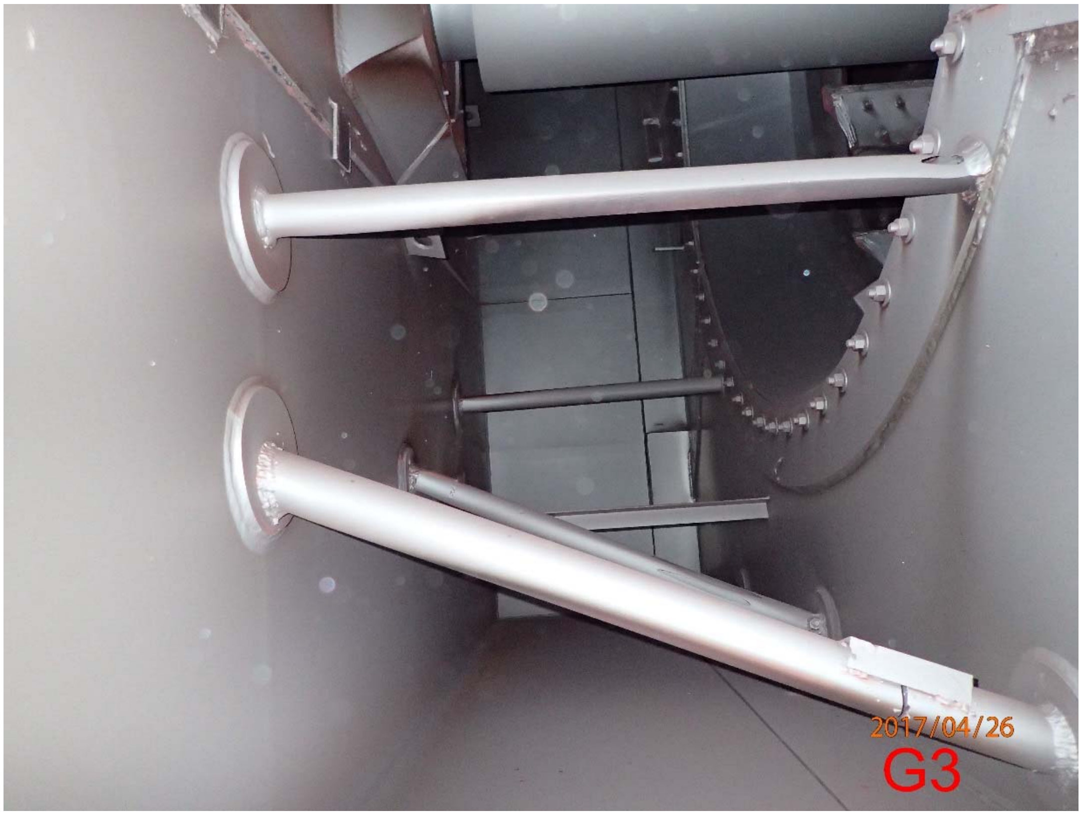

Photo 118 Windbox Inlet Side (2)

Photo 119 Multiclone Sump

Photo 120 Multiclone Cones Discharge at Ground Level (1)

Photo 121 Multiclone Cones Discharge at Ground Level (2)

Photo 122 Multiclone Cones Discharge at Ground Level (3)

Photo 123 Multiclone Cones Discharge at Ground Level (4)

Photo 124 Multiclone Cones Discharge at Ground Level (5)

Photo 125 Multiclone Cones Discharge at Ground Level (6)

Photo 126 Multiclone Cones Discharge at Ground Level (7)

Photo 127 Multiclone Cones Discharge at Ground Level (8)

Photo 128 Multiclone Cones at Second Level (1)

Photo 129 Multiclone Cones at Second Level (2)

Photo 130 Multiclone Cones at Second Level (3)

Photo 131 Multiclone Cones at Second Level (4)

Photo 132 Multiclone Cones at Second Level (5)

Photo 133 **Multiclone Cones at Second Level (6)**

Photo134 **Multiclone Cones at Second Level (7)**

Photo 135 Multiclone Cones at Second Level (8)

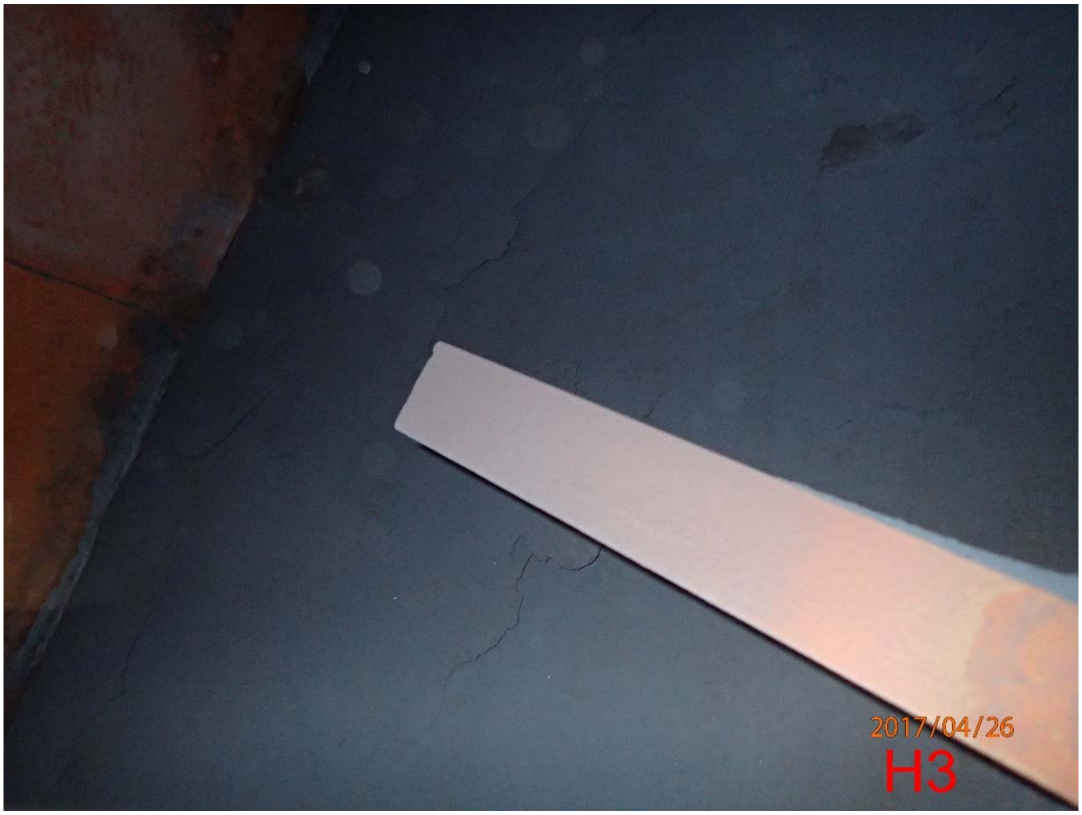

Photo 136 Multiclone Cones at Second Level (9)

Photo 137 Multiclone Cones at Second Level (10)

Photo 138 Multiclone Cones at Second Level (11)

Photo 139 Multiclone Cones at Second Level (12)

Photo 140 Multiclone Cones at Second Level (13)

Photo 141 Multiclone Cones at Second Level (14)

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Photo 143 Multiclone Cones at Second Level (16)

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Photo 145 **Multiclone Cones at Second Level (18)**

Photo 146 **Multiclone Top (1)**

Photo 147 **Multiclone Top (2)**

Photo 148 **Multiclone Top (3)**

Photo 149 **Multiclone Top (4)**

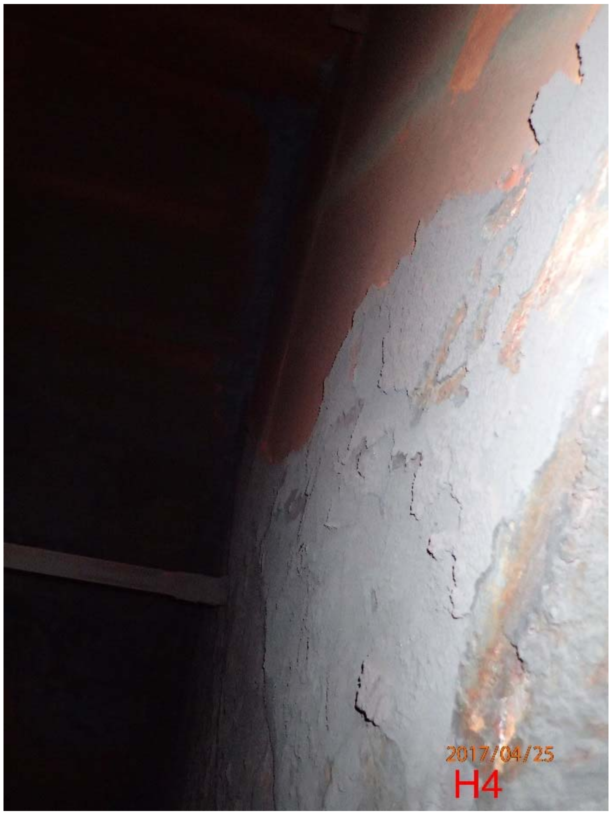

Photo 150 **Multiclone Top (5)**

Photo 151 **Multiclone Top (6)**

Photo 152 **Multiclone Top (7)**

Photo 153 **Denver Sump**

Photo 154 **Ducting off Process Gas Header (1)**

Photo 155 Ducting off Process Gas Header (2)

Photo 156 Ducting off Process Gas Header (3)

Photo 157 Ducting off Process Gas Header (4)

Photo 158 Ducting off Process Gas Header (5)

Photo 159 Ducting off Process Gas Header (6)

Photo 160 Ducting off Process Gas Header (7)

Photo 161 Ducting off Process Gas Header (8)

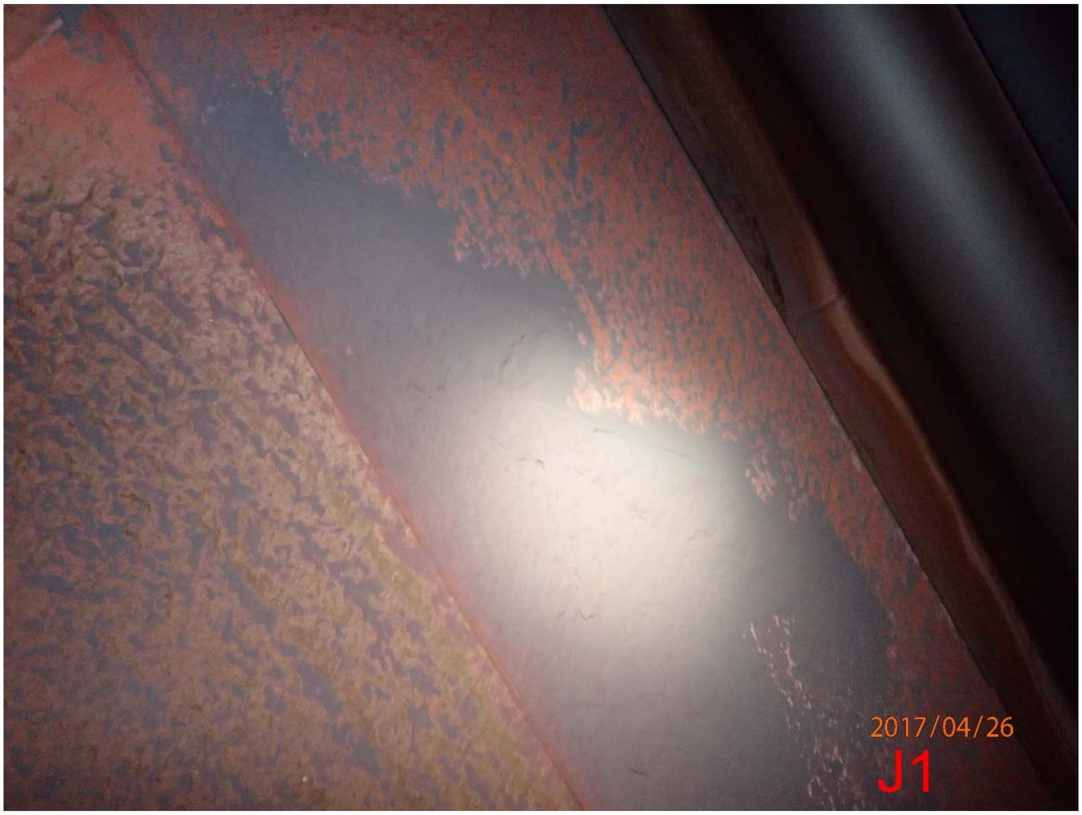

Photo 162 Ducting off Process Gas Header (9)

Photo 163 Ducting off Process Gas Header (10)

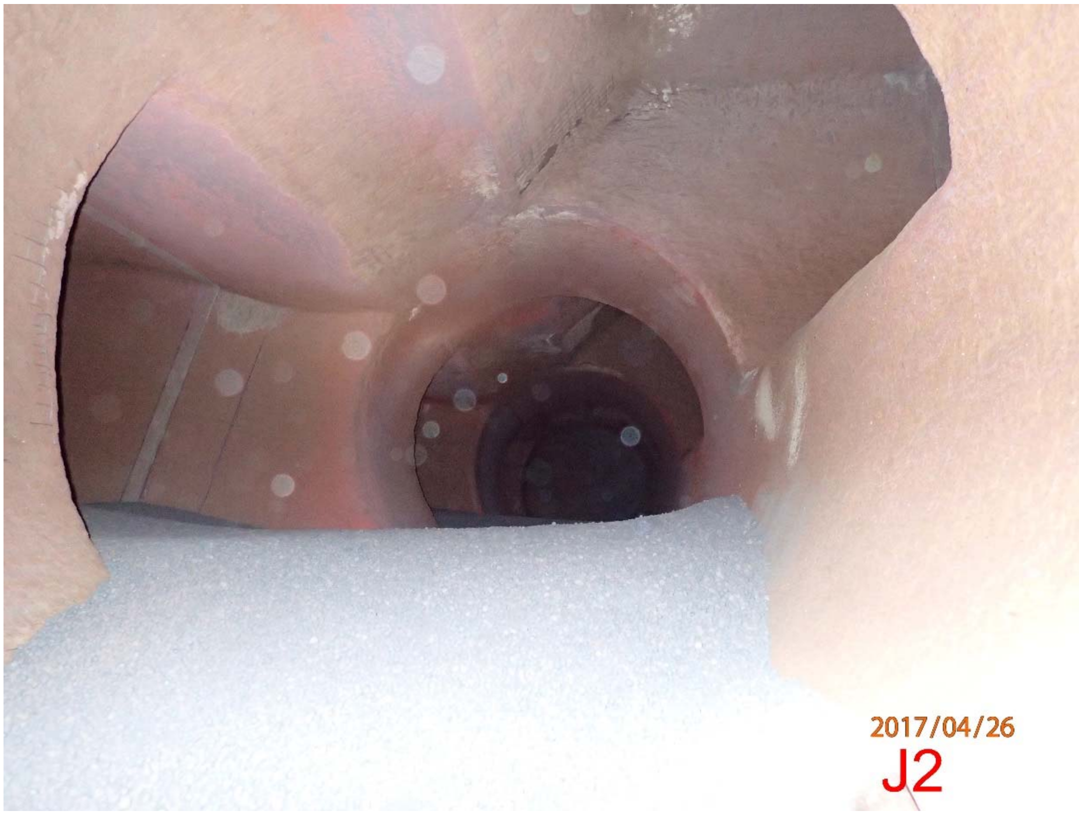

Photo 164 Access of Process Gas Header (1)

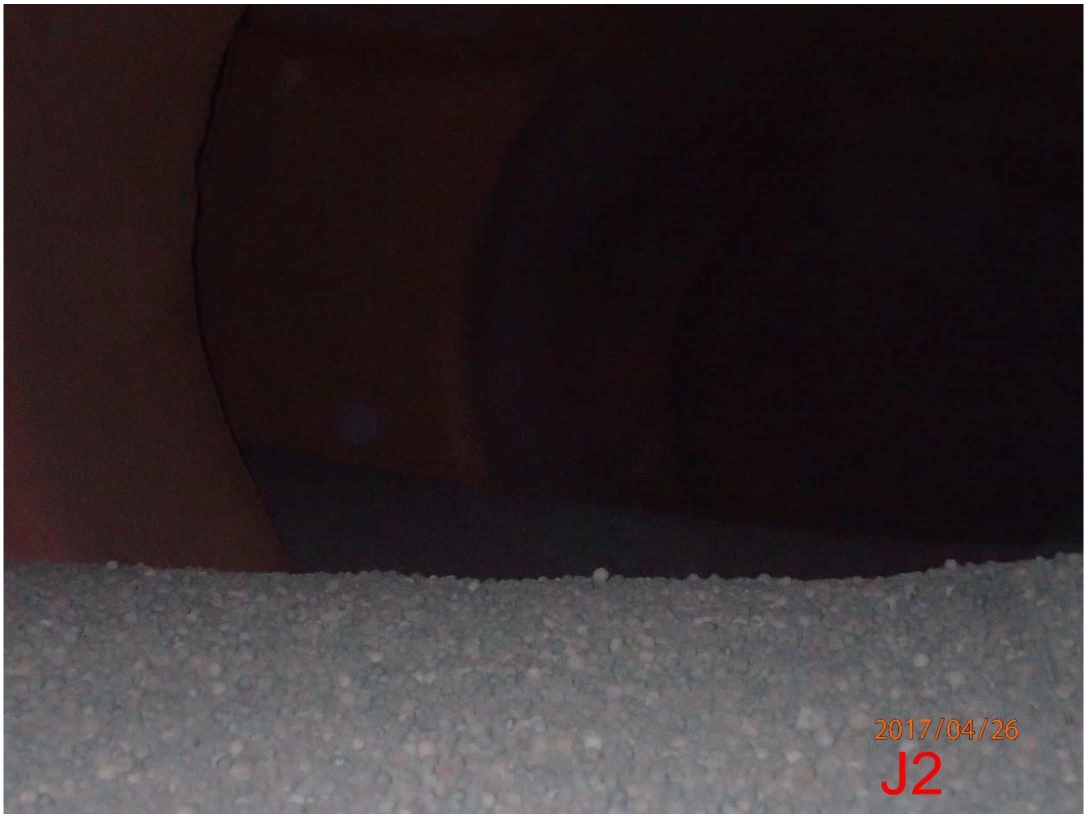

Photo 165 **Access of Process Gas Header (2)**

Appendix B-5-2

Hibbing Taconite Company. 2017 Mercury Reduction Test Report. Phase III – Gap Analysis: Halide Injection on Furnace Line 2

April 13, 2018

Hibbing Taconite Company
2017 Mercury Reduction Test Report
Phase III - Gap Analysis: Halide Injection on Furnace Line 2

By: Corie Ekholm

April 13, 2018

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Background

Minnesota mercury reduction initiatives began in 1999 focusing on the areas of municipal, household, and medical waste combustion. With reductions in those areas, Minnesota moved onto other industries including taconite production. In March 2007, the Environmental Protection Agency (EPA) approved the Minnesota Pollution Control's (MPCA) statewide mercury Total Maximum Daily Load (TMDL). The TMDL specifies that, in order to meet the water quality standards, a 93% reduction from 1990 human caused, air deposited mercury levels is required.

In accordance with the TMDL, the Minnesota taconite processing sector committed to a goal of 75% reduction from estimated 2010 taconite plant mercury emissions by 2025. In 2009, The Minnesota Taconite Mercury Control Agency Advisory Committee (MTMCAC) was formed to meet these goals. The committee consisted of academic experts, taconite company representatives, and members of government agencies, including the Minnesota Department of Natural Resources (DNR), MPCA, and the US Environmental Protection Agency, Great Lakes Restoration Initiative (EPA-GLRI). The committee was tasked with conducting research and running trials with the requirements that the control technology chosen must be technically and economically feasible, must not impair pellet quality, and must not cause excessive corrosion to the pellet furnaces or emission control equipment. MTMCAC performed numerous studies on mercury reduction from 2010 through 2014. Reports for these projects can be found on the DNR website.

The studies were performed in two phases and included the evaluation various activated and brominated carbon applications (scrubber additives, bag houses, fixed bed reactors), the corrosive effects of halides, long term gas brominated carbon injection, and Gore^{TM} Mercury Control System pilot test.

In September 2014, the State of Minnesota amended the air quality rules related to mercury emissions reporting and reductions (Minnesota Rules, part 7007.0502). These new rules require taconite processing facilities to reduce mercury air emissions by 72% of baseline emissions (defined as the maximum of either 2008 or 2010 emissions) by 2025.

Hibbing Taconite Company (Hibtac) had previously run short-term (less than one day) halide injection tests, however no long-term testing had been completed. In an effort to gain more information, Hibtac chose to run a halide injection test on its indurating furnace line 2 (herein referred to as line 2) with the following goals:

- Determine total mercury reduction rate using halide injection
- Determine final destination of mercury following halide oxidation and removal
- Evaluate scrubber performance via particulate stack testing
- Determine mercury concentration in the stack emissions with and without halide injection
- Evaluate all forms of mercury stack emissions such as vapor and particulate as well as elemental/oxidized mercury (both before and during halide injection)
- Identify safety/hygiene issues with halides
- Gather operating and maintenance cost information to be used if halide injection reaches the economic assessment step of the BAMRT analysis.
- Measure and analyze impact on pellet quality
- Determine if corrosion of plant equipment is increased using corrosion coupon analysis
- Determine halide concentration in scrubber water and waste water system
- Evaluate stack emissions of other compounds via stack testing

Hibtac has three Straight-Grate type indurating furnaces. Each furnace has four separate scrubbers and exhaust stacks for particulate matter emissions control. A diagram of the furnace can be found in Appendix A. The test plan is attached in Appendix B.

Halide Injection Background

There are three forms of mercury present in the stacks at Hibtac: elemental, oxidized, and particulate bound. The most common is elemental (85%-95% of the total mercury). Elemental mercury (Hg^0) is a non-soluble gas that passes through wet scrubbers without being captured. Gaseous halogens such as bromine and chloride are strong oxidants that react with the elemental mercury (Hg^0), forming mercury-halogen salts ($HgBr_2$). The mercury-halogen salts are soluble and can be captured in the wet scrubbers. By injecting a bromide compound (HBr or CaBr2) into the heated furnace, it will form a halogen gas (Br^-) that can then react with the elemental mercury. The mercury-halogen salt formed ($HgBr_2$) can then be captured by the wet scrubber reducing mercury emissions. Excess gas halogens are also soluble and captured by the wet scrubber.

Test Setup

The test equipment for injecting the halide chemicals was purchased and installed by Hibtac personnel. The system consisted of chemical totes, tote containment, a chemical feed skid, tubing, and injection lances.

The lances and nozzles were provided by BETE Fog Nozzle Inc. The initial nozzles were low flow air atomizing designed for the low flow chemical (<2gph). With the low flow rate and furnace environment, the nozzles plugged quickly. A larger air atomizing nozzle was installed during screening and the first half of the long-term trial. When that nozzle also plugged (see Appendix I for pictures), it was replaced with a flat fan nozzle with no atomizing air. It was initially thought that the chemical could be injected without dilution, however that plan was abandoned due to the consistent nozzle plugging. The chemical feed system allowed the chemical to be diluted down, increasing the flow to approximately 0.5gpm.

US Water Services provided the chemical feed skid (dilution system) as seen in Appendix C. The feed system was made up of two parts: the water control system and the chemical control system. The water control system consisted of a strainer, pressure gauge, manual control valve, 0.2-2.0gpm flow meter, and a check valve. The chemical system consisted of a strainer, metered chemical feed pump (0.5-4.5gph), flow calibration column, pressure relief valve and return line, and a check valve. Flow from the two systems came together after the check valves, then went through an inline mixer before going through the tubing to the lances. Flexible 3/8"ID (1/2"OD) HDPE tubing was run between the feed skid and the nozzles. Lanxess Solutions Inc. provided the test chemical in totes.

Screening Test

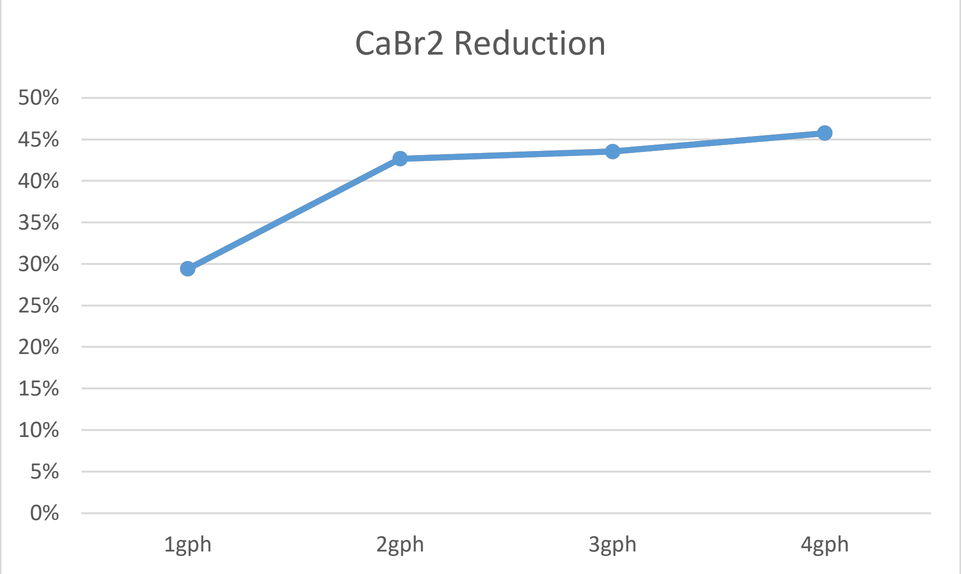
The chemical screening tests began on September 13, 2017. As described in the halide test plan, initial research guided Hibtac to test calcium bromide ($CaBr_2$) and hydrogen bromide (HBr or bromic acid). Calculations showed it would take less than 0.1gph of each chemical to react with the mercury released from the ore in the furnace.

The anticipated destination for the halides was the Hibtac tailings basin, therefore, the chosen chemicals had to be approved by the Minnesota Pollution Control Agency (MPCA) for HTC's National Pollutant

Discharge Elimination System (NPDES) Permit. The chemical approval forms were submitted and approval up to set chemical flow rates was acquired prior to chemical injection.

The chemical injection rate for testing was set at 0.5 to 2.0gph of chemical after considering the very low calculated flow and the higher flow rates of previous tests. The chemical was injected in two locations: the windbox exhaust ducts prior to the multiclones and the preheat zone of the furnace. The ideal scenario was for a substantial reduction in mercury by injecting into the windbox exhaust ducts. The windbox exhaust duct ducts would reduce the furnace chemical exposure and potential for corrosion but it was uncertain whether there was enough heat for the reaction to occur.

During the first week of screening, the following tests were conducted: 1) $CaBr_2$ into windbox exhaust ducts, 2) HBr into windbox exhaust ducts, and 3) $CaBr_2$ into the preheat zone (before the nozzles plugged). From the data collected, it became apparent that a greater reduction in mercury could be achieved by injecting the chemical into the preheat zone of the furnace. The second set of screening tests occurred October 3 and 4, 2017. Both chemicals were injected independently into the preheat zone at 2.0gph. The hydrogen bromide had a slightly lower mercury reduction. The lower reduction combined with the additional safety concerns associated with handling the hydrogen bromide led Hibtac to choose calcium bromide for long-term testing. The calcium bromide was injected at 1, 2, 3, and 4gph to see if additional reductions could be achieved at greater flow rates. After 2gph, the reduction of mercury leveled off (see Graph 1 below) leading to the decision to run the long-term test at 2gph.



Graph 1: Mercury Reduction with Calcium Bromide Injection

The screening stack tests consisted of the following tests: EPA Method 30B for mercury, EPA Method 5 for particulate, FTIR (Fourier Transform Infrared Spectroscopy) for halides, EPA Method 8A for sulfuric acid mist, and gas chromatography for hydrogen sulfide. The screening results can be found in Appendix G.

Testing

The long-term test involved injecting calcium bromide at 2.0gph into the preheat zone from October 5, 2017 to November 26, 2017 (52 days). The planned 60-day trial was reduced by the time required to redesign the system after the plugging issues were discovered during the initial screening test. The calcium bromide was injected whenever the furnace was running with a feed rate greater than 200tph. If the feed rate dropped below 200tph, the chemical pump would shut off but the water would continue to flow through the system in an effort to prevent nozzle plugging. In total, calcium bromide was injected into line 2 for 1128 hours.

Halide Injection Results

Plant Samples

Samples were collected from various locations around the plant prior to and during halide chemical injection in an effort to trace and quantify the changes in mercury concentrations during injection. The samples were collected by Hibtac employees and analyzed by Pace Analytical. The samples listed below were taken and analyzed for mercury. The multiclone dust and scrubber water/solids were also analyzed for calcium and bromide to track/quantify any increase observed during testing. Appendix D has a diagram showing the sample locations as part of the plant flow sheet.

- Rougher Tails*
- Finisher Tails*
- Concentrate*
- Thickener Overflow*
- Greenballs
- Pellets
- Multiclone Dust
- Scrubber Water/Solids*

* Samples were filtered with the water and the solids analyzed separately for mercury

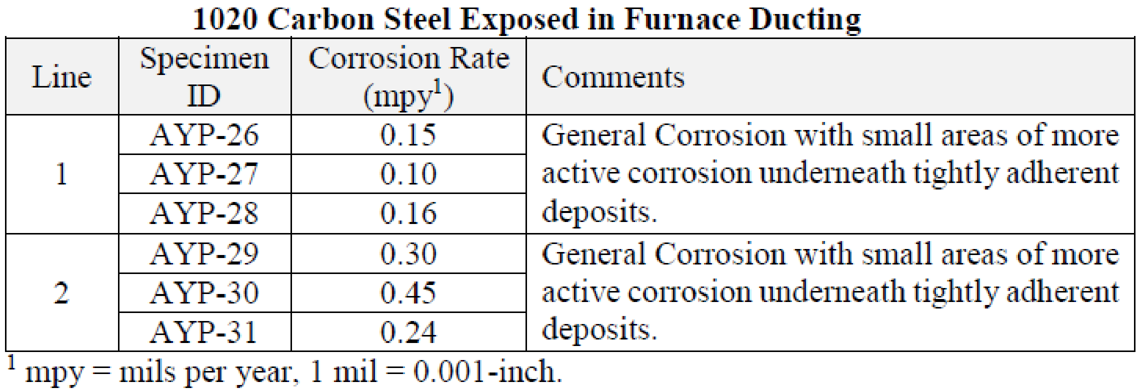
As anticipated, there was an increase in mercury in the scrubber solids as mercury was removed from the stack gases. The mercury present in the scrubber water seemed unaffected by the testing as it bounced around with some samples containing more mercury than the baseline and others containing less. This may indicate that the mercury captured in the water bonds with the solids present in the scrubber sump. An increase in the thickener overflow sample mercury was seen 2 weeks into the halide testing. An increase in the amount of bromide in the scrubber solids and multiclones was seen during the testing. There was almost no bromide found in the baseline samples. Calcium remained about the same throughout testing indicating that the additional amount of calcium from the calcium bromide was small compared to the calcium already present in the system. The sample results can be found in Appendix E.

Corrosion Testing

Corrosion coupons and test grate bars were installed during the long-term halide test to determine if there was significant halide corrosion. Due to the injection of the halide on line 2, furnace line 1 was used as a control. Mild steel coupons were installed in the windbox exhaust duct after the multiclone house and before the windbox exhaust fan. Three test grate bars were installed on the east side of a pallet car on each line. The coupons and grate bars were in both furnace lines for a total 52 days, simultaneously. Corrosion Testing Laboratories, Inc. provided the coupon, coupon holders, and corrosion analysis and performed the initial and final analysis on the grate bars provided by Hibtac (new grate bars were from those in stock).

The results from the Corrosion Testing Laboratories show significantly more corrosion of the coupons and grate bars that were installed in line 2 during testing. The coupons from line 2 had a corrosion rate 2-3 times greater than line 1 coupons (see Table 1 below). The grate bars from line 2 also showed a corrosion rate 3-4 times greater than line 1 grate bars (see Table 2 below). The higher rates of corrosion are an operational concern with long-term halide injection. The full corrosion report can be found in Appendix F. Pictures can be seen in Appendix I.

Table 1: Mild Steel Coupon Corrosion Rates

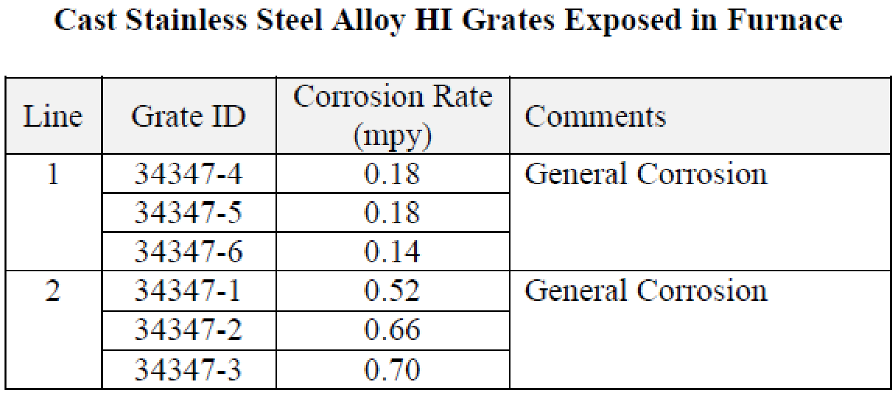


1020 Carbon Steel Exposed in Furnace Ducting

Line	Specimen ID	Corrosion Rate (mpy[1])	Comments
1	AYP-26	0.15	General Corrosion with small areas of more active corrosion underneath tightly adherent deposits.
	AYP-27	0.10	
	AYP-28	0.16	
2	AYP-29	0.30	General Corrosion with small areas of more active corrosion underneath tightly adherent deposits.
	AYP-30	0.45	
	AYP-31	0.24	

[1] mpy = mils per year, 1 mil = 0.001-inch.

Table 2: Grate Bar Corrosion Rates



Cast Stainless Steel Alloy HI Grates Exposed in Furnace

Line	Grate ID	Corrosion Rate (mpy)	Comments
1	34347-4	0.18	General Corrosion
	34347-5	0.18	
	34347-6	0.14	
2	34347-1	0.52	General Corrosion
	34347-2	0.66	
	34347-3	0.70	

Stack Testing

Barr Engineering performed the baseline, screening, and long-term stack testing. During the baseline and long-term test, the following stack tests were run: Ontario Hydro method for speciated mercury, EPA Method 5 for particulate, EPA Method 26A for hydrogen halides and halogens, EPA Method 8A for sulfuric acid mist, and gas chromatography for hydrogen sulfide. These tests allow Hibtac to quantify the mercury reduction and verify that there are no unwanted side effects or increases in the emissions of other substances.

The calcium bromide injection was found to reduce the total amount of mercury from the stacks by 33%. This reduction was determined by taking the difference between the baseline and long-term stack emissions and dividing by the baseline stack emissions. When comparing plant operating conditions and plant sample mercury content, it is estimated that there was approximately a 15%-20% increase in mercury in the furnace feed from the baseline to the long-term stack test. This increase from baseline due to changes in the ore implies that the total reduction in mercury air emissions was greater than 33%.

The mercury exiting the stacks is primarily elemental under standard operating conditions. During the calcium bromide injection, the amount of elemental mercury decreased by 84% while the oxidized mercury increased by 314% and the particulate bound mercury increased by 920% (see Tables 3 and 4 below). The decrease in elemental mercury and increase in oxidized mercury indicates the chemical was reacting with the mercury as designed but the scrubbers were not able to remove the oxidized mercury entirely. The increases in particulate and oxidized mercury is a concern as these forms of mercury tend to deposit closer to the source.

Table 3: Mercury Speciation

	Particulate	Elemental	Oxidized
Baseline	0.5%	87.5%	11.6%
Long-term	7.1%	20.6%	71.9%

Table 4: Mercury Emissions in lbs/hr

	Total Hg	Particulate	Elemental	Oxidized
Baseline	0.0102	0.00005	0.0089	0.0012
Long-term	0.0068	0.00048	0.0014	0.0049

The EPA Method 26A testing did show a minimal increase in hydrogen bromide in the stack emissions. This increase did not trigger any regulations or government limits but may be a point of concern for long-term implementation.

The other stack tests identified no other negative side effects associated with calcium bromide injection. The EPA Method 5 test showed a decrease in particulate during the long-term test. This may have been due to a lower feed rate, stronger greenballs, or normal variation. The baseline and long-term bromine, as tested by EPA Method 26A, were both below the detection limits. The EPA Method 8A test for sulfuric acid mist also showed a decrease from baseline to long-term. There was no hydrogen sulfide (H_2S) detected in either the baseline or long-term test with gas chromatography. The stack test summaries can be found in Appendix H. Full stack testing reports are maintained within Hibtac files.

Other Observations

Line 2 went down for repair immediately after the halide testing concluded. The furnace was examined for signs of additional buildup, wear, and corrosion. No additional buildup or visible corrosion was observed. While corrosion was not visible, the coupons demonstrated it was presented (see Corrosion Testing section). There was abnormal wear to the refractory and refractory curbs under the injection lance in the preheat zone. The injection spray removed or prevented normal slag buildup and damaged the outside layer of refractory. The damage was minimal and no refractory replacement was needed but the area will be monitored during future repairs. The damage was attributed to several factors including: the end of the lance narrowly clearing the inside wall of the furnace (not the curbs below), the strong downward pull of air, and the running of water during furnace cool down. This problem can be minimized or prevented in the future with a longer lance to ensure the spray clears the refractory wall and curb. Water injection would also be shut off below a certain temperature as an additional preventative measure.

The pellet quality remained consistent throughout the test period. There were no negative effects on quality or furnace operation noted.

Conclusion

Hibbing Taconite completed a 52 day halide injection test for mercury reduction on furnace line 2 during fall 2017. Screening tests were run to determine the chemical, the injection location, and the injection rate. The screening tests showed injection into the preheat zone had greater mercury reduction than injection into the windbox exhaust ducts. Calcium bromide proved to have slightly better mercury reduction and to be safer to handle than hydrogen bromide. Calcium bromide is a relatively safe chemical to use but still involves the use of proper chemical handling protocol and a response plan in case of a spill. The screening tests also demonstrated how easily the injection nozzles plugged leading to the decision to dilute the chemical and increase the flow rate through the nozzle.

During the testing period, 2.0 gallons per hour of calcium bromide was diluted down with approximately 0.5 gallons per minute of water and injected into the furnace preheat zone. The injection resulted in a 33% reduction in total mercury air emissions (not taking into account the increase in mercury in the furnace feed). The amount of elemental mercury was reduced by 84% indicating a good reaction with the chemical, however the existing scrubbers do not efficiently remove the oxidized mercury from the exhaust stream. The increase in both oxidized and particulate bound mercury is a concern due to potential local deposition. There was also an increase in hydrogen bromide stack emissions (no hydrogen bromide was detected in the baseline samples). Particulate matter and sulfuric acid mist both showed a decrease from baseline to the long-term test. Hydrogen sulfide and bromine were both below the detection limits in the baseline and long-term tests. The plant samples indicate the mercury reports to the multiclones and scrubber sump and returns to the concentrator. The mercury is expected to leave the concentrator in the tails. With the amount of mercury from halide injection being relatively small compared to the mercury present in the tails samples, the final path of the mercury could not be verified.

There were several furnace observations made during the halide injection test. A negative impact discovered was the 2-3 times greater corrosion rates of the steel coupons in the windbox exhaust ducts and the 3-4 times greater corrosion rate of furnace grate bars when compared to the control furnace. A small area of refractory damage was observed but may be prevented in the future with a different injection lance. There were no other areas of excess buildup observed. Pellet quality was not impacted by the test.

Appendix A: Furnace Diagram

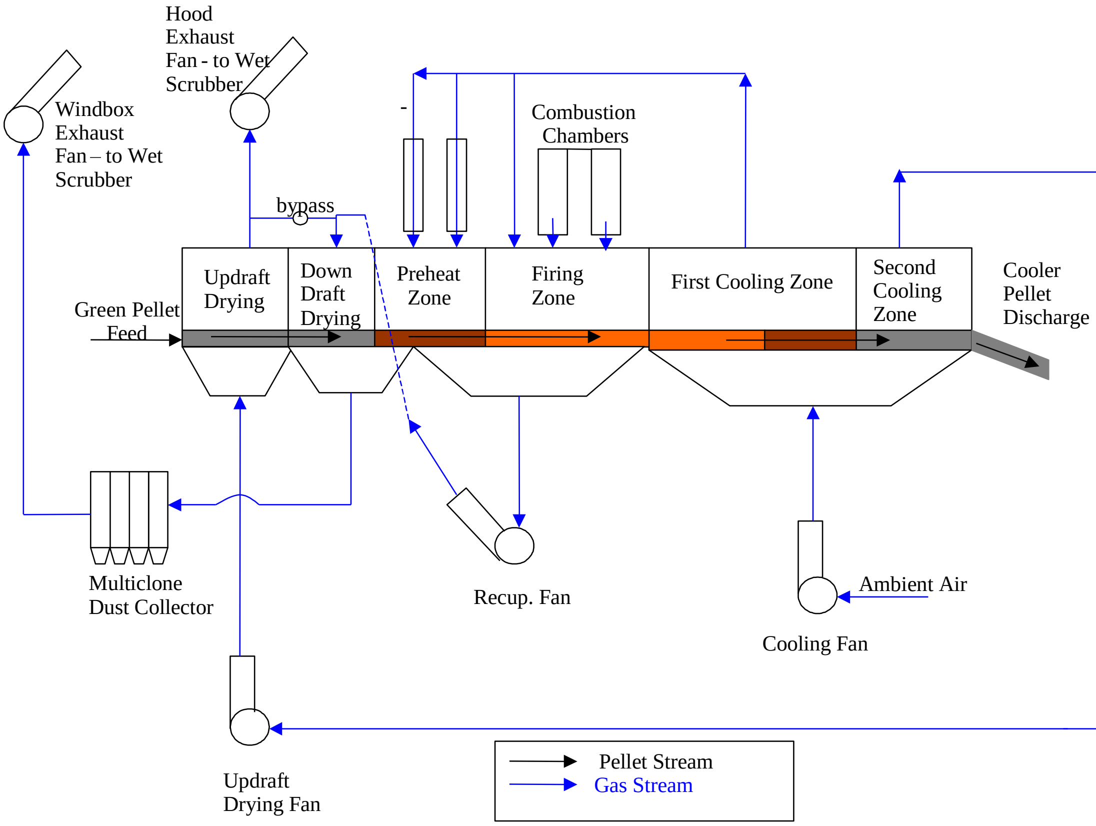


Diagram from "Mercury Transport in Taconite Processing Facilities: (III) Control Method Test Results" by Michael E. Berndt and John Engesser

Bernt, M. E. and Engesser, J. (2007) Mercury Transport in Taconite Processing Facilities: (III) Control Method Test Results. Iron Ore Cooperative Research Final Report. Minnesota Department of Natural Resources. 38 pages plus appendices.

Appendix B: Halide Test Plan

Halide Injection Test Plan – Final Revision

Prepared for
Hibbing Taconite Company

August 2017

4300 MarketPointe Drive, Suite 200
Minneapolis, MN 55435

Halide Injection Test Plan

July 2017

Contents

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List of Appendices

Acronyms

Acronym	Description
BAMRT	Best Available Mercury Reduction Technology
$CaBr_2$	Calcium Bromide
CMM	Continuous Mercury Monitor
HBr	Hydrogen Bromide
Hg	Mercury
HTC	Hibbing Taconite Company
MPCA	Minnesota Pollution Control Agency
OH	Ontario Hydro
SEA	Sorbent Enhancement Additive
TMDL	Total Maximum Daily Load

1.0 Introduction

This document provides the test plan for halide injection to analyze mercury emissions reduction from the pellet induration process. This test plan has been developed specifically for Hibbing Taconite Company (HTC). The purpose of this test plan is to define the strategy and protocol for halide injection testing.

This document outlines the next phase of testing potential mercury reduction technologies at HTC. HTC had previously completed halide injection testing on Furnace Line 3 as part of an overall Minnesota taconite industry research effort. The previous test was conducted to determine if halide injection could meet the 75% reduction Total Maximum Daily Load (TMDL) goal set by the Minnesota Pollution Control Agency’s 2009 Implementation Plan. Since the testing, Minnesota has implemented state regulations (Minn. R. 7007.0502) that require HTC to reduce mercury emissions by January 1, 2025 to no more than 28% of the mercury emitted in 2008 or 2010, whichever is greater. The State regulations also require HTC to submit a mercury emissions reduction plan by December 30, 2018 to show how HTC will achieve the 72% reduction, or propose an alternate plan if HTC concludes that 72% reduction is not technically achievable. HTC has conducted a thorough review of potential mercury reduction technologies and has determined that halide injection should be further explored as an option for Best Available Mercury Reduction Technology (BAMRT).

The purpose of this test plan is to define the strategy and protocol for additional testing to determine what amount of mercury capture is possible with halide injection. The testing will be performed over an extended period while injecting the halide. This test will explore whether or not halide injection is technically feasible, economically feasible, impairs pellet quality or causes excessive corrosion to plant equipment if HTC were to permanently implement and utilize this technology for mercury control.

2.0 Goals of Test

HTC and Barr Engineering Co. (Barr) have identified the following goals for conducting the halide injection test:

- Determine total mercury reduction rate using halides at pre-determined injection rates for all three forms of mercury (elemental, oxidized, and particulate)
- Determine final destination of mercury following halide oxidation and removal
- Evaluate scrubber performance via particulate stack testing
- Determine mercury concentration in the stack emissions with and without halide injection
- Identify safety/hygiene issues with halides
- Gather operating and maintenance cost information to be used if halide injection reaches the economic assessment step of the BAMRT analysis.
- Determine if halide injection is technically feasible to reduce mercury emissions by MPCA rule
- Measure and analyze impact on pellet quality
- Determine if corrosion of plant equipment is increased using corrosion coupon analysis
- Determine halide concentration in scrubber water and waste water system.
- Evaluate stack emissions of other compounds via stack testing.

3.0 Halide Selection

HTC and Barr have evaluated commercially available halide chemicals for possible injection according to the criteria outlined within this section. HTC has selected hydrogen bromide (HBr) and calcium bromide ($CaBr_2$) to test. HBr and $CaBr_2$will be injected into the windbox exhaust ducts. If there is insufficient reductions, the chemicals will be injected above the grate within the preheat zone. Appendix A contains the table which lists the commercially available halide chemicals and the reasoning why each chemical was chosen for study or not.

3.1 Halide Evaluation Criteria

- **The halide must oxidize mercury at flue gas temperatures and perform within a low residence time.** There is concern that use of halides to oxidize elemental mercury could cause equipment corrosion. Injection of halides after the grate rather than above reduces opportunities for corrosion; however, this also reduces the temperature and amount of time available for halides to oxidize elemental mercury, thereby restricting the choice of halides to those that will react spontaneously at the lower temperatures present in the flue. During the screening, HTC will inject the halide into the windbox exhaust ductwork, prior to the scrubber. If the chemicals shows minimal results, they will be tested at a location within the preheat zone.
- **The halide cannot contain sulfur.** HTC and Barr agreed that halides containing sulfur would not be injected due to environmental concerns that this would increase the concentration of sulfur in scrubber water that is discharged to the tailings basin.
- **Use of chloride is not preferred for purposes of this study.** Chloride is not preferred as it has shown a smaller mercury reduction than bromide in previous test work.
- **Use of iodide is not preferred for purposes of this study.** Previous studies have shown that iodide reacts with mercury less readily than bromide, so iodide injected into the flue may not have enough time to react with mercury.
- **Halides cannot contain an additive that would need collection in a baghouse.** Use of halides that contain an additive that would require collection through use of a baghouse were not considered since the facility does not currently utilize baghouses on the furnace exhaust stacks. The addition of supplementary pollution control equipment would not be economically feasible.

3.2 Halides Considered

Approximately 17 chemicals and vendors were evaluated for use in this study, as shown in Appendix A. Once all halide additives were eliminated that did not fit the criteria discussed above, three non-proprietary chemicals (sodium bromide, calcium bromide, and hydrogen bromide) and one proprietary chemical (SF12 from Midwest Energy Emissions) remained.

3.2.1 Proprietary Chemicals

Midwest Energy Emissions (Midwest) provides a proprietary chemical called SF12, with a reported mercury reduction of 60-90%. The SF12 is considered a sorbent enhancer. Midwest proposed using SF12 in conjunction with one of their two sorbent technologies, SB31 and SB33. HTC is not interested in using sorbent technologies due to particulate matter emission concerns. Midwest stated that SF12 would work better at the 500-600°F range but may work at temperatures within the windbox exhaust. They also stated that it may only achieve around 60% without using the sorbent additives. SF12 was ruled out because of concerns with scrubber particulate capture and the fact that it is not typically used as a stand-alone product.

3.2.2 Non-Proprietary Chemicals

The ability of bromide to oxidize mercury has been extensively studied by the coal industry, so the majority of bromide testing has occurred at much higher temperatures than those seen in HTC's flue gas. However, one study comparing the effectiveness of HBr and $CaBr_2$ injected into flue gas at 330°F +/- 25°F resulted in mercury oxidation efficiencies of 71% and 61%, respectively.

The vendor has indicated that $CaBr_2$ and HBr have shown more success in the coal industry than sodium bromide (NaBr). This is supported by the results seen during previous activated carbon tests containing NaBr. Therefore, testing of NaBr is not suggested for purposes of this study.

In order to determine the best chemical for HTC's injection location parameters, the change in Gibbs Free Energy (ΔG) of each reaction was calculated to determine if it is favorable or unfavorable at a given temperature. If $\Delta G < 0$, that means that the reaction is favorable (or in other words spontaneous); if $\Delta G > 0$, the reaction is unfavorable.

ΔG was calculated at a range of temperatures for the following reactions:

- $2CaBr_2 + O_2 \rightarrow 2CaO + 2Br_2$ - step 1 in the Hg reduction process where the CaBr2 is oxidized to create Br2
- $4HBr + O_2 \rightarrow 2Br_2$ - step 1 in the Hg reduction process where the HBr is oxidized to create Br2
- $Br_2 + Hg(0) \rightarrow HgBr_2$ - step 2 in the Hg reduction process where there free Br2 reacts with Hg to form HgBr2 that can be captured in the scrubber.
- $SO_2 + Br_2 + 2H_2O \rightarrow H_2SO_4 + 2HBr$ - potential side reaction that can create sulfuric acid (a PSD pollutant which could cause air permitting issues)

Figure 1 is a plot of the change in Gibbs Free Energy vs. temperature for the $CaBr_2$ and HBr reaction chain. The graph shows that the $CaBr_2$ reaction has a minimum temp requirement to be a spontaneous reaction of 475°F (blue triangles on the plot) and it becomes more favorable with increasing temperature. For the chemical reaction for the HBr solution (orange squares of the plot), the change in Gibbs Free Energy is negative over the entire temp range, which means that the reaction is spontaneous at these conditions. At about 300°F (and above) the sulfuric acid side reaction is not spontaneous, in other words not favorable (yellow diamonds on the plot). Finally, the secondary mercury reaction (Br2 + Hg(0) → HgBr2) is favorable across the entire temp range (green circles on the plot).

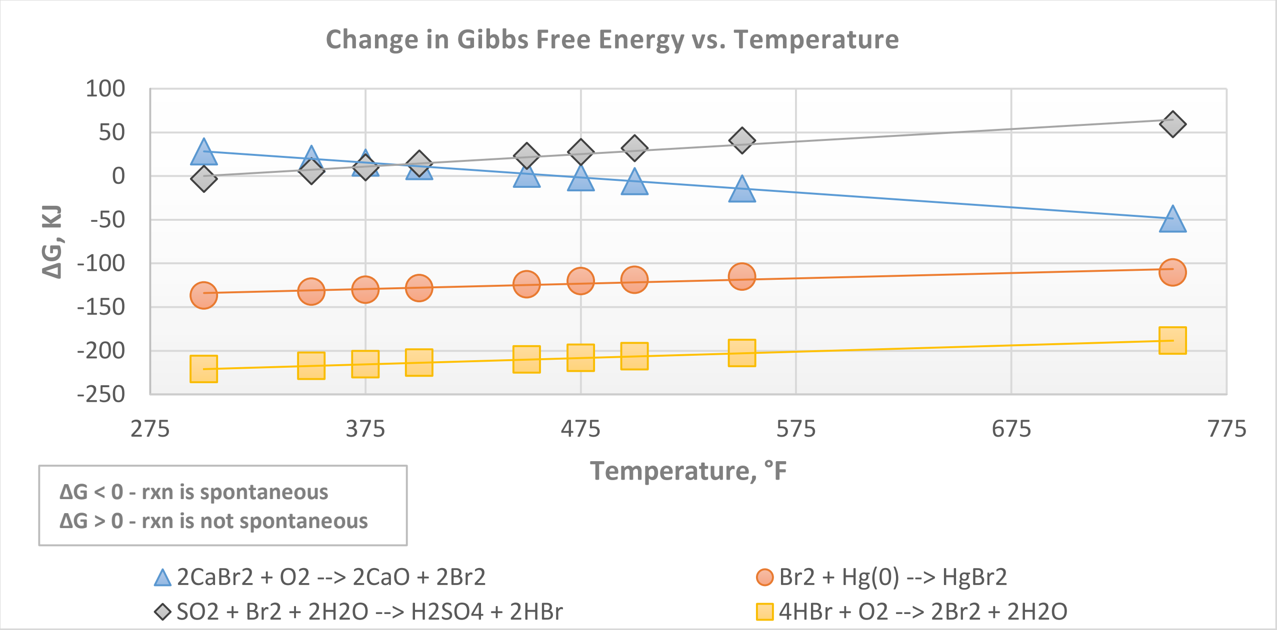


Figure 1 - Gibbs Free Energy Evaluation for CaBr2 and HBr Reactions

The results of the Gibbs Free Energy evaluation show that the $CaBr_2$ solution needs to reach a temperature of 475°F to work effectively and that H_2SO_4 will be a greater issue at temperatures less than 300°F. Therefore, the $CaBr_2$ solutions are theoretically not ideal for injection within the scrubber ducting, which is around 350°F, but the HBr solution should successfully reduce elemental mercury at the given parameters. This also suggests that HTC will need to evaluate the air permitting effects from the potential increase in sulfuric acid generation if excess halide is injected and encounters cooler temperatures downstream of the injection location.

4.0 Halide Injection Considerations

One company, Lanxess, supplies HBr solution (48% w/w) called GeoBrom HG480. Two companies, Lanxess and Nalco, supply $CaBr_2$ solution (52% w/w) called GeoBrom HG520 and MERCONTROL 7895, respectively. Considerations including cost, injection rate, and equipment setup are discussed within this section.

4.1 Injection Rate

The following parameters were used in order to determine the minimum injection rates:

Airflow	645,000 dscfm
Mercury Concentration	16.7 ug Hg/dscm
SO_2 Concentration	12.4 ppmv SO_2
Temperature	350 °F

Details on the calculations used to determine the injection rates are included in Appendix B.

The minimum injection rate for both the HBr and $CaBr_2$ solution is 0.01 gal/hr.

This rate assumes all of the halide solution reacts with the mercury present. In reality, some of the solution will be used in side reactions, so the rate should be scaled up. Therefore, HTC could consider starting at a rate of 0.3 gph. The injection rate will be varied from 0.3gph to 2.0gph to optimize the mercury reduction during the initial screening emissions testing.

At a rate of 0.3 gph to 2.0gph, a total of 432 to 2880 gallons would be used over a 60-day trial. The products are sold in drums or totes. Therefore, the total order of totes or drums will depend on the chemical injection rate chosen from the screening results.

4.2 Injection Equipment

The injection equipment consists of a stainless steel air atomizing nozzle attached to a stainless steel lance. A flexible hose runs from a lance to a chemical metering pump that is used to control the flow of solution to the nozzle. The pump is then connected to the liquid container.

The total footprint needed for the system is approximately 10' x 10'. Access to power and plant air will also be required.

Nalco quoted $5,000/mo. to rent the injection equipment. This included the Nalco's time to aid in set-up and service visits. However, Nalco's equipment cannot be used to test HBr (supplied by Lanxess). Therefore, HTC has decided to purchase the pumping equipment and perform the setup and maintenance.

4.3 Corrosion Coupon Testing

The secondary effects of halide injection are currently an unknown factor. One concern is that using halides could result in an increased risk of acid generation that creates a corrosive atmosphere for equipment. Corrosion coupons testing will take place downstream of the injection location to measure the corrosion rate during the halide injection testing. Corrosion coupon will be located in the windbox exhaust duct between the multiclone house and windbox exhaust fan. Concurrent with halide injection testing, a set of corrosion coupons will be placed in the same locations on line 1 furnace for the same duration of time to compare the corrosion rates with and without halide injection.

Corrosion Testing Laboratories, Inc. is supplying the coupon and coupon holders. The lab will supply HTC with clean, dry mild steel coupons that have been weighed and measured. HTC will send grate bars to the lab for cleaning and weighing, prior to the test, which will then be prepared according to the ASTM standard and sent back to HTC for testing. The lab will supply directions on the insertion, removal, and appropriate handling of the coupon samples.

4.4 Additional Considerations

Additional considerations such as safety concerns, handling considerations, and material storage options should be considered further. Please refer to the Safety Data Sheets are on file at HTC.

5.0 Stack Test Methods

This section provides a brief summary of the stack-test methods that will be used during the halide injection trial and Barr's recommendation.

- Ontario Hydro method (ASTM International Method D6784-16 Standard Test Method for Elemental, Oxidized, Particle-Bound, and Total Mercury in Flue Gas Generated from Coal-Fired Stationary Sources).
    a. The Ontario Hydro (OH) method has the ability to accurately measure total and particulate-bound speciated mercury emissions.
    b. The Ontario Hydro method will be used during baseline and long term stack testing.
- EPA Method 30B (Determination of Total Vapor Phase Mercury Emissions From Coal-Fired Combustion Sources Using Carbon Sorbent Traps)
    a. Method 30B is a procedure for measuring total vapor phase mercury emissions from coal-fired combustion sources using sorbent trap sampling and an extractive or thermal analytical technique. This method is only intended for use under relatively low particulate conditions and cannot measure particulate-bound mercury.
    b. Method 30B will be used during the screening tests due to its quick results and the low amount of particulate bound mercury expected.
- EPA Method 5 (Determination of Particulate Matter Emissions from Stationary Sources)
    a. When using halides, elemental mercury reacts to form oxidized mercury, which can be captured by the wet scrubber. This increase in oxidized mercury can overload the scrubber slurry to the point of 'particulate slip.'
    b. EPA Method 5 can be tested concurrently with the Ontario Hydro and EPA Method 29. If EPA Method 30B is chosen instead of Ontario Hydro and EPA Method 29, additional EPA Method 5 tests will need to be performed.
    c. EPA Method 5 will be used during baseline and long term stack testing. It will be run once at the end of the screening week under the conditions chosen for the long term test.
- EPA Method 26A (Determination of Hydrogen Halide and Halogen Emissions from Stationary Source Isokinetic Method)
    a. Method 26A is used to quantify emissions of hydrogen halides (HX) [HCl, HBr, and HF] and halogens (X2) [Cl2 and Br2]. The dissociated halogen gas should react with elemental mercury to create oxidized mercury, which can be captured by the scrubber. If unreacted halides are exiting the stack, then the reaction is likely at its saturation point. Therefore, this method can be used to determine the optimum injection rate and avoid using excess halides.

    b. Method 26A will be run during the baseline and long term stack testing.

- Fourier Transform Infrared Spectroscopy (FTIR)
    a. Fourier transform infrared spectroscopy (FTIR) is a technique which is used to obtain an infrared spectrum of absorption or emission of a solid, liquid or gas. An FTIR spectrometer simultaneously collects high spectral resolution data over a wide spectral range. FTIR could be used to collect real-time halide and sulfuric acid emission data.
    b. The FTIR will be run during the screening tests.

- EPA Method 8A (Determination of Sulfuric Acid vapor or mist and Sulfur Dioxide Emissions from Kraft recovery furnaces)
    a. Method 8A is used for the determination of H_2SO_4 (including H_2SO_4 mist and SO_3) from stationary sources. There is potential for H_2SO_4 formation from a side-reaction between the halide chemical and the SO2 present in the flue gas. H_2SO_4 is a PSD pollutant with potential air permitting impacts and therefore should be included in the stack testing regime.
    b. Method 8A will be run during the baseline, screening, and long term stack tests.

- Gas Chromatography
    a. Gas Chromatography is a technique which is used to measure gaseous organics. It separates the major organic components of a gas mixture and quantifies them by flame ionization, photoionization, electron capture, or other appropriate detection principles. Gas chromatography will be used to measure hydrogen sulfide (H_2S).
    b. Gas Chromatography will be used during baseline, screening, and long term stack testing.

6.0 Test Plan Outline

Given the main objectives and the overall activities to be accomplished during this testing campaign, the following test protocol is set forth as a guide to the operations once all equipment has been set up and commissioned.

- Team members
    a. HTC site Manager will be Corie Ekholm, 218-262-6866
        i. Alternate: Dan Aagenes, 218-262-5965
    b. Stack Testing Project Manager will be Thomas Leier, 218-929-7070
        i. Alternate: Tom Kuchinski, 763-548-4954

- Safety
    a. All staff working with the testing system:
        i. Shall be aware of the equipment and materials being used and the associated hazards of the materials and work areas
        ii. Shall be current on their MSHA training, fall protection certified, and required site-specific training

        iii. Shall wear the appropriate personal protective equipment, including safety shoes, hard hat, hearing protection, and safety glasses

- Emissions Test Planning
    a. During emissions testing, a safety briefing will occur each morning.
    b. In addition, a daily planning discussion will be held among the testing group and client operation representatives identifying the test plan and conditions with responsibilities of each team member. Communication is important to the success of the emissions test.
    c. This daily plan will guide the work for that day and the previous day testing results will be reviewed to identify good and poor performance parameters and recommend adjustments or process changes if required.

- Data Recording
    a. In order to maximize the value of this test, data must be recorded as clearly and completely as possible. The DCS historian database will be used to collect real-time process and lab data which will be critical in determining process operation and product quality during testing.
    b. HTC operations staff will develop a list of key process and lab data points to monitor during the testing. This list will include data from reports and the data historians from the process.

- Testing and Project Assistance from Barr
    a. HTC will manage testing coordination and schedules with vendors
    b. HTC will manage collection of process and test data
    c. HTC will manage plant sample collection and laboratory analytical results

- Initial Halide Dose Rate of 0.3 gph
    a. Change of dose rate will be determined by HTC
    b. Liquid halide will be injected into the windbox exhaust fan duct prior to the multiclone house using a pneumatic pumping system operated by HTC

- Stack Testing
    a. Stack testing will be completed at selected times during the test. The testing will occur during steady-state operation, determined by HTC plant management and operations.
    b. Baseline testing (no halide injection)
        i. Mercury: OH Method
        ii. Halides/Halogens: EPA Method 26A
        iii. Particulate Matter: EPA Method 5
        iv. H_2SO_4: EPA Method 8A
        v. H_2S: Gas chromatography
    c. Initial screening performance testing to determine optimized injection rate
        i. Mercury: EPA Method 30B with on-site analysis

        ii. Halides and H_2SO_4: real-time FTIR
        iii. Particulate Matter: EPA Method 5 - only on chosen test scenario
        iv. H_2S: Gas Chromatography
    d. Long-Term Performance Testing
        i. Mercury: OH Method
        ii. Halides/Halogens: EPA Method 26A
        iii. Particulate Matter: EPA Method 5
        iv. H_2SO_4: EPA Method 8A
        v. H_2S: Gas chromatography

- Stack emissions reduction evaluation—Long-term testing
    a. Evaluate emission testing results
    b. Compare emissions during halide injection trial to baseline

- Determine final destination of mercury from scrubber (Section 8.0)
- Determine whether halide injection causes increased corrosion (Section 9.0)
- Quantify operating and maintenance cost to determine economic feasibility (Section 10.0)
- Determine technical feasibility of halide injection (Section 12.0)
- Determine impact on pellet quality (Section 12.0)
- Complete test report (Section 13.0)

7.0 Proposed Schedule

Table 1 shows the preferred schedule for conducting the halide injection study.

Table 1 – Estimated Test Schedule

Date	Milestone
09/05/2017	Conduct baseline emissions testing
09/11/2017	Begin halide injection and initial screening emissions test
9/18/17	Begin long term chemical injection. Install coupon holders; make sure pallets with test grate bars are installed.
10/23/2017	Conduct long-term emissions test
11/19/2017	Finish halide injection, remove coupons and grate bars

These schedules are subject to change and will be finalized upon further review.

8.0 Mercury Fate Determination

Selected process samples are to be collected and analyzed to determine mercury concentrations throughout the system during the trial. Coordination of sample collection will be completed by Corie Ekholm of HTC working with PACE or a similar analytical lab for the specified samples. HTC staff will be responsible for coordination of analytical mercury analysis of the samples. HTC will sample the following locations for mercury analysis before and 1-2 times per week during halide injection testing:

- Scrubber water sump*
- Green ball
- Rougher tails
- Finisher Tails
- Concentrate thickener overflow
- Final Pellet
- Multi-tube house solids*
- Final Concentrate – NOLA

* Samples will also be analyzed for bromide and calcium in addition to mercury

It is recommended that at least four baseline composite samples be analyzed for mercury 2 weeks prior to halide testing. Each sample should be a composite of three grab samples, taken during steady-state operation of the process. During stack testing, these process samples should be collected while stack testing is in progress.

9.0 Corrosion Potential Determination

The baseline corrosion rate will be compared to the corrosion rate determined during the halide injection trial to determine if there is potential for excessive corrosion within the system due to halide injection. The rate of corrosion will also help inform the technical and economic feasibility determinations discussed in Sections 10.0 and 11.0 of this test plan.

10.0 Technical Feasibility Determination

Determining if halide is technically feasible can be accomplished during the test by determining the mercury reduction at each rate of halide injection without affecting normal operations. Part of the technical feasibility evaluation is to investigate the condition of the process equipment, ducting and equipment degradation. Barr recommends post-testing inspection of the multiclone house, venturi scrubber system, windbox exhaust fan, hood exhaust fan (green ball drying), all fan housing and blades, associated ducting, and duct inlets and outlets. This includes corrosion, deposits on equipment, abnormal wear at the point of injection and associated ductwork. Inspect for any unusual non-common events or equipment issues including excess wear and corrosion. Pressure checks, liquid/air flows, vibration monitors, equipment operating temperatures and motor health indicators should also be evaluated. This will also involve completing a visual inspection before and after the testing, as well as evaluation and documentation of operating parameter limits to determine real-time operating conditions and concerns.

11.0 Economic Feasibility Determination

HTC will gather information on the operating costs associated with the testing if halide injection reaches the economic assessment step of the BAMRT analysis. The costs would be documented for the estimation of operating and maintenance costs if a full-scale system were to be implemented. Operating costs would be determined by recording the total amount of halide injected and operator manpower required during the testing. Maintenance costs could vary depending on the condition of the equipment and the operating duration, however any costs associated with maintaining the testing equipment may be considered for a full-scale system.

If the results allow the selected chemical to reach the economic evaluation stage of the BAMRT, the cost information gathered will be extrapolated to determine annual site-specific full-scale implementation costs associated with halide injection. Corrosion coupons analysis will help determine what potential equipment cost implications could occur.

12.0 Impact on Pellet Quality

Pellet physical and chemical quality parameters have been defined in Table 2. Concentrate parameters will be evaluated when pellet quality parameters are out of specification. These parameters will be monitored during the testing by the HTC lab to determine impact from the halide injection testing. The pellet quality parameters during testing will be compared to historical pellet variability and quality parameter limits set by HTC. If any pellet physical or chemical qualities exceed set parameters, the change will be identified and a root cause analysis will be performed to determine the potential cause.

The quality parameters include:

- Concentrate – review and inspect when pellet properties become out of spec
- Greenball – moisture only
- Pellet – physical and chemical properties (normal)

Table 2 - Pellet Quality Parameters

Greenballs	Lower Spec	Target	Upper Spec	Frequency
Moisture	9.2%	9.4%	9.6%	3 hours
Pellets	**Lower Spec**	**Target**	**Upper Spec**	**Frequency**
% +1/4" AT	95.2%	96%	96.8%	3 hours
% -28 Mesh AT	3.1%	3.6%	4.1%	3 hours
Compression	430	470	510	3 hours
%-300 Compression		<15.3%		3 hours
% Iron	65.95%	66.15%	66.35%	Daily
% Silica	4.3%	4.5%	4.7%	Daily
Sizing +1/2"		<5		3 hours
Sizing -1/2" +3/8"	91%	93%	95%	3 hours

13.0 Report

A report will be prepared detailing the results and conclusions of the testing based on the information received from the stack testing team and process data described throughout this document. This report can be used to finalize a site-specific BAMRT analysis of halide injection at HTC.

Appendix A

List of Evaluated Halides and Selection Criteria Summary

Chemical /Product Name	Company	Contact	Primary chemical makeup (e.g. HBr, $CaBr_2$, HCl, etc.)	Are proprietary chemicals added?	Concentration	Liquid, Solid, or Gas	Temperature Requirements (°F)	Necessary Residence Time (seconds)	Chosen for Study?	Reason not Chosen
GeoBrom HG400/ 430 /460	LanXess (formerly Chemtura and Great Lakes Solutions)	Jon Lehmkuhler Glen Bowden	NaBr	No	40%, 43%, and 46% available (w/w)	liquid	-15 - 40 min depending on concentration -	Fast Reaction times Depends on configuration of system.	no	CaBr2 was proven to work better in previous studies
GeoBrom HG520	LanXess (formerly Chemtura and Great Lakes Solutions)	Jon Lehmkuhler Glen Bowden	CaBr2	No	52% (w/w)	liquid	10 min	Fast Reaction times Depends on configuration of system.	yes	
GeoBrom HG480	LanXess (formerly Chemtura and Great Lakes Solutions)	Jon Lehmkuhler Glen Bowden	HBr	No	48% (w/w)	liquid	ambient -	Fast Reaction times Depends on configuration of system.	yes	
EMO	CB&I	Randall Moore	HBr, or HI	No	6 ppmv in flue gas	liquid	150 min	1	no	CB&I eliminated their mercury control division
Novinda	CB&I	Randall Moore	proprietary sulfite in silicate base material	Yes	1 to 2 lb./mmcf	solid	300 min	1	no	Contains Sulfides

SF12	Midwest Energy Emissions	Marc Sylvester John Pavlish	Proprietary	Yes	Proprietary	solid	600 min	1-3	no	Sorbent enhancer that is not typically used as a standalone product
SB31	Midwest Energy Emissions	Marc Sylvester John Pavlish	Proprietary	Yes	Proprietary	solid	650 max	1-3	no	Sorbent - concerns of particulate emissions
SB33	Midwest Energy Emissions	Marc Sylvester John Pavlish	Proprietary	Yes	Proprietary	solid	650 max	1-3	no	Sorbent - concerns of particulate emissions
AS-ULTRA	Novida	Mark Pettibone	Clay + Metal sulfides	No	NA	solid	800 max	0.5	no	Contains Sulfides
SF14	Midwest Energy Emissions	Marc Sylvester John Pavlish	Proprietary	Yes	Proprietary	solid	1,200 min	1-3	no	Sorbent enhancer that is not typically used as a standalone product
MERCONTROL 7895	Nalco	Dave Leingang	CaBr2	No	52% w/w	liquid	1,490 min	1	yes	purchased from Lanxess
Nalco and others -	CB&I	Randall Moore	CaBr2	No	200 to 400 ppm	liquid	1,500 min	n/a	no	Requires too high of temperature
SF10	Midwest Energy Emissions	Marc Sylvester John Pavlish	Proprietary	Yes	Proprietary	solid	1,800 min	1-3	no	Requires too high of temperature
M-Prove™	ADA	Scott Terhune	KI	No	47% - 53% w/w	liquid	1,800 min	n/a	no	Requires too high of temperature
CaBr2	Albemarle	Tim Frost	CaBr2	No	54% w/w	liquid	2,000 min	>10	no	Requires too high of temperature

Redox	CB&I	Randall Moore	proprietary sulfite	Yes	50 ppmw	liquid	none	unknown	no	Requires too high of temperature

Appendix B

Injection Rate Calculations

Information Provided	
645000	dscfm
16.7	ug Hg/dscm
12.4	ppmv SO_2
350	°F

Constants		
200.59	lb/lbmol	Molecular Weight of Hg
80.9	lb/lbmol	Molecular Weight of HBr
235.98	lb/lbmol	Molecular Weight of $CaBr_2$
93.0	lb/ft^3	Density of HBr solution
109.87	lb/ft^3	Density of $CaBr_2$ solution
7.4805	gal = 1 ft^3	
453.59	g = 1 lb	

$$\frac{645000\ \text{dscf}}{\text{min}} \times \frac{16.7\ \text{ug Hg}}{\text{dscm}} \times \frac{1\ \text{scm}}{35.315\ \text{scf}} \times \frac{1\ \text{g Hg}}{1000000\ \text{ug Hg}} \times \frac{60\ \text{min}}{\text{hr}} \times \frac{1\ \text{lb}}{453.6\ \text{g}} = \frac{0.040\ \text{lb Hg}}{\text{hr}} \times \frac{1\ \text{lbmol Hg}}{200.6\ \text{lb Hg}} = \frac{0.0002\ \text{lbmol Hg}}{\text{hr}}$$

$4HBr + O_2 \text{ --> } 2Br_2 + 2H_2O$

$Br_2 + Hg^0 \text{ --> } HgBr_2$

Minimum HBr (aq) Required

$$\frac{0.0002\ \text{lbmol Hg}}{\text{hr}} \times \frac{1\ \text{lbmol } Br_2\ \text{(reacted)}}{1\ \text{lbmol Hg (reacted)}} \times \frac{4\ \text{lbmol HBr (reacted)}}{2\ \text{lbmol } Br_2\ \text{(produced)}} \times \frac{80.9\ \text{lb HBr}}{\text{lbmol}} \times \frac{1\ \text{lb HBr (aq)}}{0.48\ \text{lb HBr}} = \frac{0.068\ \text{lb HBr (aq)}}{\text{hr}}$$

$$\frac{0.068\ \text{lb HBr (aq)}}{\text{hr}} \times \frac{1\ \text{ft}^3}{93.0\ \text{lb HBr (aq)}} \times \frac{7.4805\ \text{gal}}{\text{ft}^3} = \frac{\mathbf{0.01\ gal}}{\mathbf{hr}}$$

HBr solution required to react the Hg

*this assumes <u>all</u> of the Br_2 produced reacts with the Hg to form $HgBr_2$

**should consider scaling up HBr injection rate to account for some Br_2 reacting with SO_2 in side reactions

$2CaBr_2 + O_2 \text{ --> } 2Br_2 + 2H_2O$

$Br_2 + Hg^0 \text{ --> } HgBr_2$

Minimum $CaBr_2$ (aq) Required

$$\frac{0.0002\ \text{lbmol Hg}}{\text{hr}} \times \frac{1\ \text{lbmol } Br_2\ \text{(reacted)}}{1\ \text{lbmol Hg (reacted)}} \times \frac{2\ \text{lbmol } CaBr_2\ \text{(reacted)}}{2\ \text{lbmol } Br_2\ \text{(produced)}} \times \frac{236.0\ \text{lb } CaBr_2}{\text{lbmol}} \times \frac{1\ \text{lb } CaBr_2\ \text{(aq)}}{0.52\ \text{lb } CaBr_2} = \frac{0.091\ \text{lb } CaBr_2\ \text{(aq)}}{\text{hr}}$$

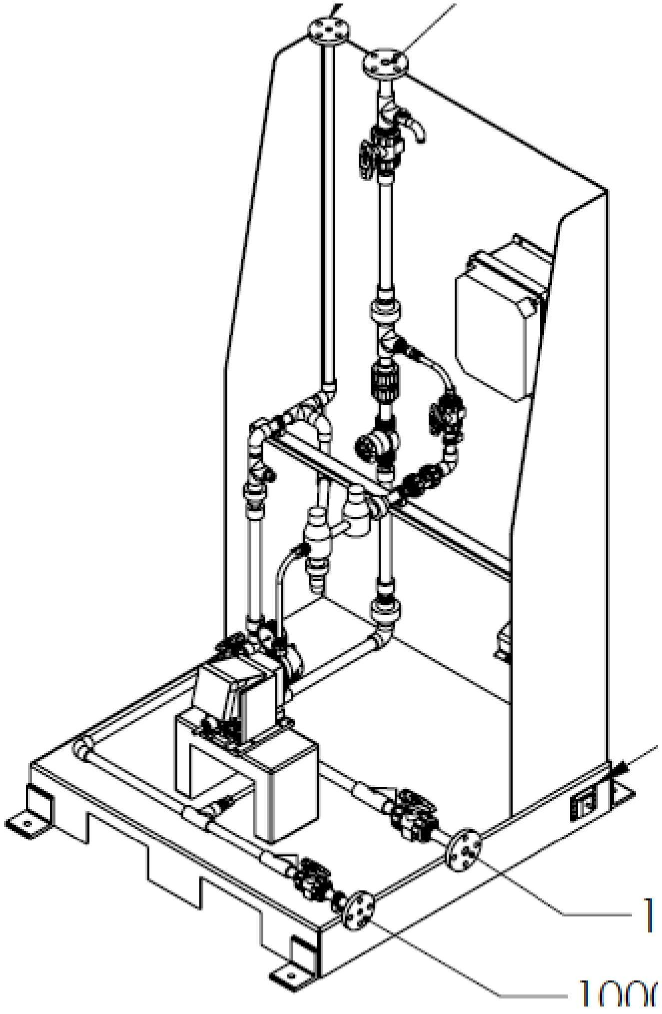
$$\frac{0.091\ \text{lb } CaBr_2\ \text{(aq)}}{\text{hr}} \times \frac{1\ \text{ft}^3}{109.9\ \text{lb } CaBr_2\ \text{(aq)}} \times \frac{7.4805\ \text{gal}}{\text{ft}^3} = \frac{\mathbf{0.01\ gal}}{\mathbf{hr}}$$

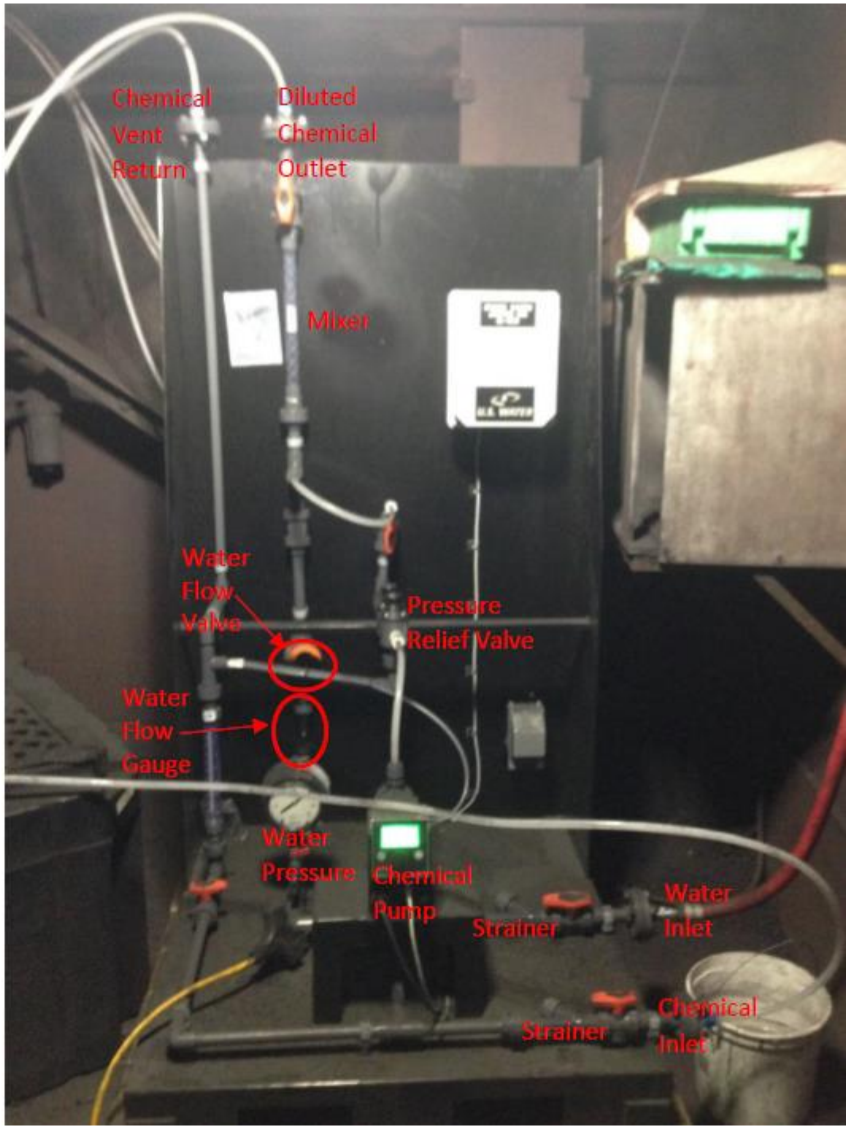
$CaBr_2$ solution required to react the Hg

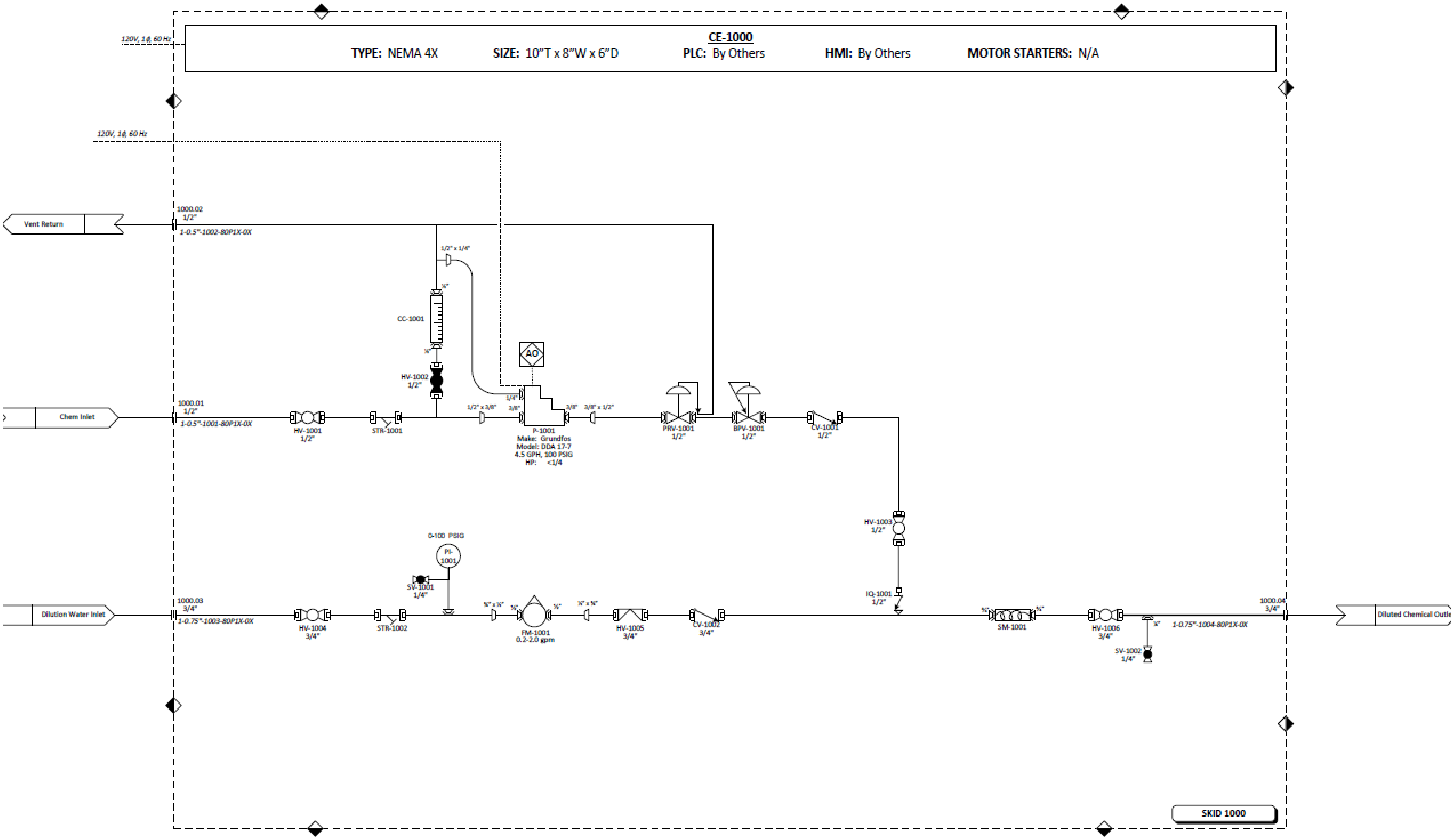
*this assumes <u>all</u> of the Br_2 produced reacts with the Hg to form $HgBr_2$

**should consider scaling up $CaBr_2$ injection rate to account for some Br_2 reacting with SO_2 in side reactions

Appendix C: Chemical Feed Skid







NOTES:
1) Chemical containment and storage by others
2) Unloading and install by others
3) Electrical termination by others

USWS SCOPE ◆ CUSTOMER SCOPE

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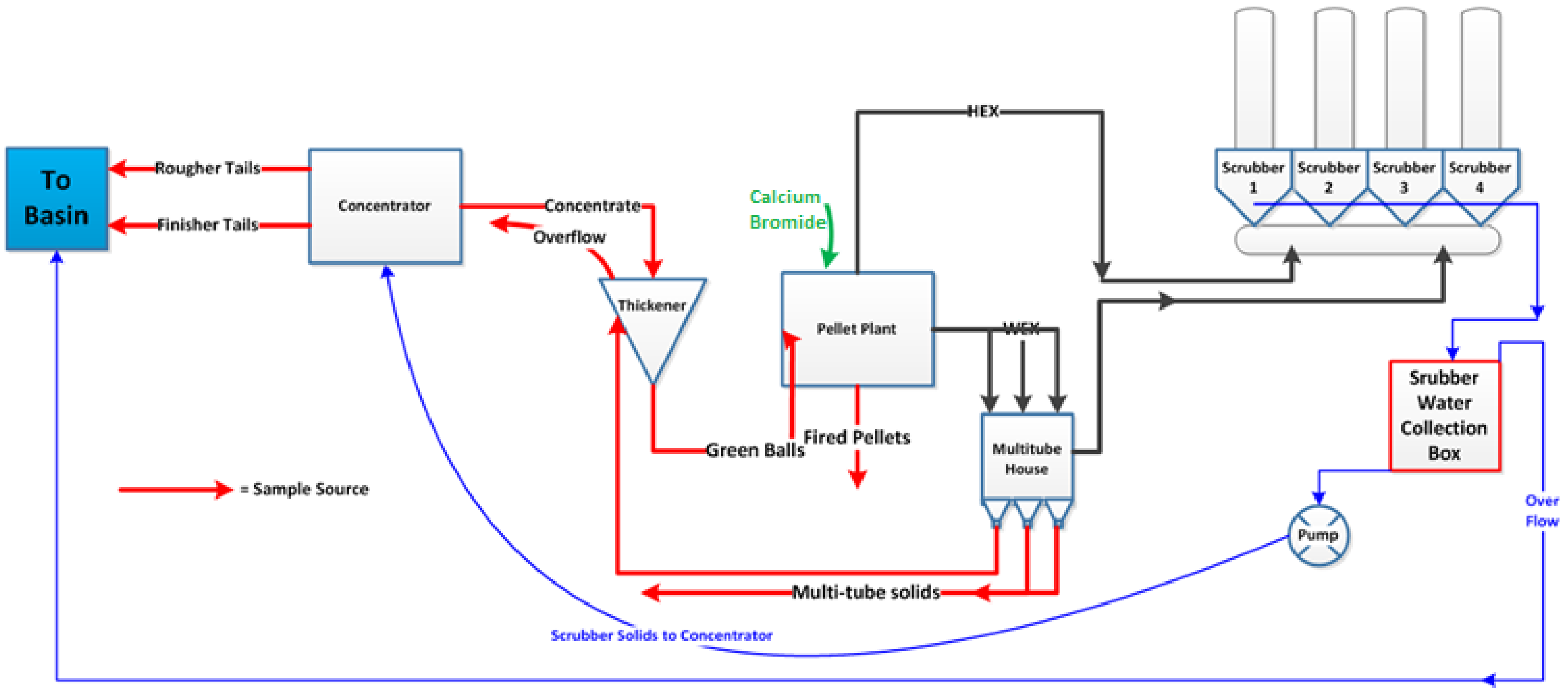
REV	DESCRIPTION	DATE	DRWN	CHK'D	APP'D
0	Initial Drawing	9/20/17	KAI	KAI	KK
1	Updated Rotameter Size	10/3/17	KAI	KAI	KK
2	Design Update	10/10/17	KAI	KAI	KK

U.S. WATER
The future of water

SYSTEM NAME: 1000: Chem Feed Skid
CUSTOMER: United Taconite
REV: 2
NAV NUMBER: 79-0704
DATE: 9/20/2017
PAGE: 1 OF 1
PROJECT NUMBER/SHEET: XXXXX_1000D

Appendix D: Sampling Diagram



Samples: 3 samples were collected from each location and combined into one daily sample that was analyzed for mercury
Scrubber Water (scrubber sump) and multi-tube (multiclones) samples were also analyzed for calcium and bromide

Appendix E: Plant Samples

Sample Number	Date	Concentrate		Greenballs	Pellets	Scrubber Solids		Multiclones	Finisher Tails		Rougher Tails		Conc Thck O'flow	
		Solid	Water	Solid	Solid	Solid	Water	Solid	Solid	Water	Solid	Water	Solid	Water
1	8/23/2017	19.5	ND	16.7	ND	1840	105	434	43.6	ND	28.8	ND	69.2	ND
2	8/28/2017	20.6	ND	12.9	ND	1310	66.1	343	35.3	ND	32.2	ND	68.1	0.665
3	9/6/2017	14.1	ND	16.2	ND	2460	84.3	206	42.6	ND	24.5	ND	64.1	1.6
4	9/7/2017	14.9	ND	9.82	ND	1750	123	52.1	40.5	ND	28.6	ND	68.4	ND
5	10/5/2017	17.6	ND	12.9	ND	3790	351	115	33.6	ND	34.4	ND	65.5	ND
6	10/10/2017	18.8	ND	13.4	ND	3490	166	229	36.3	ND	30.8	ND	57.2	ND
7	10/18/2017	20.9	ND	14.9	ND	67100	198	140	36.4	ND	48.8	ND	105	ND
8	10/25/2017	26	ND	16.1	ND	3660	135	129	58.6	ND	46.2	ND	103	ND
9	10/31/2017	22.6	ND	17.6	ND	4390	47.9	578	46.7	ND	36.7	ND	115	ND
10	11/1/2017	21.8	ND	15.1	ND	3360	72.8	310	34.8	ND	32.1	ND	95.2	ND
11	11/7/2017	21.3	ND	14.3	ND	4370	87.5	724	47.2	ND	31.8	ND	114	ND
12	11/14/2017	13.7	ND	12.3	ND	2400	867	479	36.9	ND	38.8	ND	121	ND
13	11/21/2017	16.6	ND	13.5	ND	7130	18	457	59.8	ND	43.5	ND	110	ND

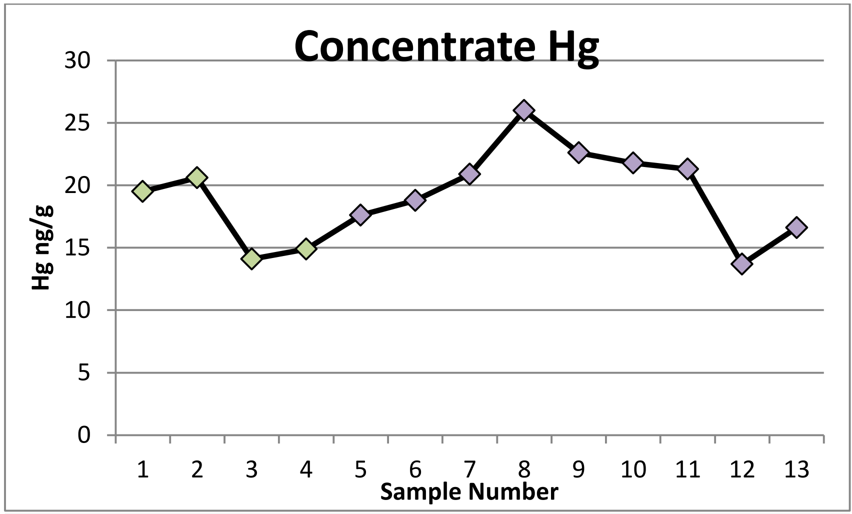
Baseline

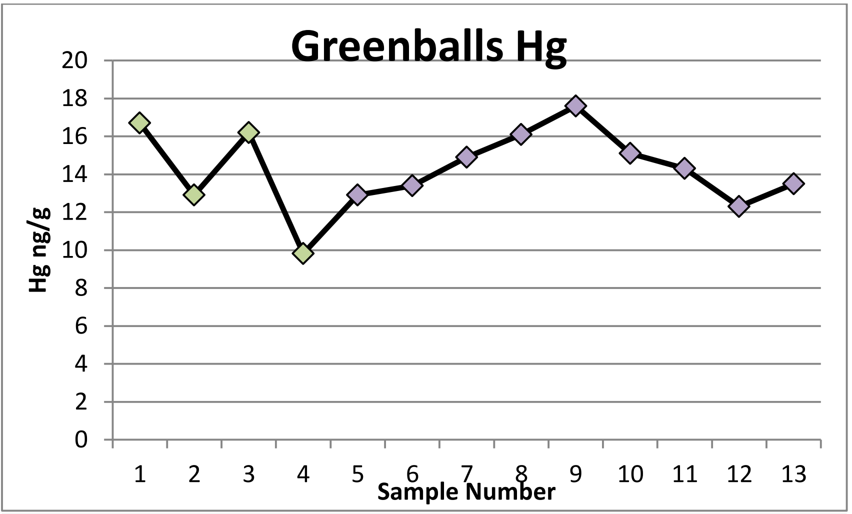
Testing

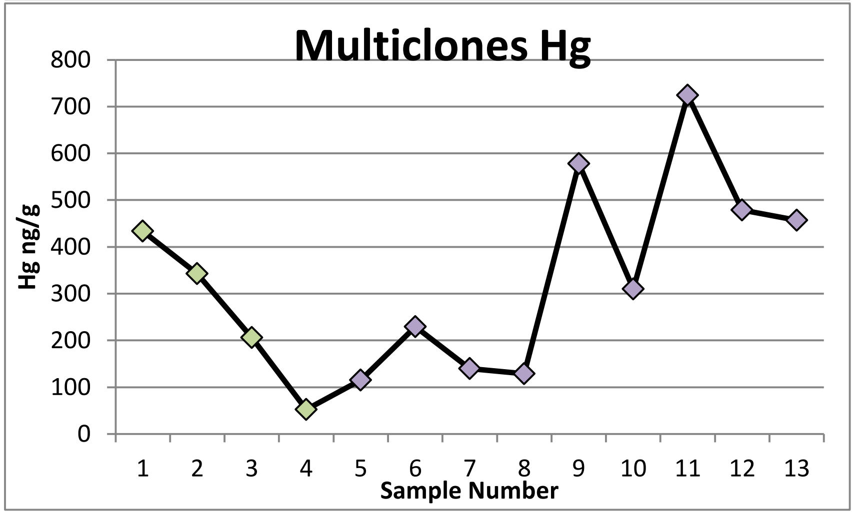
Outliers Outliers are not plotted on graphs

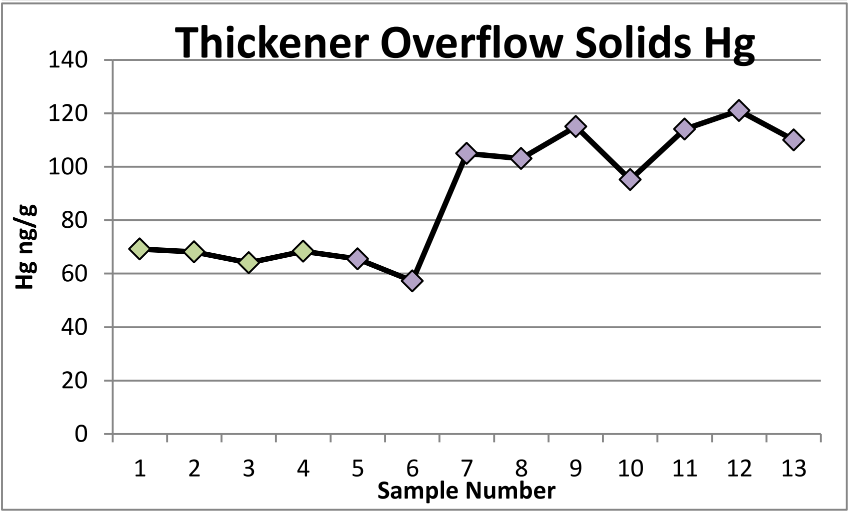
ND = non detect

Sample Graphs



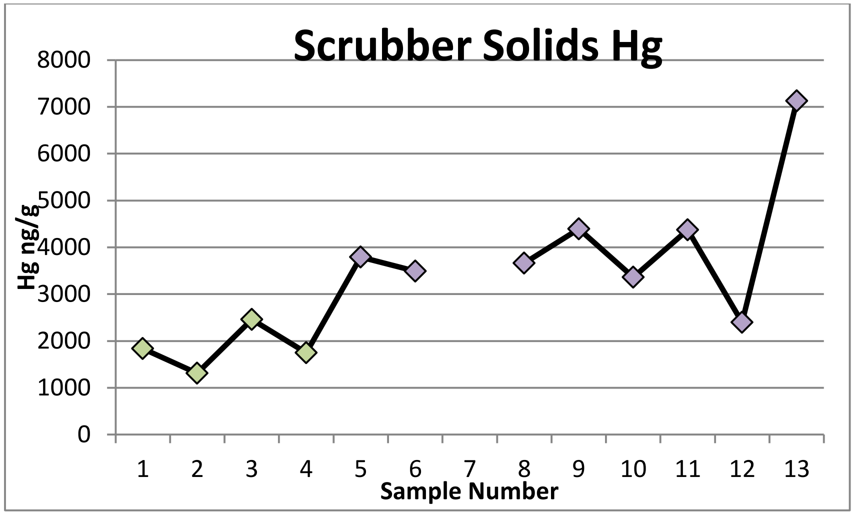


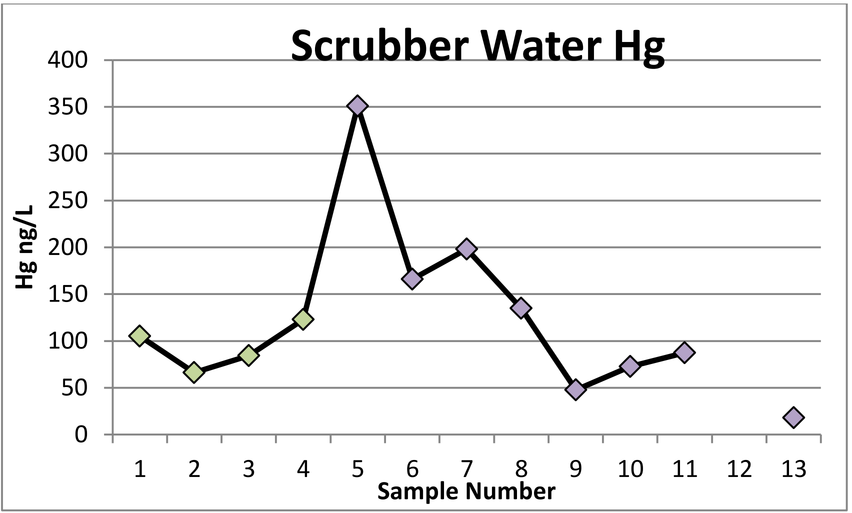


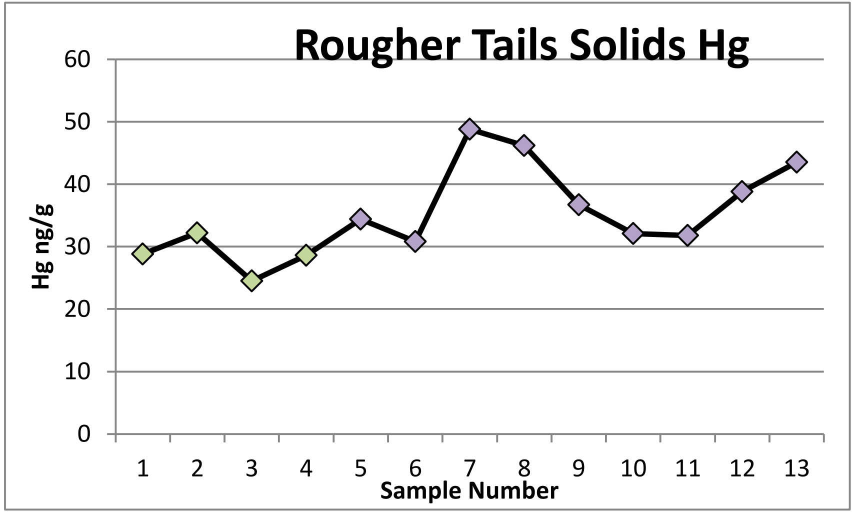


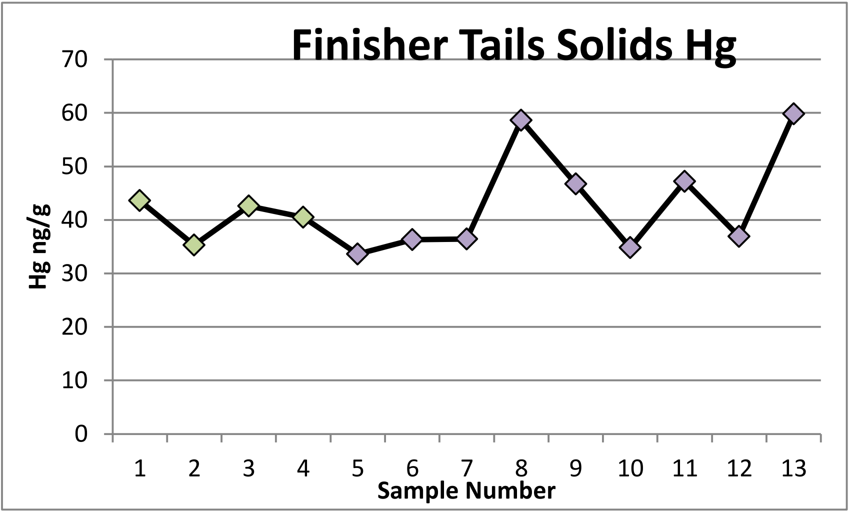
🟩 Baseline

🟪 Testing





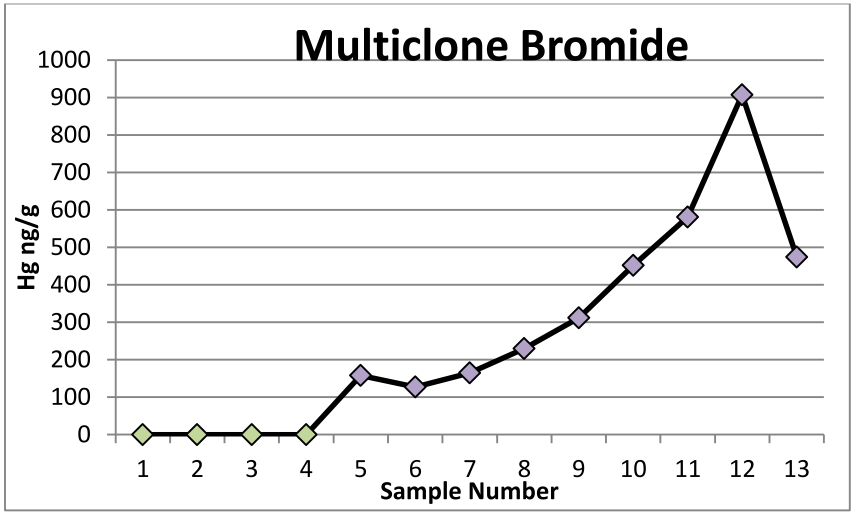


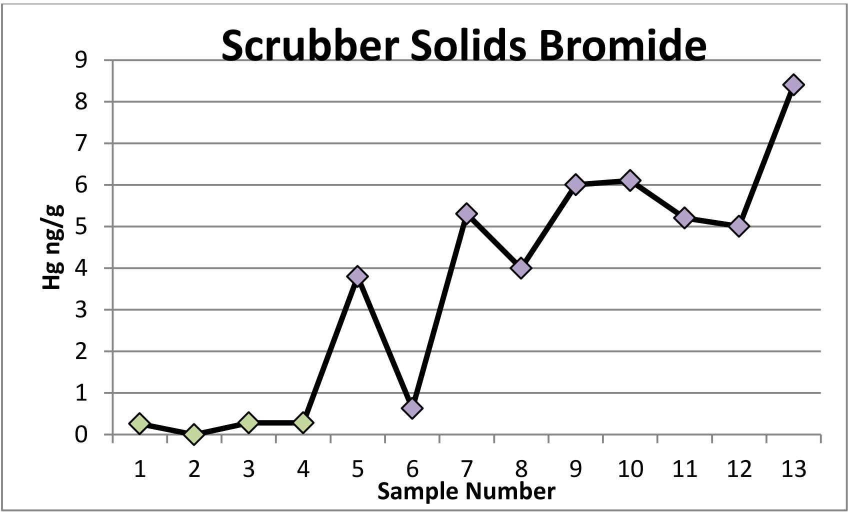


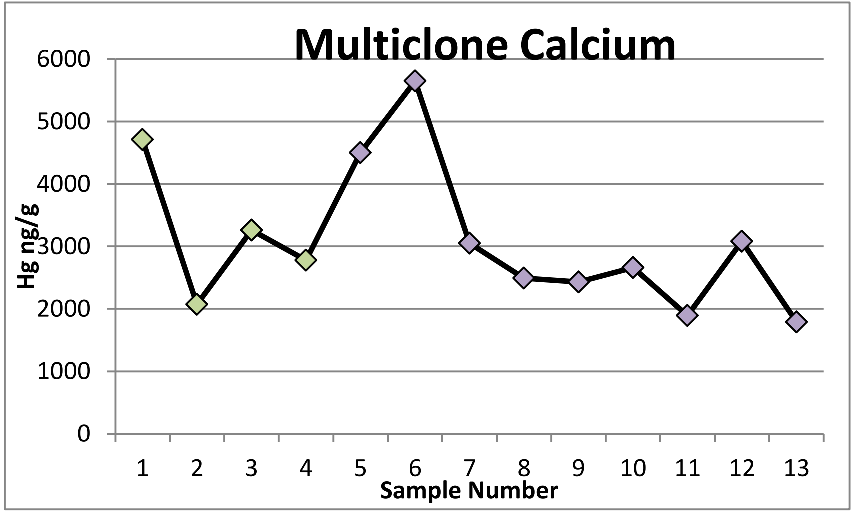
Baseline
Testing

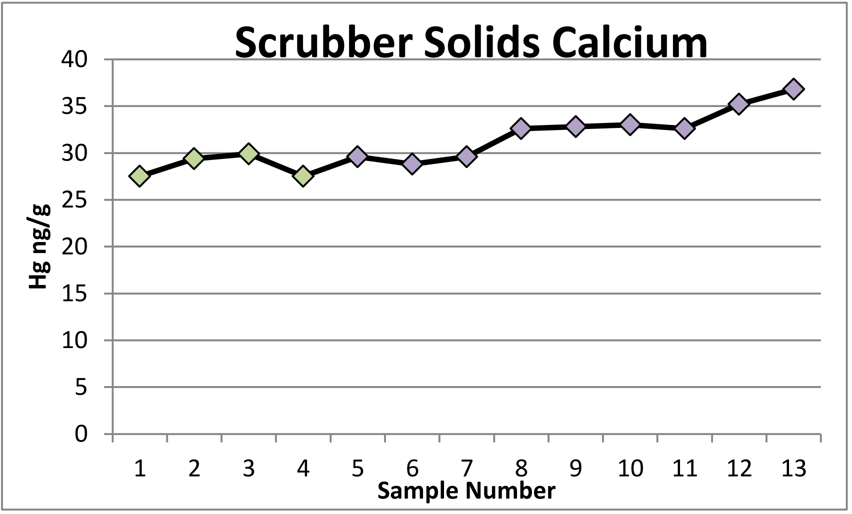
	Calcium		Bromide	
	Scrubber Solids	Multiclones	Scrubber Solids	Multiclones
8/23/2017	27.5	4710	0.26	ND
8/28/2017	29.4	2070	ND	ND
9/6/2017	29.9	3260	0.28	ND
9/7/2017	27.5	2780	0.28	ND
10/5/2017	29.6	4500	3.8	158
10/10/2017	28.8	5650	0.63	127
10/18/2017	29.6	3050	5.3	165
10/25/2017	32.6	2490	4	230
10/31/2017	32.8	2430	6	312
11/1/2017	33	2660	6.1	452
11/7/2017	32.6	1890	5.2	581
11/14/2017	35.2	3080	5	907
11/21/2017	36.8	1790	8.4	474

Baseline
Testing









🟩 Baseline
🟪 Testing

Appendix F: Corrosion Report

The corrosion report appendices are on file with HTC.

CTL

Corrosion Testing Laboratories, Inc.

January 23, 2018 **CTL REF #34347-1**

Corie Ekholm
Hibbing Taconite Company
4950 Hibbing Taconite Co Access Road
Central Warehouse
Hibbing, MN 55746

Re: <u>Onsite Exposure of Test Racks and Furnace Grates</u>

Dear Ms. Ekholm:

Presented herein are the results of the above referenced testing. This work was authorized per Hibbing Taconite Company Purchase Orders L52827 and L53832.

Hibbing Taconite requested assistance in a corrosion study being performed onsite at Hibbing Taconite. CTL provided two test racks fitted with 1020 carbon steel specimens ready for exposure. Hibbing Taconite submitted six (6) new furnace grates for initial evaluation. The Test Racks and furnace grates were sent to Hibbing Taconite for exposure and then returned to CTL for evaluation.

Test Racks
Six test specimens measuring approximately 1.5-inches by 2-inches x 0.080-inch thick were prepared form 1020 carbon steel stock. A 3/8-inch mounting hole was drilled in the center of each specimen and each specimen was stamped with a unique alpha numeric code, **Figure 1.** Each specimen was cleaned, measured to the nearest 0.1 mm, and weighed to the nearest 0.0001 gram.

Two Test racks were fabricated from 316L stainless steel and consisted of a flat plate sized to fit a 4-inch standard pipe flange with a 4-foot long length of threaded rod for attachment of the test specimens.

The test racks were assembled with three test specimens on each rack. The test specimens were isolated from the rack and each other with zirconia ceramic washers, **Figure 2**. A tab on the mounting plate for each rack was stamped with a "1" or "2".

Furnace Grates
Six identical furnace grates were received form Hibbing Taconite. The grates were reported to be cast stainless steel alloy HI (28% Cr - 15% Ni). The furnace grates were cleaned and inspected at CTL. A small area on the side of each grate was ground smooth and finished with 240 grit abrasive paper to obtain a uniform finish. The grates possessed a somewhat uniformly rough surface finish typical of castings. A small area was ground smooth to obtain a better indication of any surface corrosion that may occur during exposure. A numerical identification was stamped into each grate to the right of the polished area, **Figure 3**. The ID consisted of our Job number (34347) and a

sequential number (1 to 6). Each grate was weighed to the nearest 0.01 gram and photographed for future reference.

Exposure
The test racks and furnace grates were shipped to Hibbing Taconite and exposed onsite. The details of the exposure provided by Hibbing Taconite are tabulated below.

Test Racks

	Line 1	Line 2
Total Tons	572,612	521,021
Total Hrs	1,212	1,156
Chem Hrs	0	1096
Test Serial #s	AYP-26	AYP-29
	AYP-27	AYP-30
	AYP-28	AYP-31

Grate Bars

	Line 1	Line 2
Total Tons	691,602	629,751
Total Hrs	1,466	1,396
Chem Hrs	0	1128
Test Serial #s	34347 4	34347 1
	34347 5	34347 2
	34347 6	34347 3

It is our understanding that the test racks were exposed in ductwork exiting the furnace and the grates were exposed in the furnace. Line 1 was operated using the current processing procedures and Line 2 was operated with the addition of calcium bromide to the process.

RESULTS

Test Racks
The end of the tongue containing the test specimens was removed from each test rack and returned to CTL. The assemblies were coated with a reddish orange deposit, **Figure 4.** Deposits from each rack were sampled and set aside for analysis of elemental composition using energy dispersive spectroscopy (EDS).

The test rack was disassembled and the specimens cleaned, reweighed, examined at up to 40X magnification, and photographed. Corrosion rates were calculated based on mass loss assuming that there was uniform mass lost over the entire surface of the test specimens. Stereoscopic examination of the cleaned specimens revealed small areas of more active corrosion associated with traces of tightly adherent deposits. The depth of attack was minimal, <0.1 mils). The results are summarized in **Table 1**.

TABLE 1
1020 Carbon Steel Exposed in Furnace Ducting

Line	Specimen ID	Corrosion Rate (mpy[1])	Comments
1	AYP-26	0.15	General Corrosion with small areas of more active corrosion underneath tightly adherent deposits.
	AYP-27	0.10	
	AYP-28	0.16	
2	AYP-29	0.30	General Corrosion with small areas of more active corrosion underneath tightly adherent deposits.
	AYP-30	0.45	
	AYP-31	0.24	

[1] mpy = mils per year, 1 mil = 0.001-inch.

Photographs of the test specimens are attached in **Appendix A**.

EDS Analysis. Deposits were collected from each set of test specimens and mounted on a carbon stub that was inserted into a SciXr scanning electron microscope (SEM) equipped with a SciXr EDS light element detector (carbon and above) and software. A standardless semi-quantitative analysis was performed on the collected spectra. Note that the primary peaks for aluminum and bromine overlap and differentiation at low concentrations is not possible. The results are summarized in **Table 2**. The individual spectra are presented in **Appendix A**.

TABLE 2
Elemental Composition (Wt%) of Deposits on Test Specimens

Sample	0	Na	Al/Br	Si	S	K	Cr	Ca	Fe	As
Rack 1	47.6	1.9	<0.1	1.8	0.2	1.3	<0.1	<0.1	33.8	13.4
Rack 2	46.5	-	0.5	2.2	0.2	-	-	0.3	49.9	0.4

Furnace Grates

The exposed furnace grates were covered with reddish orange deposits that were tightly adherent. Standard cleaning with mild brushing was unable to effectively remove the deposits. Removal of the deposits required light blasting with glass beads. After cleaning some discoloration remained near the top of the furnace grates. Otherwise, the grates appeared relatively unaffected by the exposure. There were no obvious areas of corrosion or metal wastage. The cleaned grates were reweighed and corrosion rates calculated based on mass loss assuming that there was uniform mass lost over the entire surface of the grates. The results are summarized in **Table 3**.

TABLE 3
Cast Stainless Steel Alloy HI Grates Exposed in Furnace

Line	Grate ID	Corrosion Rate (mpy)	Comments
1	34347-4	0.18	General Corrosion
	34347-5	0.18	
	34347-6	0.14	
2	34347-1	0.52	General Corrosion
	34347-2	0.66	
	34347-3	0.70	

Photographs of the furnace grates are attached in Appendix B.

Metallographic cross-sections. A section from the top of each grate was removed and a metallographic mount prepared to determine if the surface microstructure had been affected by the exposure. The cross-sections were viewed in the as polished condition and hen etched to reveal the general microstructure. No unusual features were observed on the surface of the exposed grates. No intergranular or other localized forms of attack were observed. Photomicrographs are presented in Appendix B.

DISCUSSION

The corrosion rates were calculated assuming that there was uniform lass loss over the entire surface of the test specimens. When localized corrosion occurs, these calculate rates may not be an accurate representation of the metal penetration rate.

Carbon Steel Specimens Exposed in the Ductwork

Corrosion rates were low in both duct lines with corrosion rates <0.5 mpy. Both sets showed scattered areas where more active corrosion had occurred underneath tightly adherent deposits. The depth of attack in these areas was less than what could be accurately measured (<0.1 mils) It is notable that the average corrosion rate for the carbon steel specimens (0.33 mpy) exposed in Line 2 were approximately twice those of Line 1 (0.14 mpy). The deposit analysis suggests that calcium bromide is present on the deposits in Line 2 which may be the cause for the higher corrosion rates observed.

Cast Stainless Steel Grates Exposed in Furnace

The corrosion rates were also low for the furnace grates, <1 mpy. General corrosion was present on both sets with no indications of localized corrosion such as pitting or intergranular corrosion. The average corrosion rates for the grates exposed in Line 2 (0.63 mpy) were approximately 3.5 times higher than those exposed in Line 1 (0.18 mpy). Again, the data suggests that the addition of calcium bromide to the process will increase the general corrosion rates on the grates.

We trust the above will be beneficial in your study. We remain available should you want to discuss these results further.

Very truly yours,
Corrosion Testing Laboratories, Inc.

Fred M. Sherman

Bradley D. Krantz
VP of Laboratory Services

Fred M. Sherman
Sr. Materials Analyst

Policy Statement

This study was performed and this report was prepared based upon specific samples and/or information provided to Corrosion Testing Laboratories, Inc. (CTL) by Hibbing Taconite Company. The information contained in this report represents only the materials tested or evaluated. Such work was performed in accordance with CTL's Quality Assurance Manual, Revision 13, issued 22 June 2009. The conclusions and opinions provided were developed within a reasonable degree of scientific certainty and are based upon materials and information provided to date. Should additional information become available (e.g., on further continued review of the material received or submission of additional samples for examination), we reserve the right to adjust our professional opinions.

CTL assumes no responsibility for variations in sample or data quality (composition, appearance, performance, etc.) or any other feature of similar subject matter produced (measured, manufactured, fabricated, etc.) by persons or under conditions over which we have no control. This report may not be altered, added to or subtracted from and, if this does occur, CTL does not accept responsibility for such alterations, additions, or deletions. This report shall not be reproduced, except in full, without the written approval of CTL. All material that was received by CTL will be discarded six (6) months after this report has been issued, unless other arrangements have been agreed upon.

Figure 1. Prepared test specimens.

Figure 2. Assembled Test Rack

Figure 3. Furnace grate showing area that was ground and stamped ID.

Appendix G: Stack Test Screening Results

Full stack testing reports are on file at HTC.

Week 1:

September 14 & 15, 2017

Location	PH	PH	PH	WBE	WBE	Baseline
Chemical	CaBr2	CaBr2	CaBr2	HBr	CaBr2	
Dosage (gph)	2.0	2.0	2.0	2.0	2.0	
µg/dscm	3.29	3.48	4.22	6.06	6.46	7.57
% Reduction	55.9%	53.3%	43.5%	20.0%	14.0%	

Week 2

October 3 & 4, 2017

Location	PH	PH	Baseline
Chemical	HBr	CaBr2	
Dosage (gph)	2.0	2.0	
µg/dscm	3.97	3.78	6.67
% Reduction	39.9%	42.7%	

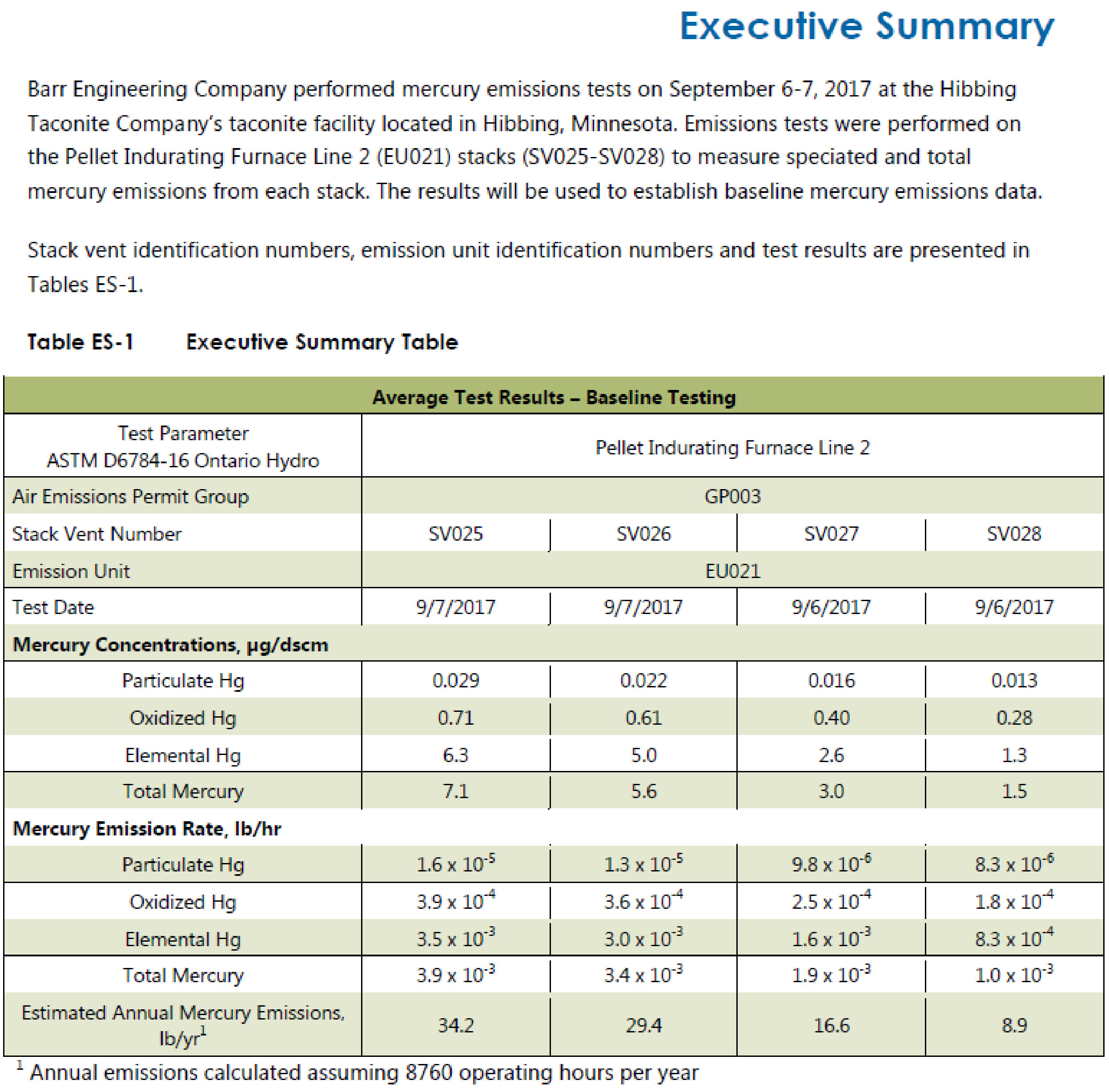
Location	PH	PH	PH	PH	Baseline
Chemical	CaBr2	CaBr2	CaBr2	CaBr2	
Dosage (gph)	1.0	2.0	3.0	4.0	
µg/dscm	4.68	3.78	3.70	3.57	6.67
% Reduction	29.4%	42.7%	43.5%	45.8%	

WBE = Windbox exhaust

PH = Preheat

Appendix H: Stack Test Results (baseline and long-term)

Full stack testing reports are on file at HTC.



Executive Summary

Barr Engineering Company performed mercury emissions tests on September 6-7, 2017 at the Hibbing Taconite Company's taconite facility located in Hibbing, Minnesota. Emissions tests were performed on the Pellet Indurating Furnace Line 2 (EU021) stacks (SV025-SV028) to measure speciated and total mercury emissions from each stack. The results will be used to establish baseline mercury emissions data.

Stack vent identification numbers, emission unit identification numbers and test results are presented in Tables ES-1.

Table ES-1 Executive Summary Table

Average Test Results – Baseline Testing				
Test Parameter ASTM D6784-16 Ontario Hydro	Pellet Indurating Furnace Line 2			
Air Emissions Permit Group	GP003			
Stack Vent Number	SV025	SV026	SV027	SV028
Emission Unit	EU021			
Test Date	9/7/2017	9/7/2017	9/6/2017	9/6/2017
Mercury Concentrations, µg/dscm				
Particulate Hg	0.029	0.022	0.016	0.013
Oxidized Hg	0.71	0.61	0.40	0.28
Elemental Hg	6.3	5.0	2.6	1.3
Total Mercury	7.1	5.6	3.0	1.5
Mercury Emission Rate, lb/hr				
Particulate Hg	1.6×10^{-5}	1.3×10^{-5}	9.8×10^{-6}	8.3×10^{-6}
Oxidized Hg	3.9×10^{-4}	3.6×10^{-4}	2.5×10^{-4}	1.8×10^{-4}
Elemental Hg	3.5×10^{-3}	3.0×10^{-3}	1.6×10^{-3}	8.3×10^{-4}
Total Mercury	3.9×10^{-3}	3.4×10^{-3}	1.9×10^{-3}	1.0×10^{-3}
Estimated Annual Mercury Emissions, lb/yr[1]	34.2	29.4	16.6	8.9

[1] Annual emissions calculated assuming 8760 operating hours per year

Executive Summary

Barr Engineering Co. performed emissions tests September 6-8, 2017 at the Hibbing Taconite Company's taconite facility located in Hibbing, Minnesota. Emissions tests were performed on the Pellet Indurating Furnace Line 2 (EU021) stacks (SV025-SV028) to establish baseline particulate matter, sulfuric acid mist, and hydrogen bromide emissions. Determinations were made using EPA Method 5, NCASI Method 8A, and EPA Method 26A.

Stack vent identification numbers, emission unit identification numbers, and test results are presented in Tables ES-1.

Table ES-1 Executive Summary Table

Average Test Results – Baseline Testing				
Test Parameter EPA Method 5, NCASI Method 8A, EPA Method 26A	Pellet Indurating Furnace Line 2			
Air Emissions Permit Group	GP003			
Stack Vent Number	SV025	SV026	SV027	SV028
Emission Unit	EU021			
Test Date	9/6, 9/8/2017	9/6, 9/8/2017	9/7-8/2017	9/7-8/2017
Particulate Matter Concentration, gr/dscf				
PM – Filterable	0.007	0.007	0.006	0.005
Particulate Matter Emission Rate, lb/hr				
PM – Filterable	9.0	9.4	8.4	7.3
Sulfuric Acid Mist Concentration				
SO3/SO4, lb/dscf	5.2×10^{-9}	1.5×10^{-8}	4.3×10^{-8}	6.3×10^{-8}
SO3/SO4, ppm dry	0.02	0.06	0.17	0.25
Sulfuric Acid Mist Emission Rate, lb/hr				
SO3/SO4	0.046	0.15	0.43	0.67
Halide Concentration, ppm dry				
Hydrogen Bromide	<0.009	<0.009	<0.008	<0.007
Bromine	<0.004	<0.004	<0.003	<0.003
Halide Emission Rate, lb/hr				
Hydrogen Bromide	<0.017	<0.018	<0.016	<0.016
Bromine	<0.014	<0.014	<0.013	<0.014

Executive Summary

Barr Engineering Company performed mercury emissions tests on October 31-November 2, 2017 at the Hibbing Taconite Company's taconite processing facility located in Hibbing, Minnesota. Emissions tests were performed on the Pellet Indurating Furnace Line 2 (EU021) stacks (SV025-SV028) during extended halide injection to evaluate the mercury emissions control. Determinations were also made for filterable particulate matter, sulfuric acid mist, halide and halogen, hydrogen sulfide (H_2S) and speciated-total mercury using ASTM D6784-16 Ontario Hydro test method.

Stack vent identification numbers, emission unit identification numbers, and mercury test results are presented in Table ES-1. Particulate matter, halide and halogen, and sulfuric acid mist results are presented in Table ES-2.

The results for H_2S are not included in the Executive Summary Table and Results section since the result for all stacks equaled zero parts per million (ppm). Gas chromatographs can be furnished upon request.

Table ES-1 Executive Summary Table - Mercury

Average Test Results – Long Term Mercury Testing				
Test Parameter ASTM D6784-16 Ontario Hydro	Pellet Indurating Furnace Line 2			
Air Emissions Permit Group	GP003			
Stack Vent Number	SV025	SV026	SV027	SV028
Emission Unit	EU021			
Test Date	11/1/17	11/1/17	10/31/2017	10/31/2017
Mercury Concentrations, µg/dscm				
Particulate Hg	0.34	0.23	0.12	0.10
Oxidized Hg	2.3	2.4	1.9	1.5
Elemental Hg	0.68	0.78	0.48	0.36
Total Mercury	3.3	3.4	2.5	1.9
Mercury Emission Rate, lb/hr				
Particulate Hg	2.0 x 10^{-4}	1.4 x 10^{-4}	7.4 x 10^{-5}	6.6 x 10^{-5}
Oxidized Hg	1.3 x 10^{-3}	1.4 x 10^{-3}	1.2 x 10^{-3}	9.9 x 10^{-4}
Elemental Hg	3.9 x 10^{-4}	4.7 x 10^{-4}	3.0 x 10^{-4}	2.4 x 10^{-4}
Total Mercury	1.9 x 10^{-3}	2.0 x 10^{-3}	1.6 x 10^{-3}	1.3 x 10^{-3}
Estimated Annual Mercury Emissions, lb/yr[1]	16.5	17.8	13.6	11.3

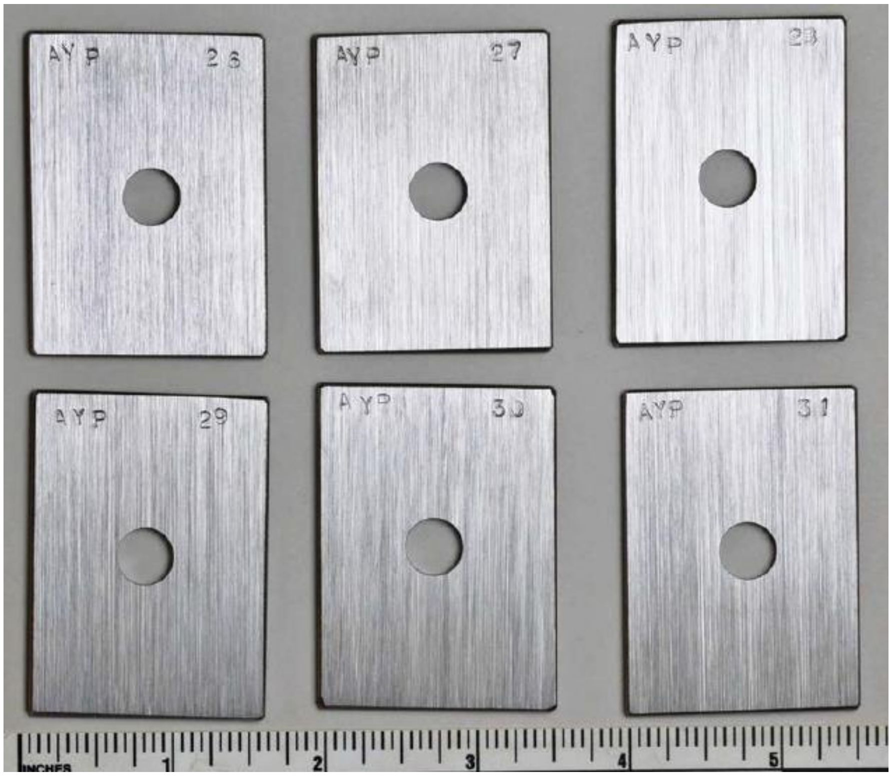
1. Annual emissions calculated assuming 8760 operating hours per year.

Table ES-2 Executive Summary Table - PM, Halide/Halogen, and SAM

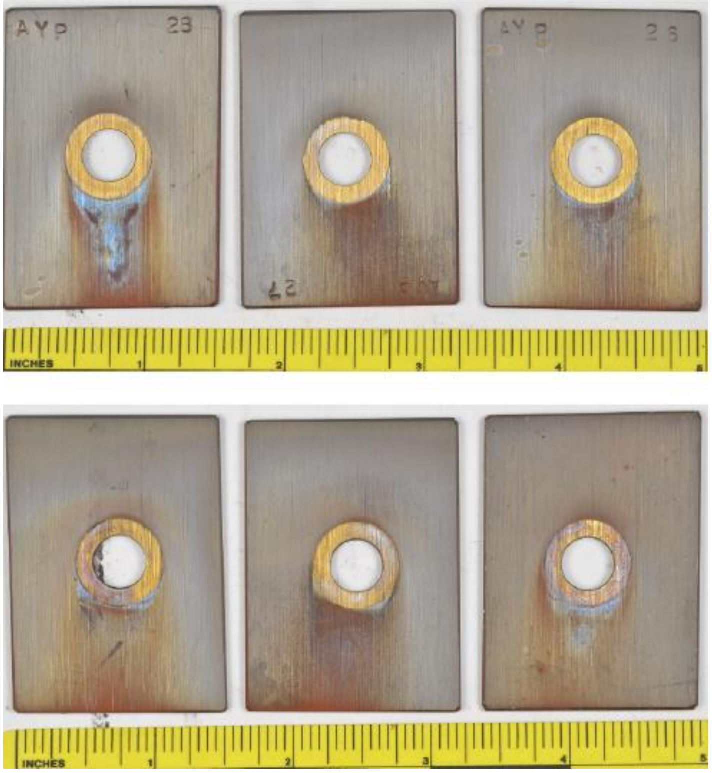
Average Test Results – Long Term Mercury Testing				
Test Parameter U.S. EPA Method 5 and 26A	Pellet Indurating Furnace Line 2			
Air Emissions Permit Group	GP003			
Stack Vent Number	SV025	SV026	SV027	SV028
Emission Unit	EU021			
Test Date	11/2/17	11/2/17	11/2/17	11/2/17
Pollutant Concentration, ppm				
Hydrogen Bromide	0.241	0.267	0.100	0.180
Bromine	<0.004	<0.003	<0.004	<0.003
Pollutant Emission Rate, lb/hr				
Hydrogen Bromide	0.45	0.53	0.23	0.40
Bromine	<0.013	<0.013	<0.015	<0.012
Particulate Concentration, gr/dscf				
PM - Filterable	0.005	0.005	0.004	0.004
Particulate Emissions Rate, lb/hr				
PM - Filterable	6.8	6.5	5.7	5.9
Test Parameter NCASI Method 8A				
Stack Vent Number	SV025	SV026	SV027	SV028
Test Date	10/31/17	10/31/17	11/1/17	11/1/17
Pollutant Concentration				
SO_3/SO_4 lb/dscf	1.0×10^{-9}	2.6×10^{-9}	2.9×10^{-8}	4.8×10^{-8}
SO_3SO_4 ppm-dry	0.0041	0.010	0.11	0.19
Pollutant Emissions Rate, lb/hr				
SO_3/SO_4	0.0095	0.025	0.29	0.51

Appendix I: Pictures

Coupons before test (photo courtesy of Corrosion Testing Laboratories, Inc.)



Coupons after test (photo courtesy of Corrosion Testing Laboratories, Inc.)



Grate Bars before test (photo courtesy of Corrosion Testing Laboratories, Inc.)

Grate Bars after test (photo courtesy of Corrosion Testing Laboratories, Inc.)

Additional photos are on file at HTC

Injection lance before test

Injection lance after test

Injection nozzle before test

after test

Appendix B-5-3

Minorca Mine – Scrubber Solids Mass Balance

December 5, 2018

resourceful. naturally.
engineering and environmental consultants
BARR

Technical Memorandum

To: Jaime Johnson, Nate Holmes (ArcelorMittal Minorca Mine)
Bill Hefner, Environmental Law Group, Ltd.
From: Boyd Eisenbraun, Chad Haugen, Nick Sosalla
Subject: Minorca Mine – Scrubber Solids Mass Balance
Date: December 5, 2018
Project: Minorca Scrubber Solids Mass Balance (23691981)
c: Ryan Siats, Paul Taylor

Project Background

Barr Engineering Co. (Barr) has been assisting ArcelorMittal Minorca Mine Inc. (Minorca) with the development of a mercury mass balance for the mine and process facility. During 2016 and 2017, Minorca (with the assistance of Barr) completed sampling campaigns in the concentrator and pellet plant to quantify mercury levels throughout the process. The goal of the sampling campaigns was to provide analytical data to understand the movement of mercury through the process. This includes the mercury in the final pellet and the rejection of mercury to the tailings basin. One area identified from previous research, initial mass balance campaigns, and industry application was to conduct additional sampling to quantify the mercury reduction capabilities by removing the scrubber solids waste stream to tailings instead of recycling the scrubber solids through the process.

In Minorca's current operations, waste gases from the pellet plant furnace are directed to the scrubber system before reporting to the atmosphere. The scrubbers at Minorca utilize a moisture curtain that the waste gases must pass through before exiting the stack. The water currently used in the moisture curtain is a combination of recycled water from the scrubber recirculation tank and process water. The scrubber effluent, containing a combination of liquid and solids, flows to the scrubber recirculation tank. Minorca has indicated that approximately 75% of the scrubber effluent flow is recycled as makeup water back to the scrubber recirculation pumps while the remaining 25% is removed from the scrubber recirculation tank by the scrubber blowdown pump system and sent to the concentrate thickener lower splitter box, where is still can be recycled through the concentrate system..

The scrubber blowdown stream that is removed from the scrubber recirculation tank is replaced with water from the plant process system. Under normal operating conditions, this scrubber blowdown stream is sent to the concentrate lower splitter box which divides the flow between two concentrate thickeners to recover water and the potential iron units captured by the scrubber.

The mercury that is captured in the scrubber effluent stream is recycled back into the current process in two ways, the concentrate thickener system and the scrubber recirculation tank, with no potential opportunity for mercury to leave the process other than being volatilized in the furnace.

Minorca has indicated that it is necessary to remove the solids from the scrubber effluent through the scrubber recirculation tank in order to maintain the performance of the scrubbers. The scrubber recirculation tank has an internal baffle to help segregate the solids from the liquid. The scrubber effluent (scrubber blowdown stream) contains approximately 18-23 lb of mercury per year based on the two mercury mass balance sampling campaigns completed in 2016.

Previous testing conducted by Coleraine Research and reported by Michael Berndt in 2003 "Mercury and Mining in Minnesota" indicated that there is also potential for reducing mercury from the process by redirecting the scrubber blowdown stream to the tailings thickener system, and ultimately to the tailings basin. Therefore, Minorca determined that additional sampling and analysis of the process was necessary to identify the potential mercury reduction associated with diverting the scrubber blowdown stream to the tailings thickener instead of to the concentrate thickeners.

1.0 Sample Campaign Description

The test plan, located in Attachment A, was intended to identify the potential mercury reduction associated with redirecting the scrubber blowdown stream to the tailings thickener and ultimately to the tailings basin, versus the current process of pumping to the concentrate thickener.

The sampling campaign started the week of January 22nd, 2018 and extended through April 11th, 2018. Initial baseline sampling, corresponding to the current process in which the scrubber blowdown stream goes to the concentrate thickener, was conducted during the first two weeks of the test. The scrubber blowdown stream was redirected to the tailings thickener on Wednesday February 7th, 2018. There was a two week pause in sampling between the baseline samples and the first sample taken once the scrubber solids were redirected to allow the scrubber solids and recycle streams to adjust to their new process outputs. The sample schedule dates are identified in Table 1 below.

The process sample locations for this study are identified in Table 2 below and listed on the process flow diagram provided in Attachment B. The 10 sample locations were selected based on historical testing that identified them as the most representative streams to evaluate the mercury levels throughout the process once the scrubber solids were redirected to the tailings thickener.

After preliminary evaluation of the test data within the original sampling dates, additional sampling was warranted, and the final sampling event occurred on April 11th, prior to the annual maintenance shutdown. The additional sampling event was selected due to the continuous increase in mercury noted in the tailings underflow sample, along with elevated mercury noted in the tailings thickener overflow stream.

Table 1 Sampling Schedule

Sampling Date	Process Condition
Tuesday January 23, 2018	Baseline
Tuesday January 30, 2018	Baseline
No Sample - Wednesday February 7, 2018	Redirect scrubber solids
No Sample, Week of February 11-17	Process stabilization
Monday February 19, 2018	Redirected scrubber solids
Thursday March 1, 2018	Redirected scrubber solids
Tuesday March 6, 2018	Redirected scrubber solids
Tuesday March 13, 2018	Redirected scrubber solids
Wednesday April 11, 2018	Redirected scrubber solids

Table 2 Process Sampling Locations

Location ID	Location	Input/Internal/Output
1	Tails Thickener Underflow (Fine Tails)	Output
2	Tails Thickener Overflow (Process Water)	Internal
3	Finishers Concentrate Discharge to Concentrate Thickener/FMS Sump	Internal
4	Concentrate Thickener Feed (Float Plant Discharge)	Internal
5	Concentrate Thickener (Underflow)	Internal
6	Concentrate Thickener (Overflow)	Internal
7	Repulper Feed Belt[1]	Internal
8	Greenball (After Roll Screen – Furnace Feed to the Grate)	Internal
9a	Scrubber Blowdown (Sampling for mercury)	Output
9b	Scrubber Blowdown (Sampling for iron)	Output
10	Make-up Water Sample from Plant Head Tank/Raw Water Feed to Plant	Input

[1] Sampled only if operating

2.0 Discussion

The results from the sampling events are summarized in Table 3.

Table 3 Results Summary

Sample Location	Parameter	Sampling Event/Date								
		1 1/23/2018	2 1/30/2018	Baseline Average	3 2/19/2018	4 3/1/2018	5 3/6/2018	6 3/13/2018	7 4/11/2018	Average Post Redirection
	Pattern	**48B15 LR : 47B7 EP1**	**48B15 LR : 11B17 LR**		**12B9 EP1 : 49B7 EP1**	**12B9 EP1 : 12B17 LR**	**12B9 EP1 : 13B17 LR**	**12B9 EP1 : 13B17 LR**	**15B17 LR : 19B6 EP2**	
	Ore Type	**LC4 : LC5**	**LC5 : LC4**		**LC4 : LC5**	**LC4 : LC5**	**LC4 : LC5**	**LC4 : LC5**	**LC5 : LC4**	
	Blend %	**30% : 70%**	**30% : 70%**		**40% : 60%**	**60% : 40%**	**25% : 75%**	**25% : 75%**	**50% : 50%**	
	Average Mag, Fe	**22.76 : 19.00 = 20.13**	**22.76 : 27.09 = 25.79**		**25.58 : 19.71 = 22.06**	**25.58 : 22.82 = 24.48**	**25.58 : 22.82 = 23.51**	**25.58 : 22.82 = 23.51**	**23.92 : 20 = 21.96**	
	Average D.T. Silica	**2.21 : 3.50 = 3.11**	**2.21 : 4.60 = 3.88**		**2.51 : 3.24 = 2.95**	**2.51 : 5.28 = 3.62**	**2.51 : 4.15 = 3.74**	**2.51 : 4.15 = 3.74**	**4.5 : 2 = 3.25**	
	Float Feed Silica	**5.03**	**5.83**		**4.8**	**5.68**	**5.99**	**5.99**	**5.34**	
	Conc. % Dry Weight Recovery	**26.85**	**36.82**		**30.25**	**34.5**	**32.8**	**32.8**	**30.07**	
Inputs, lb Hg/yr	10 - Dissolved: Make-up Water Sample	0.02	0.02	0.02	0.02	0.07	0.04	0.04	0.02	0.03
Internal Streams, lb Hg/yr	2 - Tails Thickener Overflow	46	0.44	23	0.56	1.3	1.5	1.7	0.64	1.1
	3 - Finishers Concentrate Discharge to Concentrate Thickener/FMS Sump	69	74	72	320	160	81	130	140	170
	4 - Concentrate Thickener Feed (Flot Plant Discharge)	45	52	48	290	120	65	94	61	130
	4 - Concentrate Thickener Feed (Flot Plant Discharge) wastewater	1.1	0.44	0.79	0.86	0.39	0.34	0.72	0.78	0.62
	5 - Concentrate Thickener (Underflow)	79	35	57	400	130	70	180	92	170
	6 - Concentrate Thickener (Overflow)	0.00	1.5	0.74	0.69	0.90	0.19	1.1	0.59	0.69
	7 - Repulper Tank (Concentrate Reclaim Feed to Acid Conc - Slurry)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	8 - Greenball (After Roll Screen – Furnace Feed to the Grate)	57	23	40	52	89	62	50	56	62
Outputs, lb Hg/yr	1 - Tails Thickener Underflow (Fine Tails)	270	240	260	460	620	580	940	280	580
	9 - Scrubber Blowdown solids	1.9	10.6	6.2	0.8	4.7	1.8	2.6	5.5	3.1
	9 - Scrubber Blowdown (Dissolved)	0.63	0.24	0.43	0.40	0.47	0.26	0.26	1.47	0.57
Total Sample Inputs, lb Hg/yr		**0.02**	**0.02**	**0**	**0.02**	**0.07**	**0.04**	**0.04**	**0.02**	**0.04**
Total Sample Outputs, lb Hg/yr		**270**	**250**	**260**	**470**	**630**	**580**	**950**	**290**	**580**

Minorca was responsible for staffing and directing the sampling activities for each of the seven sampling events. Barr coordinated the scheduling of lab analysis which included providing sampling containers to Minorca and coordinating the sample analysis with Legend Technical Services (Legend) in St. Paul, and North Shore Analytical (NSA) in Duluth. The samples collected during each sampling event were shipped the same day to the respective labs based on analytical methods. The sampling was conducted according to the sampling test plan, provided in Attachment A. Solid samples were analyzed using ASTM E 1915-07a and liquid samples were analyzed using EPA 6010C. A summary of the results is included in Attachment C and the individual sampling event results are included in Attachment D.

2.1 General Observations

The following are general observations from the analysis of the scrubber solids redirection and mass balance:

1. The mercury data from this sampling campaign did provide information that redirecting the scrubber blowdown stream from the concentrate thickener will increase the mercury concentration in the tailings thickener and will reduce the mercury in the greenball.
2. The mercury levels in the final concentrate reporting to the thickener underflow increased when compared to the baseline samples average. An increase of approximately three times the level was noted between the baseline sampling events and after redirecting the scrubber blowdown stream (57 lb/yr baseline average; 170 lb/yr average after redirecting the blowdown). However, the sampling efforts during this campaign were focused on the mercury recycle associated with the scrubber blowdown process stream.
3. The mercury in the tailings thickener underflow stream increased once the scrubber blowdown stream was redirected to the tailings thickener. The mercury levels were at 260 lb/yr on average during baseline sampling prior to redirection of the scrubber blowdown stream. Once the scrubber blowdown stream was redirected to the tailings thickener the mercury increase in the underflow stream to an average of 580 lb/yr.
4. The tailings thickener underflow mercury levels continually increased as the process scrubber waste stream was sent to the tailings thickener until the last sample which indicated similar results as the baseline samples.
5. The tailings thickener overflow did not see a significant increase in mercury once the scrubber blowdown stream was redirected to the tailings thickener. Although sampling did not show an increase, the tailings thickener overflow stream is recycled back to the process water tank and could be a major contributor to recycle of mercury back into the process. The mercury level in the tailings thickener overflow increased slightly from 0.44 lb/yr to 1.34 lb/yr once the scrubber solids were redirected to the tailings thickener.
6. The mercury levels in the scrubber solids saw a reduction once the scrubber solids blowdown stream was redirected away from the concentrate thickener. This indicates that purging the solids from the scrubber recirculation tank does reduce the mercury recycle..

7. The mercury levels in the final concentrate from previous sampling campaigns completed in 2016 provided analytical results of 37.1 lb/yr and 57.5 lb/yr of mercury. This sample campaign noted a much higher average mercury analysis in the final concentrate at 170 lb/yr.
8. The mercury in the greenball was similar and stable during all sampling events. The analytical data indicated that the mercury levels measured in the greenball did not increase with increases noted in the final concentrate. Based on historical sampling, it is assumed that the mercury levels in the greenball would correlate to the mercury levels measured in the final concentrate.
9. Sampling event 3 indicated a much higher level of mercury in all concentrate streams at 396 lb/yr compared to the average of 170 lb/yr. However, this high level of mercury in the final concentrate did not increase the mercury in the greenball during the same sampling event. The greenball average after redirecting the solids was 62 lb/yr. Sampling event 3 was 52 lb/yr.
10. Across the sampling events, varying amounts of mercury were seen throughout the process. This variation appears to occur both with and without changes in ore blends. Throughout the sampling events, six different ore blends were seen in the plant feed, varying from 25% LC4/75% LC5 to 70% LC4/30% LC5. Using the concentrate thickener feed as a basis of the mercury in the concentrate, the mercury varied from 45 lb/yr (Sampling event 1) to 290 lb/yr (Sampling event 3) in the concentrate with no noticeable correlation to the specific ore blends. The analytical results indicated that during sampling event 3 a significant increase in the mercury can be directly attributed to the ore. We know that the mercury in the ore blends vary, based on blending ratios, locations from the mine and liberation characteristics. However, the recycling of mercury within the process also adds variability, but not at the increases noted from the ore.
11. The process mass balance associated with this sampling campaign indicates a reduction in mercury in the concentrate after the flotation plant. However, the mercury levels in the final concentrate increased and is similar to the mercury from the finisher concentrate before flotation. This indicates that the majority of mercury discharging from the finishers concentrate discharge ends up in the finished concentrate thickener underflow.
12. The mercury level in the concentrate thickener overflow decreased from 1.47lb/yr to 0.69 lb/yr once the scrubber solids were redirected to the tailings thickener.
13. The iron losses and tonnage associated with the process scrubber solids being sent to the tailings thickener averaged about 0.15 Ltph with an iron concentration similar to the final concentrate. This equates to approximately 1,260 Ltpy of concentrate that would be lost to tailings.
14. During the sampling campaign it was noted that the concentrate repulper was not utilized to supplement concentrate requirements.

2.2 Evaluation of Wasting Scrubber Solids

To further investigate the effects of the scrubber solids removal independent of the varying levels of mercury elsewhere in the process, Figure 1 and Figure 2 were created to compare the relative mercury present in the concentrate and the greenballs. Under normal operation, the mercury present in the scrubber solids is recycled back to the concentrate thickener. Figures 1 and 2 therefore compare stream "4 – Concentrate Thickener Feed (Flot Plant Discharge)" and stream "8 – Greenball (After Roll Screen –

Furnace Feed to the Grate)". To accurately represent the mercury in the concentrate prior to the scrubber solid recycle stream, stream 4 (Concentrate Thickener Feed) is used for comparison instead of stream 5 (Concentrate Thickener Underflow), and can be compared to the mercury present in the greenballs. There is currently no process step that would remove mercury from the final concentrate once it is filtered and sent to the pellet plant to make greenballs. The only opportunity at this time to remove mercury in the pellet plant is to redirect the process scrubber blowdown stream to the tailings thickener. Therefore, it is expected that while removing the scrubber solids recycle stream, the mercury in the greenball should decrease relative to a decrease shown in the concentrate.

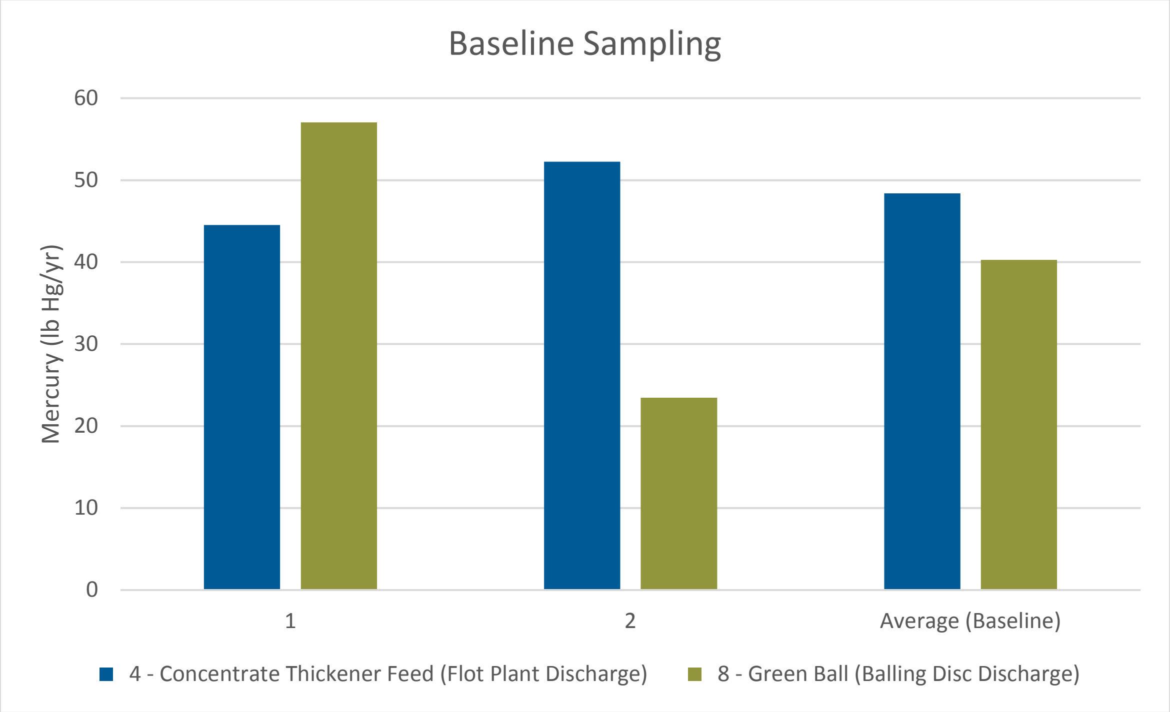


Figure 1 Calculated Mercury (lb/yr) for Concentrate and Greenballs (Baseline Sampling)

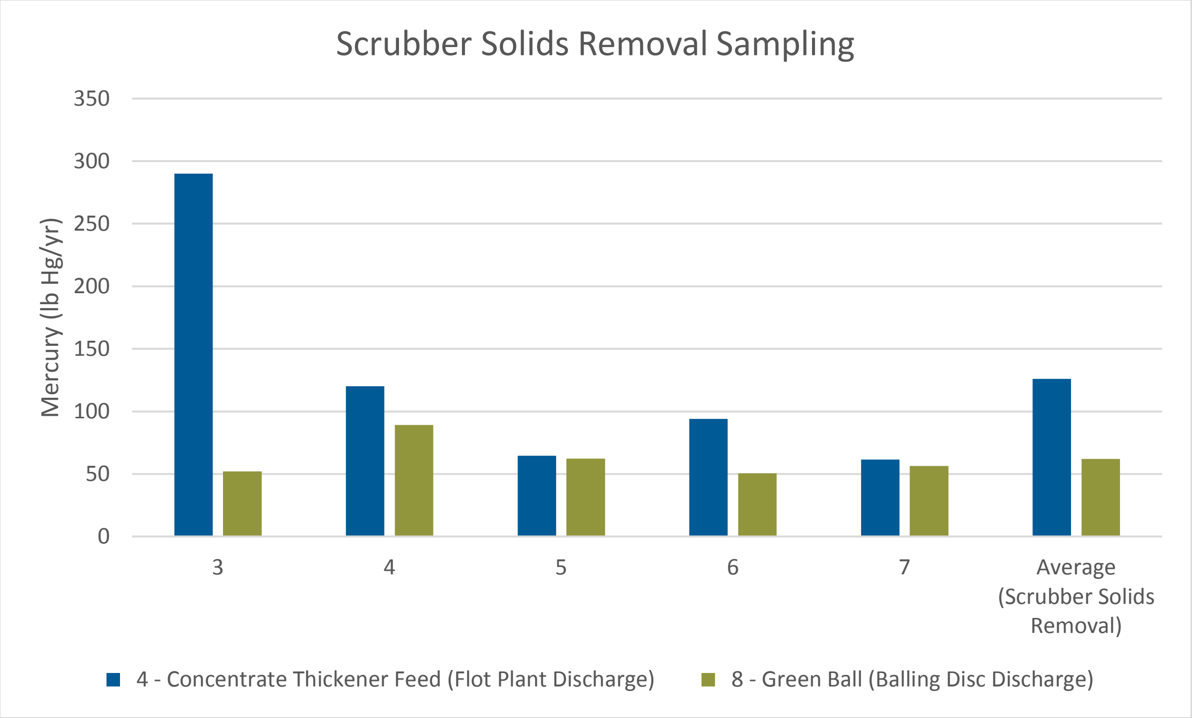


Figure 2 **Calculated Mercury (lb/yr) for Concentrate and Greenballs (Scrubber Solids Removal Sampling)**

Figure 1 and Figure 2 show that, on average, the relative mercury concentration in the greenballs compared to the concentrate did decrease once the scrubber solids stream was removed from the process instead of being recycled. During the two baseline samples, the mercury in the greenballs were on average 83% of the mercury contained in the concentrate. During the scrubber solids removal sampling events, the mercury in the greenballs averaged 49% of the mercury present in the concentrate. In general, it was expected that the mercury in the greenballs would be higher than the mercury in the concentrate during normal operation and equal to or less than the mercury in the greenballs during scrubber solid removal periods. From the data in Figure 1 and Figure 2, it can be seen that this expected trend was accurate for all but the baseline sampling event 2.

Based on the comparison between the average of the two baseline samples and the average of the five scrubber solid removal samples, the preliminary analysis shows that the scrubber solids discharge could provide up to a 41% mercury reduction in the greenballs. This reduction may be based on the specific ore characteristics and plant operation at the time of the sampling campaign. This 41% reduction was calculated as the difference between the greenball mercury contents relative to the flotation concentrate (83% and 49% for the baseline and removal samples, respectively) divided by the 83% baseline average to normalize the potential reduction to a common basis of mercury present in the concentrate.

Mercury baseline sampling conducted in 2016 at Minorca, and a mercury mass balance report from January of 2018, provided data that indicated the mercury concentration within the fired pellets is nearly negligible. It can be assumed therefore that the majority of the mercury present in the greenballs reports to the scrubber system via the furnace off gas. Assuming constant scrubber mercury capture performance, the 41% reduction in the greenball mercury could correlate to a similar reduction in stack mercury.

One thing to note in this analysis, using the raw results as the basis of the overall average can unfairly skew the results in the presence of an extreme outlier such as the mercury lb/yr for the Concentrate Thickener Feed sample in sampling event 3 as seen in Figure 2. To remove this bias, an average can be calculated using the individual averages of each sampling event. This approach will produce an average that treats each sampling event equally instead of weighted based on the results of that sampling event. Data using this calculation method can be seen below in Table 4.

Table 4 Calculated Mercury Reduction for Each Sampling Event

	Sampling event	Mercury (lb Hg/yr) 4 – Concentrate Thickener Feed (Flot Plant Discharge)	Mercury (lb Hg/yr) 8 – Greenball (Balling Disc Discharge)	Mercury Ratio (Sample 8 / Sample 4)	Estimated Reduction
Baseline	1	45	57	127%	-
	2	52	23	44%	-
			Average	85%	-
Scrubber Solids Removal	3	290	52	18%	79%
	4	120	89	74%	13%
	5	65	62	95%	-12%
	6	94	50	53%	38%
	7	61	56	92%	-7%
			Average	66%	22%

Using this method, the mercury in the greenballs was on average 85% of the mercury contained in the concentrate during the baseline samples. During the scrubber solids removal sampling events, the mercury in the greenballs averaged 66% of the mercury present in the concentrate. Based on these two averages, up to a 22% mercury reduction in the greenballs can be calculated. This is a more conservative value than the previously calculated 41% reduction, and therefore should be used as the expected reduction going forward based on the specific ore characteristics and plant operation at the time of the sampling campaign.

3.0 Conclusion

The mercury mass balance sampling campaign associated with removing scrubber solids from the process was successful in providing additional data for mercury levels in the concentrator and pellet plant. Removing the scrubber blowdown and solids from the concentrate thickener did provide data that the mercury levels in the greenball were held constant and minimized during higher levels of mercury noted in upstream concentrate process streams. Removal of the scrubber solids from the concentrate thickener did remove the mercury recycle. The average mercury level in the concentrate thickener underflow during baseline sampling was 57 lb/yr, and once the scrubber blowdown stream was redirected the average mercury level increased to 170 lb/yr.

The increase in mercury in the concentrate is likely a direct correlation with mercury from the ore during the 3rd sampling campaign, which was not sampled. The liberation for each type of ore is complex and not always similar. This liberation of the ore can affect the mercury rejection to tailings early on in the process and does affect the mercury levels moving forward in the magnetic concentrate. Once the redirection of the scrubber blowdown stream to the tailings thickener was completed, the mercury level in the concentrate thickener underflow was higher than baseline sampling and more variable. The removal of the scrubber blowdown stream was expected to reduce the mercury in the concentrate underflow, and not increase. However, the increased mercury levels in the final concentrate noted during the removal of the scrubber blowdown did not carry over to the greenball. There is currently no process step that would remove mercury from the final concentrate once it is filtered and sent to the pellet plant to make greenballs to feed the pellet furnace. The only opportunity at this time to remove mercury in the pellet plant is to redirect the process scrubber blowdown stream, which has mercury, to the tailings thickener.

Removing the scrubber blowdown from the concentrate thickener and redirecting it to the tailings thickener did result in an increase in the mercury to the tailings thickener underflow stream. The levels of mercury in the tailings thickener underflow averaged 580 lb/hr during the redirection of scrubber blowdown. The mercury level in the tailings thickener underflow stream averaged approximately 260 lb/hrs for the two samples taken prior to redirection of the scrubber blowdown. This increase in mercury in the tailings thickener is likely the result of redirection of the scrubber blowdown stream. The mercury level in the tailings thickener solids could also be an indication of increased mercury in the ore based on similar increases noted in the concentrate. However, the mercury level in thickener tails underflow continued to increase during the sampling events, as the mercury level in the final concentrates was reduced.

The mercury level in the largest source of recycle water, the tailings thickener overflow, did not increase significantly. This recycle stream increased from baseline testing but was not enough to impact the overall mercury balance. A second recycle stream identified as the concentrate thickener overflow water saw a reduction in mercury after redirection. This data indicates that the mercury in the scrubber blowdown once redirected to the tailings thickener appears to leave in the tailings thickener underflow to the tailings basin, as represented by the increase in mercury concentration in the analytical data.

The mercury level in the greenball increased from 40 lb/yr to 62 lb/yr at the same time as scrubber blowdown from the concentrate thickener was redirected to the tailings thickener. This data indicates that redirecting the scrubber solids during this sample period did not have an impact on reducing the mercury in the greenball on a total basis. However, data shown earlier in this memorandum in Table 4 shows that on a comparing mercury in the concentrate to that in the greenball indicates a possibility of up to a 22% mercury reduction on a relative basis.

The redirection of the scrubber solids to the tailings thickener did not provide evidence to indicate a major iron loss to the tailings. The average loss of 0.15 Ltph in the scrubber solids would be approximately 3.6 Ltpd of iron. This equates to approximately 1,260 Ltpy of concentrate that would be lost to tailings.

The overall tests and analytical results from this sampling campaign provides information that redirecting the scrubber blowdown to the tailings thickener does remove additional mercury from the process. This mercury level from the scrubber blowdown stream, if not redirected to the tailings thickener, does impact the mercury recycle in the process. The impact of the redirection of the scrubber blowdown with associated mercury level is based on the seven samples during a three month period. The data from this sampling campaign indicates that once the scrubber blowdown was redirected to the tailings thickener, the mercury levels in the tailings thickener underflow increased and was not recycled to the concentrate. The water from the scrubber blowdown stream will eventually report to the tailings thickener whether the scrubber solids are being recycled or not. Due to this, the removal of scrubber solids should not change the overall water balance in the plant. There may be relatively small changes in the overall energy balance due to the flow path of the warm scrubber water, but this was not considered or quantified as a part of this sampling campaign.

4.0 Recommendations

Based on the findings of this sampling campaign, Barr recommends that Minorca evaluate the data from the test report and determine the potential long term impact of the redirection of scrubber blowdown to the tailings thickener. The evaluation would include understanding the process implications and costs associated with removing the scrubber solids from the process. Barr also recommends that Minorca evaluate the potential reduction of air mercury emissions associated with redirection of the scrubber blowdown.

Attachment A

Mercury Mass Balance Sampling Test Plan

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BARR

To: Jaime Johnson, Nate Holmes, ArcelorMittal Minorca Mine
Bill Hefner, Environmental Law Group, Ltd.
From: Chad Haugen, Boyd Eisenbraun
Subject: Minorca Mine – Test Plan for Scrubber Solids Removal
Date: February 1, 2018
Project: 23691981
c: Ryan Siats, Paul Taylor

Purpose: The purpose of this memorandum is to provide details on a sampling plan for the ArcelorMittal Minorca Mine to generate additional data and information on continued mercury reduction efforts.

This document provides a test plan for scrubber solids removal from the pellet plant induration process scrubber system. This plan also includes procedures for plant sampling and analysis associated with the evaluation of the effect removing scrubber solids has on mercury concentrations within the induration process. This test plan has been developed specifically for the ArcelorMittal Minorca Mine facility (Minorca) located in Virginia, Minnesota.

1.0 Introduction

The purpose of this document is to provide the background for developing a test plan to further evaluate the removal of scrubber solids from the pellet induration process at Minorca. It defines the goals of the test plan, the test plan procedures and sampling requirements, and a mercury mass balance to determine the effect of removing scrubber solids, and its impact on mercury concentration levels in the process. As a result of the test plan and sampling, Minorca wishes to obtain a quantitative analysis of the benefit in mercury reduction associated with removing the scrubber solids from the process.

This document outlines the next phase of testing at Minorca. State regulations (Minn. R. 7007.0502) require Minorca to reduce mercury emissions by January 1, 2025 to no more than 28% of the mercury emitted in 2008 or 2010, whichever is greater. The rule also requires Minorca to submit a mercury emissions reduction plan by December 30, 2018 to define which technology will achieve a 72% reduction, or propose an alternate plan if Minorca concludes that a 72% reduction is not technically or economically feasible, impairs pellet quality, and/or causes excessive corrosion to plant equipment. Minorca has conducted a thorough review of potential mercury reduction technologies and has determined that removal of scrubber solids from the process as one potential option for Best Available Mercury Reduction Technology (BAMRT). The removal of the scrubber solids was chosen for further review.

During 2016 and 2017, Minorca (with the assistance of Barr Engineering Co. (Barr)) completed a mercury mass balance sampling campaign in the concentrator and pellet plant to quantify mercury concentrations throughout the process. This mercury analysis also identified possible operational changes that could aid in reducing overall mercury air emissions from the induration process. One recommendation resulting from the mass balance was to perform additional sampling to quantify the mercury reduction capabilities of removing scrubber solids instead of recycling them through the process.

During current operation at Minorca, process waste gases from the pellet plant furnace are directed to the waste gas scrubber system before reporting to the atmosphere. The waste gas scrubber at Minorca utilizes a wet scrubber system including a moisture curtain that the process gas must pass through before exiting the stack. This scrubber utilizes water and the current source is a combination of recycled water from the process scrubber recirculation tank and fresh water. The scrubber effluent from the scrubber contains a combination of liquid and solids. This scrubber effluent is returned to the process scrubber recirculation tank. A large portion of this scrubber effluent that reports to the process scrubber recirculation tank is recycled back to the process waste gas scrubber. Discussions with Minorca has indicated that approximately 75% of the scrubber effluent flow returned from the waste gas scrubber to the process scrubber recirculation tank is recycled as makeup back to the process scrubber feed pumps. The remaining 25% of the scrubber effluent flow is assumed to be purged from the process scrubber recirculation tank by the scrubber blowdown pump system.

The scrubber blowdown stream flow that is removed from the process scrubber recirculation tank is replaced with water from the plant process system. Under normal operating conditions, this purged scrubber blowdown stream is sent to the concentrate lower splitter box which divides the flow between two concentrate thickeners. The water is sent to these concentrate thickeners to recover potential iron units captured by the waste gas scrubber. The mercury that is captured in the scrubber effluent stream and scrubber solids is recycled back into the current process through two ways, the concentrate thickener system and the process scrubber recirculation tank, with no potential opportunity for purging the mercury.

Minorca operations has indicated that without the purge stream from the process scrubber recirculation tank, the solids in the scrubber effluent will build up in the system and effect the performance of the waste gas scrubber. The process scrubber recirculation tank has a baffle in the tank to help segregate the solids from the liquid. The scrubber effluent and solids from the waste gas scrubber contained levels of mercury of approximately 18-23 lbs per year. Previous testing also indicated that there is potential for reducing mercury in the recycle by removing the scrubber solids via the scrubber blowdown stream and sending this process stream to the tailing thickener system, with this process stream sent to the tailings basin.

2.0 Test Plan

The following test plan is intended to identify and quantify the mercury reduction associated with eliminating scrubber solids from the process versus recycling them to the concentrate thickener. This process stream be redirected to the tailings system for removal of this mercury recycle stream. Minorca will be responsible for collection of the process samples identified within Table 2. Barr staff will be responsible for providing sample containers and coordinating and scheduling the analysis for these samples. Process samples should be taken during steady state operation, which will be determined by Minorca staff.

2.1 Goals

- Obtain balanced mercury concentrations throughout the pellet plant process and recycle streams. This includes the balling area and induration furnace.
- Measure mercury concentration of final concentrates, green ball, water recycle streams, and scrubber solids streams.
- Estimate the amount of mercury reduced in the process by removing scrubber solids.
- Estimate the associated iron losses corresponding to removal of scrubber solids.
- Identify the rate at which the system responds to removing scrubber solids by comparing finisher concentrate, flotation concentrate, concentrate thickener underflow and overflow, and green ball mercury concentrations.
- Measure the process water mercury levels during the test to determine the effects of removal of the scrubber solids.

2.2 Plant Performance Data

Plant performance data will be collected during the test periods to determine recovery and chemical analysis. During the testing duration it is important to collect the process flow measurements of solids, slurry, and water. This will inform a mass balance when combining the chemical analysis of the solids and liquids. Flow data requested is listed in Table 2.

2.3 Proposed Schedule

The 60 day test for Minorca is scheduled to start with baseline sampling, with current path of the scrubber solids. Once the baseline sampling is complete, the scrubber solids system will be redirected to the tailings system. The testing will commence the week of January 22nd, 2018 and extend through March 12th, 2018. However, if additional sampling is warranted, sampling may occur the up until April 16th.

The proposed sampling schedule is provided in Table 1.

Table 1 Sampling Schedule

Sample Date	Process Condition	Sample Time	NTS Personnel	Minorca Personnel
Tuesday January 23, 2018	Baseline	8:00am	2	1-2 Lab, Dave Vidmar
Tuesday January 30, 2018	Baseline	8:00am	2	1-2 Lab, Dave Vidmar
No Sample	Redirect scrubber solids	No Sampling	No Sampling	No Sampling
No Sample	Process stabilization	No Sampling	No Sampling	No Sampling
Monday February 19, 2018	Redirected scrubber solids	8:00am	2	1-2 Lab, Dave Vidmar
Thursday March 1, 2018	Redirected scrubber solids	8:00am	2	1-2 Lab, Nate or Jaime
Tuesday March 6, 2018	Redirected scrubber solids	8:00am	2	1-2 Lab, Dave Vidmar
Tuesday March 13, 2018	Redirected scrubber solids	8:00am	2	1-2 Lab, Dave Vidmar

- Collect one composite sample at each location.
    - For each location the composite sample will consist of three sample cuts during each event.
- Use lab results and process data to complete the mercury mass balance.
- Compare the analyzed results to the results of the historical mercury mass balance completed in late 2016 and early 2017.

2.4 Sample Protocol and Sample Locations

The mercury sampling campaigns over the last two years provide good baseline data for the mercury concentrations in the process around the concentrate and pellet plant operations. Two sampling events of the process prior to scrubber solids removal testing will be completed to compare to previous baseline data. To fully sample the process streams the slurry or solids samples at each of the following locations will be included. The sample locations were chosen specific to process input streams, where the process splits to two different locations and recycle streams.

Sample points have been identified within the concentrator and pellet plant process to evaluate the effect of removing the waste gas scrubber solids and the effect of the mercury concentration levels in the process. A reference process flow diagram of the process is included to identify the sample locations (see Appendix A). The following is a list of the sampling locations:

1. Tails thickener underflow (fine tails)
2. Tails thickener overflow (process water)
3. Finishers concentrate discharge to concentrate thickener/FMS sump
4. Concentrate thickener feed (float plant discharge)

5. Concentrate thickener (underflow)

6. Concentrate thickener (overflow)

7. Repulper feed belt

    - Only applicable if reclaiming during sampling; no sample required if not reclaiming

8. Green ball (balling disc discharge) – after over/under size roll deck

9. Scrubber blowdown – sample slurry from scrubber blowdown and separate liquid and solids by filtering after sample collection. A separate sampling campaign may be considered during mercury reduction technology testing to analyze the effect residence time may play on the form of mercury.

10. Make-up water (plant head tank/raw water feed to plant) – Multiple feed sources including make-up water from upland tailings basin, plant site settling basin, Minorca In-Pit, or freshwater from Enterprise pit.

Each sample location will require evaluation to determine if there is safe accessibility for sampling. Existing sample locations may be suitable to meet the needs of a mercury mass balance, and should be evaluated on a case-by-case basis. A review will be completed of any past analytical results for possible inclusion in the statistical analysis of the mercury mass balance.

To complete an accurate mass balance, flow measurements will be needed at each sample location. If real-time process flow rate measurements are not available it is important to review pump data (including performance curves) based on electrical measurements and equipment design flow rates. Additionally, flows can be determined by performing a chemical and material balance. Each sampling location will be reviewed to determine the best option for flow rate measurement. A detailed sample matrix is provided in Appendix B.

The sample locations have been marked on the PFD included with this memo. The attached sampling matrix may be used as reference for understanding the associated sample volume and metric with additional process information when sampling each of the sample locations.

2.5 Scrubber Solids Removal

To remove the scrubber solids from the system, the following process changes will be made (depending on process feasibility):

- Scrubber solids will not be rerouted until two sample events or base line samples have been collect prior to solids removal.

- Reroute the scrubber discharge to remove the scrubber solids from the system. This exact route of removal will be determined by Minorca staff. The scrubber solids will be transferred/pumped with the scrubber blowdown stream to the tailings feed launder then to the tailings thickener. This effort will direct all tailings thickener underflow with the mercury solids and liquids to the tailings basin, thus reducing the potential for mercury recycle back into in the process water. Previous research has shown that mercury attenuates to tailings and does not leaving the tailings basin. Minorca currently recycles the scrubber blowdown stream with solids back to the process through the concentrate thickener and a portion of this process flow is recycled to the process scrubber recirculation tank.

The proposed schedule duration is eight weeks of sampling with one set of samples per week. This will allow for the system to adequately re-equilibrate after removing the recycle of material through the system.

These samples will be collected and filtered at Minorca. The slurry samples will be processed to separate the solids portion from the liquid portion of the slurry. The solid portion of the slurry should be analyzed using EPA method 7473 (or its accepted equivalent). The liquid portion of the slurry should be analyzed using EPA method 200.8 (or its accepted equivalent). Table 2 provides a summary of the sample locations and methods for analysis.

Table 2 Sample Locations Summary

Sample Point	Location	Type	Matrix	Frequency	Amount Collected	Lab Analysis Method
1. Tails Thickener Underflow (Fine Tails)	Tailings Thickener	Grab	Slurry	1/Week	1 Gallon Container/Bucket with lid	EPA 7473 (Solids), EPA 200.8 (Liquid)
2. Tails Thickener Overflow (Fine Tails)	Tailings Thickener	Grab	Liquid	1/Week	1 Gallon Container/Bucket with lid	EPA 1631E (Liquid)
3. Finishers Concentrate Discharge to Concentrate Thickener/FMS Sump	Finisher Magnetic Separator	Grab	Slurry	1/week	1 Gallon Container/Bucket with lid	EPA 7473 (Solids), EPA 200.8 (Liquid)
4. Concentrate Thickener Feed (Float Plant Discharge)	Concentrate Thickener Feed	Grab	Slurry	1/Week	1 Gallon Container/Bucket with lid	EPA 7473 (Solids), EPA 200.8 (Liquid)
5. Concentrate Thickener (Underflow)	Concentrate Thickener	Grab	Slurry	1/Week	1 Gallon Container/Bucket with lid	EPA 7473 (Solids), EPA 200.8 (Liquid)
6. Concentrate Thickener (Overflow)	Concentrate Thickener	Grab	Liquid	1/Week	1 Gallon Container/Bucket with lid	EPA 1631E (Liquid)
7. Repulper Feed Belt[1]	Repulper Feed Belt	Grab	Solid	1/week	1 Gallon Container/Bucket with lid	EPA 7473 (Solids)
8. Green Ball (Balling Disc Discharge)	Balling Drum Floor	Grab	Solid	1/Week	1 Gallon Container/Bucket with lid	EPA 7473 (Solids)
9. Scrubber Blowdown (Sampling for iron and mercury)	Scrubber Sump	Grab	Slurry	1/Week	1 Gallon Container/Bucket with lid	EPA 7473 (Solids), EPA 200.8 (Liquid)
	Scrubber Sump	Grab, 5 gallon bucket	Slurry	1/Week	5 Gallon Container/Bucket with lid	Iron analysis completed by Minorca
10. Make-up Water Sample from Plant Head Tank/Raw Water Feed to Plant	Makeup Tank	Grab	Liquid	1/Week	1 Gallon Container/Bucket with lid	EPA 1631E (Liquid)

[1] Only collect if repulping during sampling event

2.6 Sample Collection Method

The sampling method will consist of collecting three cross-cut samples for each location, composited into one sample for that specific location. This technique will apply to all of the sample locations. The multiple cross-cut samples should be spaced appropriately to cover the sampling window selected by the sample collection team, collecting a single sample at each location and then repeating this process two times to form the final composite sample for analysis.

In collecting samples of water for mercury analysis, EPA Method 1631E calls for the use of the “clean hands–dirty hands” protocol identified in EPA Method 1669. This method requires that two people collect samples to prevent contamination. Quoting EPA Method 1669, “upon arrival at the sampling site, one member of the two-person sampling team is designated as "dirty hands"; the second member is designated as "clean hands." All operations involving contact with the sample bottle and transfer of the sample from the sample collection device to the sample bottle are handled by the individual designated as "clean hands." "Dirty hands" is responsible for preparation of the sampler (except the sample container itself), operation of any machinery, and for all other activities that do not involve direct contact with the sample.

As outlined by EPA Method 1669, the following rules should be followed by personnel conducting the sampling:

- Whenever possible, samples are collected facing upstream and upwind to minimize introduction of contamination.
- Surface samples are collected using a grab sampling technique. The principle of the grab technique is to fill a sample bottle by rapid immersion in water and capping to minimize exposure to airborne particulate matter.
- Subsurface samples are collected by suction of the sample into an immersed sample bottle or by pumping the sample to the surface.

For slurry streams whose liquid portions are anticipated to have high levels of dissolved mercury (for instance, scrubber blowdown), it is recommended that after collecting a sample, the technician separate or filter the solid from the liquid. A clean filter press would likely provide the easiest dewatering, but would not allow for capture of the filtrate needed for analysis. Therefore, collection via vacuum filtration with a vacuum flask is to be used (Nalgene™ Rapid-Flow™ Sterile Disposable Filter Units with PES Membrane and 0.45 micron cloth; conducted in the on-site laboratory if possible). For example, when samples are collected from the scrubber blowdown/recycle, the solids and liquid will need to be filtered at the facility location, preferable in the laboratory location at the site. Both resulting samples must then be stored in separate containers. The Previous Minnesota Department of Natural Resource studies (Berndt, Michael E. "Mercury and Mining in Minnesota." 15 Oct. 2003) indicate that the concentration of dissolved mercury in scrubber-water blowdown liquid will decrease with time if the liquid is stored in the same container as the solids because the mercury in the water will eventually be absorbed by the solids.

The following outlines the procedure for using a Nalgene™ Rapid-Flow™ Sterile Disposable Filter Units with PES Membrane for the mercury samples (1000 mL filter unit will be used; using "clean hands-dirty hands" method):

- After collecting one liter of the slurry sample the solids will be filtered from the liquid using the disposable filter unit described above.
    - The solids portion of the slurry in the sample container will usually settle to the bottom of the container and the liquid portion of the sample can be used for the filtration.
    - A new filter must be used for each slurry sample to avoid contamination.
- In the field filtering will require a hand vacuum pump connected to the filter hose connection. Filter the sample until all the liquid is collected in the bottom portion while the solids are retained in the filter. Put the separated samples in separate designated containers for lab analysis.
    - Scrape off solids left on the filter membrane using a clean spatula or other appropriate tool.
    - The solids and filtered slurry solid samples will be stored in a 4 oz. glass container and placed in ice for shipment.
    - The filtered liquid portions of the slurry samples will be stored in a 250 mL or 500 mL plastic sample bottle containing HNO_3 and also kept on ice during shipping.
- Use the same procedure for filtering if completed in the lab using an electric vacuum pump.

2.7 Sample Collection, Preparation, Analysis, and Storage

Samples undergoing mercury analysis must be processed and stored in an environment that prevents contamination from outside sources. Mercury from the atmosphere can be absorbed by liquid and solid samples if the containers are not properly sealed. Samples should be capped and stored in sealed containers (not paper envelopes or paper boxes). The sample containers for sampling collection and shipment must be clean and not previously used. The sample containers for shipment will be provided by Barr.

The sample collection method, filtering, and analysis for the iron sample from the scrubber solids should be completed utilizing existing pressure filtration and equipment at the Minorca lab. This will be a secondary sample separate from the sample collected for mercury analysis. The sample volume required to determine the amount of iron is a minimum of 20 grams of solids once filtered. The filtering procedure for this sample should follow existing Minorca QA/QC for filtering of slurry samples. This sample will only be utilized for iron analysis.

2.8 Analytical Methods

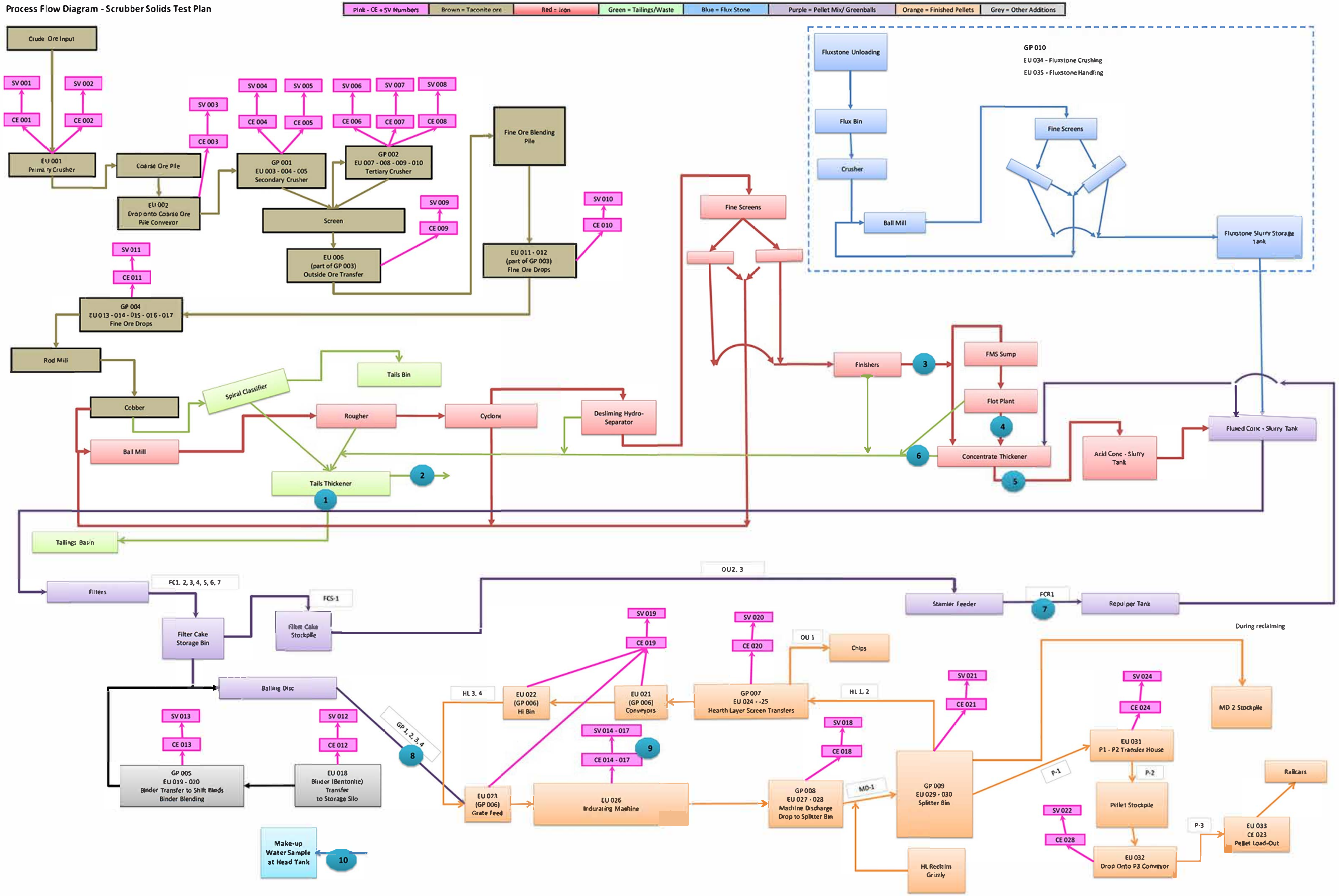
Solid (green ball) and filtered solid (scrubber solids and final concentrate) will be measured using EPA Method 7473 (Mercury in Solid or Semisolid Waste – Manual Cold-Vapor Technique), while the filtered liquid portion of samples is to be measured using EPA Method 200.8 (Mercury in Liquid Wastes – Manual Cold-Vapor Technique). The water samples (tails thickener overflow, concentrate thickener overflow, and make-up water) are to be measured using EPA Method 1631E. Barr recommends Legend Technical in St. Paul or an alternate approved lab for analyzing solid and liquid samples according to EPA Method 7473 and 200.8, and North Shore Analytical in Duluth for analyzing water samples according to EPA Method 1631E.

3.0 Results Analysis

The weekly samples for analysis should be paired with the plant production records from the plant historian. A mercury mass balance similar to past balances will be created to determine if removal of the scrubber solids from the induration process is effective at reducing the mercury in the process. A technical memo will be prepared to document the results and provide additional recommendations as part of the overall mercury reduction plan.

Appendix A – Sample Locations

ArcelorMittal Minorca Mine
Process Flow Diagram - Scrubber Solids Test Plan



● Process Sampling Locations

1. Tails Thickener Underflow (Fine Tails)
2. Tails Thickener Overflow (Process Water)
3. Finishers Concentrate Discharge to Concentrate Thickener/FMS Sump
4. Concentrate Thickener Feed (Flot Plant Discharge)
5. Concentrate Thickener (Underflow)
6. Concentrate Thickener (Overflow)
7. Repulper Feed Belt
8. Green Ball (Balling Disc Discharge)
9. Scrubber Blowdown
10. Make-up Water (Plant Head Tank/Raw Water Feed to Plant)

Appendix B – Sampling Matrix

Project: 23691981 Scrubber Solids Test Plan
Subject: Scrubber Solids Test Sample Matrix
Date: 2/1/18

Sample Point	Phase (Liquid, Slurry, or Solid)	Current Sample Collection Metrics	Current Sample Volume	Flow Measurement (TPH,%solids, GPM) **	Use Exisiting Sample	Proposed Mercury Sample Collection Metrics	Proposed Sample Volume	Additional Process Information Needed
1. Tails Thickener Underflow (Fine Tails)	Slurry	sample duration, 3 sample cuts		TPH	Yes/No		1 L initial sample, filter Solids - 4 oz. glass jar Liquid - 250 or 500 mL plastic bottle	
2. Tails Thickener Overflow (Process Water)	Liquid	sample duration, 3 sample cuts		GPM	Yes/No		1 L initial sample, 3 cuts, composite placed in a 500 mL glass bottle	
3. Finishers Concentrate Discharge to Concentrate Thickener/FMS Sump	Slurry	sample duration, 3 sample cuts		TPH	Yes/No		1 L initial sample, filter Solids - 4 oz. glass jar Liquid - 250 or 500 mL plastic bottle	
4. Concentrate Thickener Feed (Flot Plant Discharge)	Slurry	sample duration, 3 sample cuts		TPH	Yes/No		1 L initial sample, filter Solids - 4 oz. glass jar Liquid - 250 or 500 mL plastic bottle	
5. Concentrate Thickener (Underflow)	Slurry	sample duration, 3 sample cuts		TPH	Yes/No		1 L initial sample, filter Solids - 4 oz. glass jar Liquid - 250 or 500 mL plastic bottle	
6. Concentrate Thickener (Overflow)	Liquid	sample duration, 3 sample cuts		GPM	Yes/No		1 L initial sample, 3 cuts, composite placed in a 500 mL glass bottle	
7. Repulper Feed Belt	Solid	sample duration, 3 sample cuts		TPH	Yes/No		1 kg initial sample, 3 cuts composite placed in a 4oz bottle	
8. Green Ball (Balling Disc Discharge)	Solid	sample duration, 3 sample cuts		TPH	Yes/No		1 kg initial sample, 3 cuts composite placed in a 4oz bottle	
9. Scrubber Blowdown	mercury sample Slurry	sample duration, 3 sample cuts		GPM/TPH	Yes/No		1 L initial sample, filter Solids - 4 oz. glass jar Liquid - 250 or 500 mL plastic bottle	
	iron sample Slurry	sample duration, 3 sample cuts		GPM/TPH	Yes/No		1 L initial sample placed in a 500ml bottle, 3 cuts	
10. Make-up Water (Plant Head Tank/Raw Water Feed to Plant)	Liquid	sample duration, 3 sample cuts		GPM	Yes/No		1 L initial sample, 3 cuts, composite placed in a 500 mL glass bottle	

* Mine data required to determine ore blends and tonnage

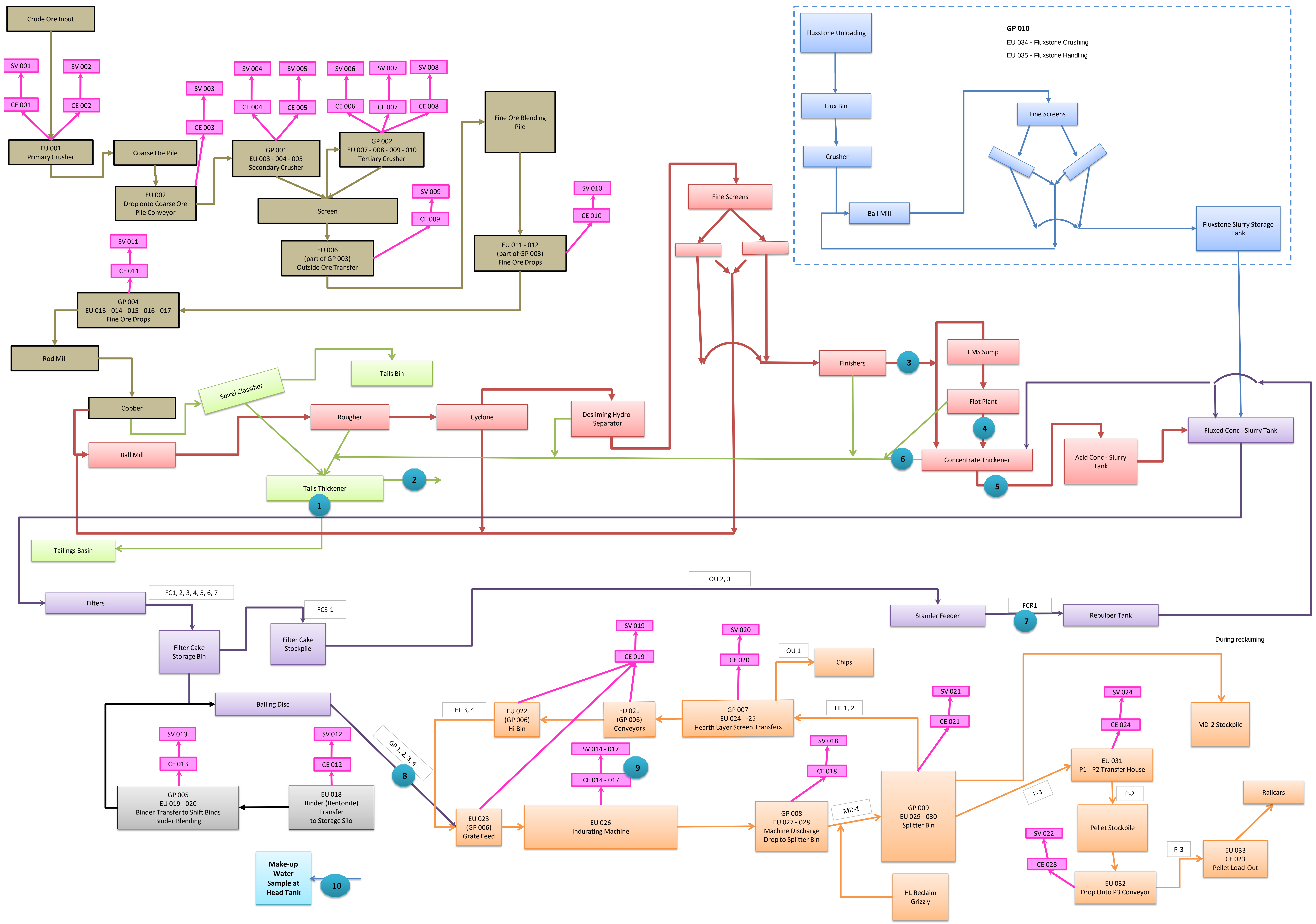
** The mass flow measurement could come from DCS realtime measurement, database, production reports, or process design if not currently measured

Attachment B

Mass Balance Sampling Locations

ArcelorMittal Minorca Mine
Process Flow Diagram - Scrubber Solids Test Plan

Pink - CE + SV Numbers	Brown = Taconite ore	Red = Iron	Green = Tailings/Waste	Blue = Flux Stone	Purple = Pellet Mix/ Greenballs	Orange = Finished Pellets	Grey = Other Additions



Process Sampling Locations

1. Tails Thickener Underflow (Fine Tails)
2. Tails Thickener Overflow (Process Water)
3. Finishers Concentrate Discharge to Concentrate Thickener/FMS Sump
4. Concentrate Thickener Feed (Flot Plant Discharge)
5. Concentrate Thickener (Underflow)
6. Concentrate Thickener (Overflow)
7. Repulper Feed Belt
8. Greenball (After Roll Screen - Furnace Feed to Grate)
9. Scrubber Blowdown
10. Make-up Water (Plant Head Tank/Raw Water Feed to Plant)

Attachment C

Mass Balance Results Summary

DRAFT SCRUBBER SOLIDS MERCURY MASS BALANCE RESULTS SUMMARY

	Sample Event								
Parameter	1	2		3	4	5	6	7	
Test Date	1/23/2018	1/30/2018	---	2/19/2018	3/1/2018	3/6/2018	3/13/2018	4/11/2018	---
Test Period			---						---
Pattern	48B15 LR : 47B7 EP1	48B15 LR : 11B17 LR	--	12B9 EP1 : 49B7 EP1	12B9 EP1 : 12B17 LR	12B9 EP1 : 13B17 LR	39 EP1 : 13B17	317 LR : 19B6 E	--
Ore Type	LC4 : LC5	LC5 : LC4	--	LC4 : LC5	LC4 : LC5	LC4 : LC5	LC4 : LC5	LC5 : LC4	--
Blend %	30% : 70%	30% : 70%	--	40% : 60%	60% : 40%	25% : 75%	25% : 75%	50% : 50%	--
Average Mag, Fe	22.76 : 19.00 = 20.13	22.76 : 27.09 = 25.79	--	25.58 : 19.71 = 22.06	25.58 : 22.82 = 24.48	25.58 : 22.82 = 23.51	.58 : 22.82 = 23	3.92 : 20 = 21.9	--
Average D.T. Silica	2.21 : 3.50 = 3.11	2.21 : 4.60 = 3.88	--	2.51 : 3.24 = 2.95	2.51 : 5.28 = 3.62	2.51 : 4.15 = 3.74	.51 : 4.15 = 3.7	4.5 : 2 = 3.25	--
Float Feed Silica	5.03	5.83	--	4.8	5.68	5.99	5.99	5.34	--
Conc. % Dry Weight Recovery	26.85	36.82	--	30.25	34.5	32.8	32.8	30.07	--
Sample Location - Inputs, lb Hg/yr			Baseline Average						Average Post Redirection
10 - Dissolved: Make-up Water Sample	0.02	0.02	0.02	0.02	0.07	0.04	0.04	0.02	0.03
Sample Location - Internal Streams, lb Hg/yr									
2 - Tails Thickener Overflow (Process Water)*	46	0.44	23	0.56	1.3	1.5	1.7	0.64	1.1
3 - Finishers Concentrate Discharge to Concentrate Thickener/FMS Sump	69	74	72	325	156	81	130	141	167
4 - Concentrate Thickener Feed (Flot Plant Discharge)	45	52	48	287	121	65	94	61	126
4 - Concentrate Thickener Feed (Flot Plant Discharge) wastewater	1.1	0.44	0.79	0.86	0.39	0.34	0.72	0.78	0.62
5 - Concentrate Thickener (Underflow)	79	35	57	396	128	70	181	92	173
6 - Concentrate Thickener (Overflow)	0.00	1.5	0.74	0.69	0.90	0.19	1.1	0.59	0.69
7 - Repulper Tank (Concentrate Reclaim Feed to Acid Conc - Slurry)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8 - Greenball (After Roll Screen - Furnace Feed to Grate)	57	23	40	52	89	62	50	56	62
Sample Location - Outputs, lb Hg/yr									
1 - Tails Thickener Underflow (Fine Tails)	270	240	260	460	620	580	940	280	580
9 - Scrubber Blowdown solids	1.9	11	6	0.80	4.7	1.8	2.6	5.5	3
9 - Scrubber Blowdown (Dissolved)	0.63	0.24	0	0.40	0.47	0.26	0.26	1.5	1
Total Sample Inputs, lb Hg/yr	0.02	0.02	0	0.02	0.07	0.04	0.04	0.02	0.04
Total Sample Outputs, lb Hg/yr	270	250	260	470	630	580	950	290	580

* The first event had larger concentration than others. However, Legend provided the concentration (ug/L) for this event while NSA provided the process water concentration thereafter and had much lower results presented as ng/L.

Attachment D

Mass Balance Sampling Results

Sampling event 1 – 01/23/18
Sampling event 2 – 01/30/18
Sampling event 3 – 02/19/18
Sampling event 4 – 03/01/18
Sampling event 5 – 03/06/18
Sampling event 6 – 03/13/18
Sampling event 7 – 04/11/18

LEGEND
Technical Services, Inc.

88 Empire Drive
St Paul, MN 55103
Tel: 651-642-1150
Fax: 651-642-1239

January 31, 2018

Mr. James E. Taraldsen
Barr Engineering Co.
325 South Lake Avenue, Suite 700
Duluth, MN 55802

Work Order Number: 1800322
RE: 23691845

Enclosed are the results of analyses for samples received by the laboratory on 01/24/18. If you have any questions concerning this report, please feel free to contact me.

Results are not blank corrected unless noted within the report. Additionally, all QC results meet requirements unless noted.

All samples will be retained by Legend Technical Services, Inc., unless consumed in the analysis, at ambient conditions for 30 days from the date of this report and then discarded unless other arrangements are made. All samples were received in acceptable condition unless otherwise noted.

All test results and QC meet requirements of the 2003 NELAC standard.

MDH (NELAP) Accreditation #027-123-295

Prepared by,
LEGEND TECHNICAL SERVICES, INC

BACH PHAM

Bach Pham
Client Manager II
bpham@legend-group.com

88 Empire Drive
St Paul, MN 55103
Tel: 651-642-1150
Fax: 651-642-1239

Barr Engineering Co.	Project: 23691845	
325 South Lake Avenue, Suite 700	Project Number: 23691845.00 001 001	Work Order #: 1800322
Duluth, MN 55802	Project Manager: Mr. James E. Taraldsen	Date Reported: 01/31/18

ANALYTICAL REPORT FOR SAMPLES

Sample ID	Laboratory ID	Matrix	Date Sampled	Date Received
Tails Thickener Underflow	1800322-01	Other	01/23/18 09:11	01/24/18 09:50
Finishers Concentrate Discharge	1800322-02	Other	01/23/18 08:22	01/24/18 09:50
Concentrate Thickener Feed	1800322-03	Other	01/23/18 08:54	01/24/18 09:50
Concentrate Thickener Underflow	1800322-04	Other	01/23/18 08:30	01/24/18 09:50
Green Balls	1800322-05	Other	01/23/18 08:21	01/24/18 09:50
Scrubber Blowdown	1800322-06	Other	01/23/18 08:33	01/24/18 09:50
Tails Thickener Underflow	1800322-07	Wastewater	01/23/18 09:11	01/24/18 09:50
Tails Thickener Overflow	1800322-08	Wastewater	01/23/18 09:03	01/24/18 09:50
Finishers Concentrate Discharge	1800322-09	Wastewater	01/23/18 08:22	01/24/18 09:50
Concentrate Thickener Feed	1800322-10	Wastewater	01/23/18 08:54	01/24/18 09:50
Concentrate Thickener Underflow	1800322-11	Wastewater	01/23/18 08:30	01/24/18 09:50
Concentrate Thickener Overflow	1800322-12	Wastewater	01/23/18 08:37	01/24/18 09:50
Scrubber Blowdown	1800322-13	Wastewater	01/23/18 08:33	01/24/18 09:50
Make Up Water Sample	1800322-14	Wastewater	01/23/18 08:45	01/24/18 09:50

Shipping Container Information

Default Cooler Temperature (°C):

Received on ice: Yes	Temperature blank was not present	Received on ice pack: No
Received on melt water: Yes	Ambient: No	Acceptable (IH/ISO only): No
Custody seals: No		

Case Narrative:

Mercury was detected between the MDL and RL in the 200.8 batch B8A3106 method blank.

The results are reported on an 'as received' basis for samples Concentrate Thickener Feed and Scrubber Blowdown due to limited sample.

.

Barr Engineering Co.	Project: 23691845		
325 South Lake Avenue, Suite 700	Project Number: 23691845.00 001 001	Work Order #:	1800322
Duluth, MN 55802	Project Manager: Mr. James E. Taraldsen	Date Reported:	01/31/18

TOTAL MERCURY ANALYSIS
Legend Technical Services, Inc.

Analyte	Result	RL	MDL	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
Tails Thickener Underflow (1800322-01) Other Sampled: 01/23/18 09:11 Received: 01/24/18 9:50										
Mercury	**0.029**	0.050	0.0044	mg/kg dry	1	B8A3004	01/30/18	01/31/18	EPA 7473	J
Finishers Concentrate Discharge (1800322-02) Other Sampled: 01/23/18 08:22 Received: 01/24/18 9:50										
Mercury	**0.0093**	0.050	0.0044	mg/kg dry	1	B8A3004	01/30/18	01/31/18	EPA 7473	J
Concentrate Thickener Feed (1800322-03) Other Sampled: 01/23/18 08:54 Received: 01/24/18 9:50										
Mercury	**0.0062**	0.050	0.0044	mg/kg wet	1	B8A3004	01/30/18	01/31/18	EPA 7473	J
Concentrate Thickener Underflow (1800322-04) Other Sampled: 01/23/18 08:30 Received: 01/24/18 9:50										
Mercury	**0.011**	0.050	0.0044	mg/kg dry	1	B8A3004	01/30/18	01/31/18	EPA 7473	J
Green Balls (1800322-05) Other Sampled: 01/23/18 08:21 Received: 01/24/18 9:50										
Mercury	**0.0090**	0.050	0.0044	mg/kg dry	1	B8A3004	01/30/18	01/31/18	EPA 7473	J
Scrubber Blowdown (1800322-06) Other Sampled: 01/23/18 08:33 Received: 01/24/18 9:50										
Mercury	**0.48**	0.050	0.0044	mg/kg wet	1	B8A3004	01/30/18	01/31/18	EPA 7473	

Barr Engineering Co.
325 South Lake Avenue, Suite 700
Duluth, MN 55802

Project: 23691845
Project Number: 23691845.00 001 001
Project Manager: Mr. James E. Taraldsen

Work Order #: 1800322
Date Reported: 01/31/18

TOTAL METALS ANALYSIS
Legend Technical Services, Inc.

Analyte	Result	RL	MDL	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
Tails Thickener Underflow (1800322-07) Wastewater Sampled: 01/23/18 09:11 Received: 01/24/18 9:50										
Mercury	**0.31**	0.20	0.035	ug/L	1	B8A3106	01/31/18	01/31/18	EPA 200.8	B-01
Tails Thickener Overflow (1800322-08) Wastewater Sampled: 01/23/18 09:03 Received: 01/24/18 9:50										
Mercury	**0.15**	0.20	0.035	ug/L	1	B8A3106	01/31/18	01/31/18	EPA 200.8	B-01, J
Finishers Concentrate Discharge (1800322-09) Wastewater Sampled: 01/23/18 08:22 Received: 01/24/18 9:50										
Mercury	**0.13**	0.20	0.035	ug/L	1	B8A3106	01/31/18	01/31/18	EPA 200.8	B-01, J
Concentrate Thickener Feed (1800322-10) Wastewater Sampled: 01/23/18 08:54 Received: 01/24/18 9:50										
Mercury	**0.10**	0.20	0.035	ug/L	1	B8A3106	01/31/18	01/31/18	EPA 200.8	B-01, J
Concentrate Thickener Underflow (1800322-11) Wastewater Sampled: 01/23/18 08:30 Received: 01/24/18 9:50										
Mercury	**0.26**	0.20	0.035	ug/L	1	B8A3106	01/31/18	01/31/18	EPA 200.8	B-01
Concentrate Thickener Overflow (1800322-12) Wastewater Sampled: 01/23/18 08:37 Received: 01/24/18 9:50										
Mercury	**0.20**	0.20	0.035	ug/L	1	B8A3106	01/31/18	01/31/18	EPA 200.8	B-01
Scrubber Blowdown (1800322-13) Wastewater Sampled: 01/23/18 08:33 Received: 01/24/18 9:50										
Mercury	**0.14**	0.20	0.035	ug/L	1	B8A3106	01/31/18	01/31/18	EPA 200.8	B-01, J
Make Up Water Sample (1800322-14) Wastewater Sampled: 01/23/18 08:45 Received: 01/24/18 9:50										
Mercury	**0.098**	0.20	0.035	ug/L	1	B8A3106	01/31/18	01/31/18	EPA 200.8	B-01, J

Barr Engineering Co.	Project: 23691845	
325 South Lake Avenue, Suite 700	Project Number: 23691845.00 001 001	Work Order #: 1800322
Duluth, MN 55802	Project Manager: Mr. James E. Taraldsen	Date Reported: 01/31/18

PERCENT SOLIDS
Legend Technical Services, Inc.

Analyte	Result	RL	MDL	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
Tails Thickener Underflow (1800322-01) Other Sampled: 01/23/18 09:11 Received: 01/24/18 9:50										
% Solids	**80**			%	1	B8A3112	01/31/18	01/31/18	% calculation	
Finishers Concentrate Discharge (1800322-02) Other Sampled: 01/23/18 08:22 Received: 01/24/18 9:50										
% Solids	**87**			%	1	B8A3112	01/31/18	01/31/18	% calculation	
Concentrate Thickener Underflow (1800322-04) Other Sampled: 01/23/18 08:30 Received: 01/24/18 9:50										
% Solids	**87**			%	1	B8A3112	01/31/18	01/31/18	% calculation	
Green Balls (1800322-05) Other Sampled: 01/23/18 08:21 Received: 01/24/18 9:50										
% Solids	**91**			%	1	B8A3112	01/31/18	01/31/18	% calculation	

Barr Engineering Co.
325 South Lake Avenue, Suite 700
Duluth, MN 55802

Project: 23691845
Project Number: 23691845.00 001 001
Project Manager: Mr. James E. Taraldsen

Work Order #: 1800322
Date Reported: 01/31/18

TOTAL MERCURY ANALYSIS - Quality Control
Legend Technical Services, Inc.

Analyte	Result	RL	MDL	Units	Spike Level	Source Result	%REC	%REC Limits	%RPD	%RPD Limit	Notes
Batch B8A3004 - EPA 7473											
Blank (B8A3004-BLK1)					Prepared: 01/30/18		Analyzed: 01/31/18				
Mercury	< 0.0044	0.050	0.0044	mg/kg wet							
LCS (B8A3004-BS1)					Prepared: 01/30/18		Analyzed: 01/31/18				
Mercury	0.991	0.050	0.0044	mg/kg wet	1.00	<0.050	99.1	80-120			
LCS Dup (B8A3004-BSD1)					Prepared: 01/30/18		Analyzed: 01/31/18				
Mercury	0.986	0.050	0.0044	mg/kg wet	1.00	<0.050	98.6	80-120	0.513	20	
Matrix Spike (B8A3004-MS1)	**Source: 1800322-01**				Prepared: 01/30/18		Analyzed: 01/31/18				
Mercury	0.390	0.050	0.0044	mg/kg dry	0.362	<0.050	99.8	80-120			
Matrix Spike Dup (B8A3004-MSD1)	**Source: 1800322-01**				Prepared: 01/30/18		Analyzed: 01/31/18				
Mercury	0.344	0.050	0.0044	mg/kg dry	0.356	<0.050	88.5	80-120	12.7	20	

TOTAL METALS ANALYSIS - Quality Control
Legend Technical Services, Inc.

Analyte	Result	RL	MDL	Units	Spike Level	Source Result	%REC	%REC Limits	%RPD	%RPD Limit	Notes
Batch B8A3106 - General Prep											
Blank (B8A3106-BLK1)					Prepared & Analyzed: 01/31/18						
Mercury	0.0955	0.20	0.035	ug/L							B-02, J
LCS (B8A3106-BS1)					Prepared & Analyzed: 01/31/18						
Mercury	26.3	0.20	0.035	ug/L	25.0	<0.20	105	85-115			
LCS Dup (B8A3106-BSD1)					Prepared & Analyzed: 01/31/18						
Mercury	26.1	0.20	0.035	ug/L	25.0	<0.20	104	85-115	0.923	20	
Matrix Spike (B8A3106-MS1)	**Source: 1800322-08**				Prepared & Analyzed: 01/31/18						
Mercury	24.1	0.20	0.035	ug/L	25.0	<0.20	95.7	75-125			
Matrix Spike Dup (B8A3106-MSD1)	**Source: 1800322-08**				Prepared & Analyzed: 01/31/18						
Mercury	25.3	0.20	0.035	ug/L	25.0	<0.20	101	75-125	4.92	20	

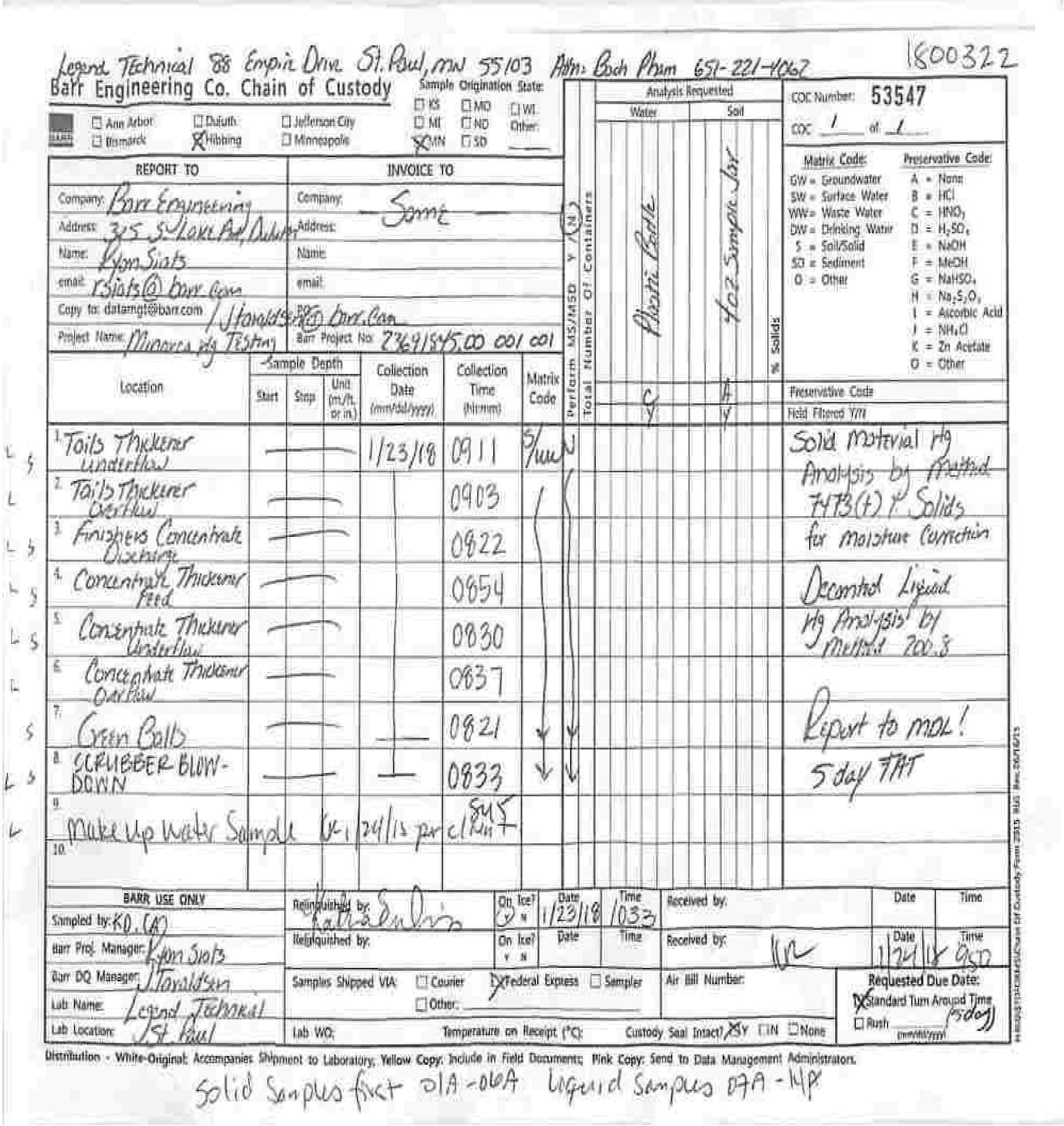
PERCENT SOLIDS - Quality Control
Legend Technical Services, Inc.

Analyte	Result	RL	MDL	Units	Spike Level	Source Result	%REC	%REC Limits	%RPD	%RPD Limit	Notes
Batch B8A3112 - General Preparation											
Duplicate (B8A3112-DUP1)	**Source: 1800322-05**			Prepared & Analyzed: 01/31/18							
% Solids	91.0			%		91.0			0.00	20	

Barr Engineering Co.	Project:	23691845			
325 South Lake Avenue, Suite 700	Project Number:	23691845.00 001 001		Work Order #:	1800322
Duluth, MN 55802	Project Manager:	Mr. James E. Taraldsen		Date Reported:	01/31/18

Notes and Definitions

J	Parameter was present between the MDL and RL and should be considered an estimated value
B-02	Target analyte was present in the method blank between the MDL and RL.
B-01	Analyte was present in the method blank. Sample result is less than or equal to 10 times the blank concentration.
<	Less than value listed
dry	Sample results reported on a dry weight basis
NA	Not applicable. The %RPD is not calculated from values less than the reporting limit.
MDL	Method Detection Limit; Equivalent to the method LOD (Limit of Detection)
RL	Reporting Limit
RPD	Relative Percent Difference
LCS	Laboratory Control Spike = Blank Spike (BS) = Laboratory Fortified Blank (LFB)
MS	Matrix Spike = Laboratory Fortified Matrix (LFM)



Legend Technical 88 Empire Drive St. Paul, MN 55103 Attn: Bach Pham 651-221-4062

1800322

Barr Engineering Co. Chain of Custody

☐ Ann Arbor ☐ Bismarck ☐ Duluth ☒ Hibbing ☐ Jefferson City ☐ Minneapolis

Sample Origination State: ☐ KS ☐ MI ☒ MN ☐ MO ☐ ND ☐ SD ☐ WI Other: ____

COC Number: **53547**

COC 1 of 1

REPORT TO	INVOICE TO
Company: Barr Engineering	Company: — Same —
Address: 325 S. Lake Ave, Duluth	Address:
Name: Ryan Siats	Name:
email: rsiats@barr.com	email:
Copy to: datamgt@barr.com / jtoraldsen@barr.com	
Project Name: Minorca Hg Testing	Barr Project No: 23691545.00 001 001

Analysis Requested: Water: Plastic Bottle; Soil: 4oz Sample Jar; % Solids

Perform MS/MSD: Y / (N)

Preservative Code: C (Plastic Bottle), A (4oz Sample Jar)

Field Filtered Y/N: Y (Plastic Bottle), Y (4oz Sample Jar)

	Location	Sample Depth Start	Sample Depth Stop	Unit (m/ft. or in.)	Collection Date (mm/dd/yyyy)	Collection Time (hh:mm)	Matrix Code	Perform MS/MSD	Total Number Of Containers
L S	1. Tails Thickener underflow	—	—		1/23/18	0911	S/WW	N	
L	2. Tails Thickener Overflow	—	—			0903			
L S	3. Finishers Concentrate Discharge	—	—			0822			
L S	4. Concentrate Thickener Feed	—	—			0854			
L S	5. Concentrate Thickener Underflow	—	—			0830			
L	6. Concentrate Thickener Overflow	—	—			0837			
S	7. Green Balls	—	—		—	0821			
L S	8. SCRUBBER BLOW-DOWN	—	—		—	0833			
L	9. Make up water Sample Rec 1/24/18 per client SMS								
	10.								

Matrix Code:
GW = Groundwater
SW = Surface Water
WW = Waste Water
DW = Drinking Water
S = Soil/Solid
SD = Sediment
O = Other

Preservative Code:
A = None
B = HCl
C = HNO_3
D = H_2SO_4
E = NaOH
F = MeOH
G = $NaHSO_4$
H = $Na_2S_2O_3$
I = Ascorbic Acid
J = NH_4Cl
K = Zn Acetate
O = Other

Solid Material Hg Analysis by Method 7473(t) & Solids for moisture correction

Decanted Liquid Hg Analysis by Method 200.8

Report to MDL!

5 day TAT

BARR USE ONLY	Relinquished by:	On Ice?	Date	Time	Received by:	Date	Time
Sampled by: KO, (A)	Katie Embrev	(Y) N	1/23/18	1033			
Barr Proj. Manager: Ryan Siats	Relinquished by:	On Ice? Y N	Date	Time	Received by:	1/24/18	950
Barr DQ Manager: J Toraldsen							
Lab Name: Legend Technical							
Lab Location: St. Paul							

Samples Shipped VIA: ☐ Courier ☒ Federal Express ☐ Sampler ☐ Other: ____

Air Bill Number:

Requested Due Date: ☒ Standard Turn Around Time (5 day) ☐ Rush ____ (mm/dd/yyyy)

Lab WO:

Temperature on Receipt (°C):

Custody Seal Intact? ☒ Y ☐ N ☐ None

Distribution - White-Original: Accompanies Shipment to Laboratory; Yellow Copy: Include in Field Documents; Pink Copy: Send to Data Management Administrator.

Solid Samples first 01A - 06A Liquid Samples 07A - 14A

The results in this report apply to the samples analyzed in accordance with the chain of custody document. This analytical report must be reproduced in its entirety.

LEGEND
Technical Services, Inc.

88 Empire Drive
St Paul, MN 55103
Tel: 651-642-1150
Fax: 651-642-1239

February 08, 2018

Mr. James E. Taraldsen
Barr Engineering Co.
325 South Lake Avenue, Suite 700
Duluth, MN 55802

Work Order Number: 1800411
RE: 23691845

Enclosed are the results of analyses for samples received by the laboratory on 01/31/18. If you have any questions concerning this report, please feel free to contact me.

Results are not blank corrected unless noted within the report. Additionally, all QC results meet requirements unless noted.

All samples will be retained by Legend Technical Services, Inc., unless consumed in the analysis, at ambient conditions for 30 days from the date of this report and then discarded unless other arrangements are made.   All samples were received in acceptable condition unless otherwise noted.

All test results and QC meet requirements of the 2003 NELAC standard.

MDH (NELAP) Accreditation #027-123-295

Prepared by,
LEGEND TECHNICAL SERVICES, INC

BACH PHAM

Bach Pham
Client Manager II
bpham@legend-group.com

Barr Engineering Co.	Project: 23691845		
325 South Lake Avenue, Suite 700	Project Number: 23691845.00 001 001	Work Order #:	1800411
Duluth, MN 55802	Project Manager: Mr. James E. Taraldsen	Date Reported:	02/08/18

ANALYTICAL REPORT FOR SAMPLES

Sample ID	Laboratory ID	Matrix	Date Sampled	Date Received
Tails Thickener Underflow	1800411-01	Other	01/30/18 09:16	01/31/18 09:40
Finishers Concentrate Discharge	1800411-02	Other	01/30/18 08:27	01/31/18 09:40
Concentrate Thickener Feed	1800411-03	Other	01/30/18 09:00	01/31/18 09:40
Concentrate Thickener Underflow	1800411-04	Other	01/30/18 08:35	01/31/18 09:40
Concentrate Thickener Overflow	1800411-05	Other	01/30/18 08:43	01/31/18 09:40
Green Balls	1800411-06	Other	01/30/18 08:30	01/31/18 09:40
Scrubber Blowdown	1800411-07	Other	01/30/18 08:40	01/31/18 09:40
Tails Thickener Underflow	1800411-08	Wastewater	01/30/18 09:16	01/31/18 09:40
Finishers Concentrate Discharge	1800411-09	Wastewater	01/30/18 08:27	01/31/18 09:40
Concentrate Thickener Feed	1800411-10	Wastewater	01/30/18 09:00	01/31/18 09:40
Concentrate Thickener Underflow	1800411-11	Wastewater	01/30/18 08:35	01/31/18 09:40
Concentrate Thickener Overflow	1800411-12	Wastewater	01/30/18 08:43	01/31/18 09:40
Scrubber Blowdown	1800411-13	Wastewater	01/30/18 08:40	01/31/18 09:40

Shipping Container Information

Default Cooler Temperature (°C): 3.2

Received on ice: Yes
Received on melt water: Yes
Custody seals: No

Temperature blank was not present
Ambient: No

Received on ice pack: No
Acceptable (IH/ISO only): No

Case Narrative:

Mercury was detected between the MDL and RL in the 200.8 batch B8B0106 method blank.

The results are reported on an 'as received' basis for samples Concentrate Thickener Feed, Concentrate Thickener Overflow, and Scrubber Blowdown due to limited sample.

LEGEND
Technical Services, Inc.

88 Empire Drive
St Paul, MN 55103
Tel: 651-642-1150
Fax: 651-642-1239

Barr Engineering Co.	Project:	23691845			
325 South Lake Avenue, Suite 700	Project Number:	23691845.00 001 001		Work Order #:	1800411
Duluth, MN 55802	Project Manager:	Mr. James E. Taraldsen		Date Reported:	02/08/18

TOTAL MERCURY ANALYSIS
Legend Technical Services, Inc.

Analyte	Result	RL	MDL	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
Tails Thickener Underflow (1800411-01) Other Sampled: 01/30/18 09:16 Received: 01/31/18 9:40										
Mercury	**0.037**	0.050	0.0044	mg/kg dry	1	B8B0611	02/06/18	02/07/18	EPA 7473	J
Finishers Concentrate Discharge (1800411-02) Other Sampled: 01/30/18 08:27 Received: 01/31/18 9:40										
Mercury	**0.015**	0.050	0.0044	mg/kg dry	1	B8B0611	02/06/18	02/07/18	EPA 7473	J
Concentrate Thickener Feed (1800411-03) Other Sampled: 01/30/18 09:00 Received: 01/31/18 9:40										
Mercury	**0.011**	0.050	0.0044	mg/kg wet	1	B8B0611	02/06/18	02/07/18	EPA 7473	J
Concentrate Thickener Underflow (1800411-04) Other Sampled: 01/30/18 08:35 Received: 01/31/18 9:40										
Mercury	**0.0074**	0.050	0.0044	mg/kg dry	1	B8B0611	02/06/18	02/07/18	EPA 7473	J
Concentrate Thickener Overflow (1800411-05) Other Sampled: 01/30/18 08:43 Received: 01/31/18 9:40										
Mercury	**0.075**	0.050	0.0044	mg/kg wet	1	B8B0611	02/06/18	02/07/18	EPA 7473	
Green Balls (1800411-06) Other Sampled: 01/30/18 08:30 Received: 01/31/18 9:40										
Mercury	<0.0044	0.050	0.0044	mg/kg dry	1	B8B0611	02/06/18	02/07/18	EPA 7473	
Scrubber Blowdown (1800411-07) Other Sampled: 01/30/18 08:40 Received: 01/31/18 9:40										
Mercury	**2.7**	0.050	0.0044	mg/kg wet	1	B8B0611	02/06/18	02/07/18	EPA 7473	

The results in this report apply to the samples analyzed in accordance with the chain of custody document. This analytical report must be reproduced in its entirety.

Barr Engineering Co.	Project: 23691845		
325 South Lake Avenue, Suite 700	Project Number: 23691845.00 001 001	Work Order #:	1800411
Duluth, MN 55802	Project Manager: Mr. James E. Taraldsen	Date Reported:	02/08/18

TOTAL METALS ANALYSIS
Legend Technical Services, Inc.

Analyte	Result	RL	MDL	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
Tails Thickener Underflow (1800411-08) Wastewater Sampled: 01/30/18 09:16 Received: 01/31/18 9:40										
Mercury	**0.21**	0.20	0.035	ug/L	1	B8B0106	02/01/18	02/06/18	EPA 200.8	B-01
Finishers Concentrate Discharge (1800411-09) Wastewater Sampled: 01/30/18 08:27 Received: 01/31/18 9:40										
Mercury	**0.11**	0.20	0.035	ug/L	1	B8B0106	02/01/18	02/06/18	EPA 200.8	B-01, J
Concentrate Thickener Feed (1800411-10) Wastewater Sampled: 01/30/18 09:00 Received: 01/31/18 9:40										
Mercury	**0.070**	0.20	0.035	ug/L	1	B8B0106	02/01/18	02/06/18	EPA 200.8	B-01, J
Concentrate Thickener Underflow (1800411-11) Wastewater Sampled: 01/30/18 08:35 Received: 01/31/18 9:40										
Mercury	**0.061**	0.20	0.035	ug/L	1	B8B0106	02/01/18	02/06/18	EPA 200.8	B-01, J
Concentrate Thickener Overflow (1800411-12) Wastewater Sampled: 01/30/18 08:43 Received: 01/31/18 9:40										
Mercury	**0.088**	0.20	0.035	ug/L	1	B8B0106	02/01/18	02/06/18	EPA 200.8	B-01, J
Scrubber Blowdown (1800411-13) Wastewater Sampled: 01/30/18 08:40 Received: 01/31/18 9:40										
Mercury	**0.053**	0.20	0.035	ug/L	1	B8B0106	02/01/18	02/06/18	EPA 200.8	B-01, J

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Barr Engineering Co.	Project:	23691845			
325 South Lake Avenue, Suite 700	Project Number:	23691845.00 001 001	Work Order #:	1800411
Duluth, MN 55802	Project Manager:	Mr. James E. Taraldsen	Date Reported:	02/08/18

PERCENT SOLIDS
Legend Technical Services, Inc.

Analyte	Result	RL	MDL	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
Tails Thickener Underflow (1800411-01) Other Sampled: 01/30/18 09:16 Received: 01/31/18 9:40										
% Solids	**76**			%	1	B8B0707	02/07/18	02/07/18	% calculation	
Finishers Concentrate Discharge (1800411-02) Other Sampled: 01/30/18 08:27 Received: 01/31/18 9:40										
% Solids	**86**			%	1	B8B0707	02/07/18	02/07/18	% calculation	
Concentrate Thickener Underflow (1800411-04) Other Sampled: 01/30/18 08:35 Received: 01/31/18 9:40										
% Solids	**87**			%	1	B8B0707	02/07/18	02/07/18	% calculation	
Green Balls (1800411-06) Other Sampled: 01/30/18 08:30 Received: 01/31/18 9:40										
% Solids	**91**			%	1	B8B0707	02/07/18	02/07/18	% calculation	

Barr Engineering Co.	Project: 23691845		
325 South Lake Avenue, Suite 700	Project Number: 23691845.00 001 001	Work Order #:	1800411
Duluth, MN 55802	Project Manager: Mr. James E. Taraldsen	Date Reported:	02/08/18

TOTAL MERCURY ANALYSIS - Quality Control
Legend Technical Services, Inc.

Analyte	Result	RL	MDL	Units	Spike Level	Source Result	%REC	%REC Limits	%RPD	%RPD Limit	Notes
Batch B8B0611 - EPA 7473											
Blank (B8B0611-BLK1)					Prepared: 02/06/18	Analyzed: 02/07/18					
Mercury	< 0.0044	0.050	0.0044	mg/kg wet							
LCS (B8B0611-BS1)					Prepared: 02/06/18	Analyzed: 02/07/18					
Mercury	0.975	0.050	0.0044	mg/kg wet	1.00	<0.050	97.5	80-120			
LCS Dup (B8B0611-BSD1)					Prepared: 02/06/18	Analyzed: 02/07/18					
Mercury	0.964	0.050	0.0044	mg/kg wet	1.00	<0.050	96.4	80-120	1.09	20	
Matrix Spike (B8B0611-MS1)	**Source: 1800411-01**				Prepared: 02/06/18	Analyzed: 02/07/18					
Mercury	0.374	0.050	0.0044	mg/kg dry	0.401	<0.050	84.1	80-120			
Matrix Spike Dup (B8B0611-MSD1)	**Source: 1800411-01**				Prepared: 02/06/18	Analyzed: 02/07/18					
Mercury	0.379	0.050	0.0044	mg/kg dry	0.361	<0.050	94.6	80-120	1.11	20	

TOTAL METALS ANALYSIS - Quality Control
Legend Technical Services, Inc.

Analyte	Result	RL	MDL	Units	Spike Level	Source Result	%REC	%REC Limits	%RPD	%RPD Limit	Notes
Batch B8B0106 - General Prep											
Blank (B8B0106-BLK1)					Prepared: 02/01/18	Analyzed: 02/06/18					
Mercury	0.0681	0.20	0.035	ug/L							B-02, J
LCS (B8B0106-BS1)					Prepared: 02/01/18	Analyzed: 02/06/18					
Mercury	25.5	0.20	0.035	ug/L	25.0	<0.20	102	85-115			
LCS Dup (B8B0106-BSD1)					Prepared: 02/01/18	Analyzed: 02/06/18					
Mercury	25.7	0.20	0.035	ug/L	25.0	<0.20	103	85-115	1.02	20	
Matrix Spike (B8B0106-MS1)	**Source: 1800411-09**				Prepared: 02/01/18	Analyzed: 02/06/18					
Mercury	25.1	0.20	0.035	ug/L	25.0	<0.20	99.9	75-125			
Matrix Spike Dup (B8B0106-MSD1)	**Source: 1800411-09**				Prepared: 02/01/18	Analyzed: 02/06/18					
Mercury	24.8	0.20	0.035	ug/L	25.0	<0.20	98.7	75-125	1.13	20	

Barr Engineering Co.	Project:	23691845			
325 South Lake Avenue, Suite 700	Project Number:	23691845.00 001 001		Work Order #:	1800411
Duluth, MN 55802	Project Manager:	Mr. James E. Taraldsen		Date Reported:	02/08/18

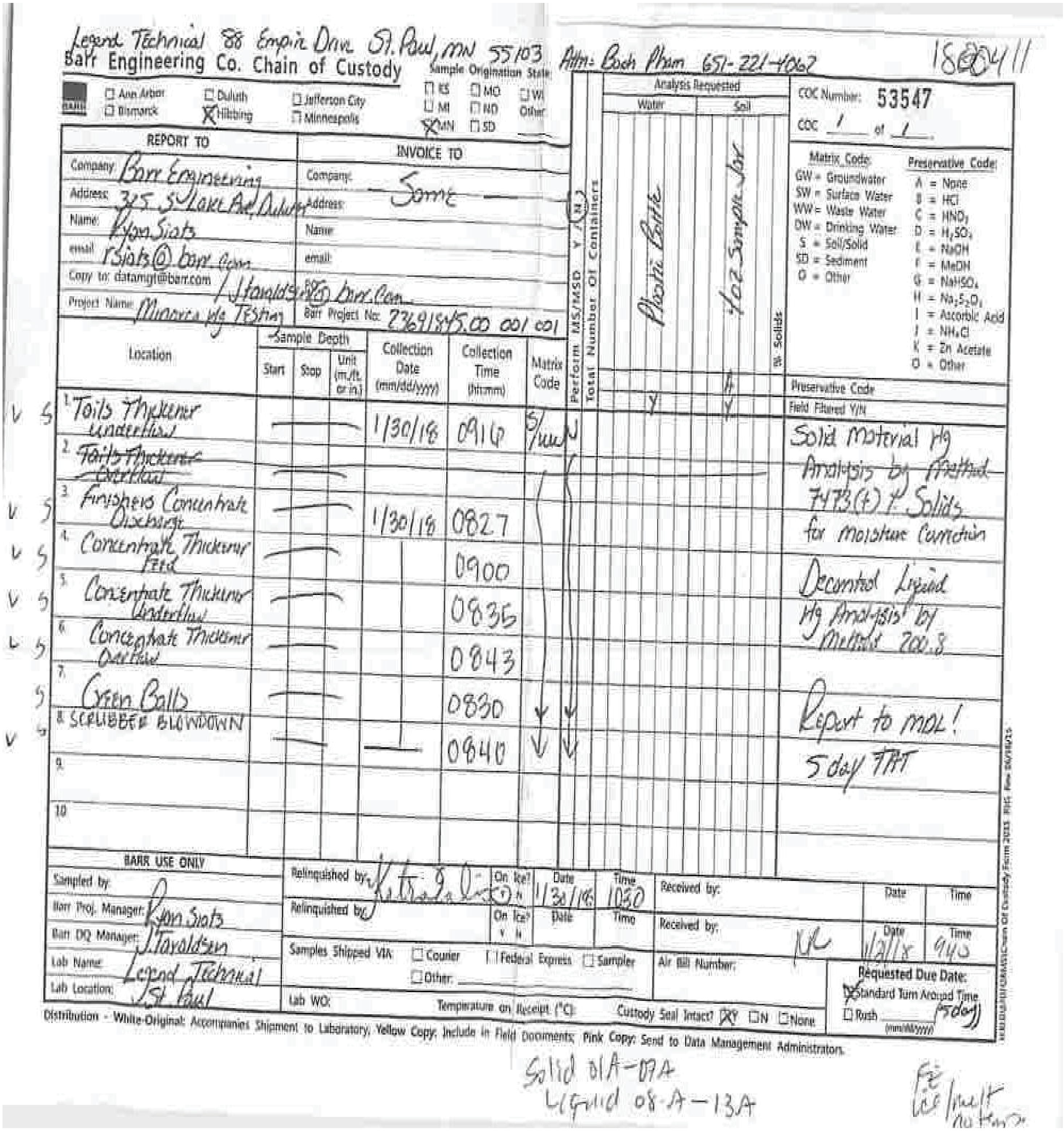
PERCENT SOLIDS - Quality Control
Legend Technical Services, Inc.

Analyte	Result	RL	MDL	Units	Spike Level	Source Result	%REC	%REC Limits	%RPD	%RPD Limit	Notes
Batch B8B0707 - General Preparation											
Duplicate (B8B0707-DUP1)	**Source: 1800459-05**			Prepared & Analyzed: 02/07/18							
% Solids	82.0			%		84.0			2.41	20	

Barr Engineering Co.	Project:	23691845			
325 South Lake Avenue, Suite 700	Project Number:	23691845.00 001 001		Work Order #:	1800411
Duluth, MN 55802	Project Manager:	Mr. James E. Taraldsen		Date Reported:	02/08/18

Notes and Definitions

J	Parameter was present between the MDL and RL and should be considered an estimated value
B-02	Target analyte was present in the method blank between the MDL and RL.
B-01	Analyte was present in the method blank. Sample result is less than or equal to 10 times the blank concentration.
<	Less than value listed
dry	Sample results reported on a dry weight basis
NA	Not applicable. The %RPD is not calculated from values less than the reporting limit.
MDL	Method Detection Limit; Equivalent to the method LOD (Limit of Detection)
RL	Reporting Limit
RPD	Relative Percent Difference
LCS	Laboratory Control Spike = Blank Spike (BS) = Laboratory Fortified Blank (LFB)
MS	Matrix Spike = Laboratory Fortified Matrix (LFM)



Legend Technical 88 Empire Drive St. Paul, MN 55103 Attn: Bach Pham 651-221-4062 180411

Barr Engineering Co. Chain of Custody

☐ Ann Arbor ☐ Bismarck ☐ Duluth ☒ Hibbing ☐ Jefferson City ☐ Minneapolis

Sample Origination State: ☐ KS ☐ MI ☒ MN ☐ MO ☐ ND ☐ SD ☐ WI Other

COC Number: 53547

COC 1 of 1

REPORT TO		INVOICE TO	
Company:	Barr Engineering	Company:	Same
Address:	325 S Lake Ave, Duluth	Address:	
Name:	Ryan Siats	Name:	
email:	rsiats@barr.com	email:	
Copy to: datamgt@barr.com	/ Jtaraldsen@barr.com		
Project Name:	Minorca Hg Testing	Barr Project No:	23691845.00 001 001

Perform MS/MSD Y / [✓ N]

Analysis Requested: Water: Plastic Bottle; Soil: 4oz Sample Jar

Preservative Code: A (4oz Sample Jar)

Field Filtered Y/N: Y (Plastic Bottle), Y (4oz Sample Jar)

		Location	Sample Depth Start	Stop	Unit (m./ft. or in.)	Collection Date (mm/dd/yyyy)	Collection Time (hh:mm)	Matrix Code	Perform MS/MSD	Total Number Of Containers
V	S	1. Tails Thickener Underflow	—	—	—	1/30/18	0916	S/WW	N	
		2. ~~Tails Thickener Overflow~~	—	—						
V	S	3. Finishers Concentrate Discharge	—	—		1/30/18	0827			
V	S	4. Concentrate Thickener Feed	—				0900			
V	S	5. Concentrate Thickener Underflow	—				0835			
V	S	6. Concentrate Thickener Overflow	—				0843			
	S	7. Green Balls	—				0830			
V	S	8. SCRUBBER BLOWDOWN	—				0840			
		9.								
		10								

Matrix Code:
GW = Groundwater
SW = Surface Water
WW = Waste Water
DW = Drinking Water
S = Soil/Solid
SD = Sediment
O = Other

Preservative Code:
A = None
B = HCl
C = HNO_3
D = H_2SO_4
E = NaOH
F = MeOH
G = $NaHSO_4$
H = $Na_2S_2O_3$
I = Ascorbic Acid
J = NH_4Cl
K = Zn Acetate
O = Other

Solid Material Hg Analysis by Method 7473(?) % Solids for moisture Correction

Decanted Liquid Hg Analysis by Method 200.8

Report to MDL!

5 day TAT

BARR USE ONLY
Sampled by:
Barr Proj. Manager: Ryan Siats
Barr DQ Manager: J Taraldsen
Lab Name: Legend Technical
Lab Location: St Paul

Relinquished by:	On Ice? [✓ Y] N	Date 1/30/18	Time 1030	Received by:		Date	Time
Relinquished by:	On Ice? Y N	Date	Time	Received by:		Date 1/31/18	Time 940

Samples Shipped VIA: ☐ Courier ☐ Federal Express ☐ Sampler ☐ Other:

Air Bill Number:

Lab WO:

Temperature on Receipt (°C):

Custody Seal Intact? ☒ Y ☐ N ☐ None

Requested Due Date: ☒ Standard Turn Around Time (5 day) ☐ Rush (mm/dd/yyyy)

Distribution - White-Original: Accompanies Shipment to Laboratory; Yellow Copy: Include in Field Documents; Pink Copy: Send to Data Management Administrators.

Solid 01A-07A
Liquid 08-A-13A

Ice melt

LEGEND
Technical Services, Inc.

88 Empire Drive
St Paul, MN 55103
Tel: 651-642-1150
Fax: 651-642-1239

February 27, 2018

Mr. James E. Taraldsen
Barr Engineering Co.
325 South Lake Avenue, Suite 700
Duluth, MN 55802

Work Order Number: 1800671
RE: 23691845

Enclosed are the results of analyses for samples received by the laboratory on 02/20/18. If you have any questions concerning this report, please feel free to contact me.

Results are not blank corrected unless noted within the report. Additionally, all QC results meet requirements unless noted.

All samples will be retained by Legend Technical Services, Inc., unless consumed in the analysis, at ambient conditions for 30 days from the date of this report and then discarded unless other arrangements are made. All samples were received in acceptable condition unless otherwise noted.

All test results and QC meet requirements of the 2003 NELAC standard.

MDH (NELAP) Accreditation #027-123-295

Prepared by,
LEGEND TECHNICAL SERVICES, INC

Bach Pham

Bach Pham
Client Manager II
bpham@legend-group.com

Barr Engineering Co.	Project: 23691845	
325 South Lake Avenue, Suite 700	Project Number: 23691845.00 001 001	Work Order #: 1800671
Duluth, MN 55802	Project Manager: Mr. James E. Taraldsen	Date Reported: 02/27/18

ANALYTICAL REPORT FOR SAMPLES

Sample ID	Laboratory ID	Matrix	Date Sampled	Date Received
Tails Thickener Underflow	1800671-01	Other	02/19/18 09:16	02/20/18 10:45
Finishers Concentrate Discharge	1800671-02	Other	02/19/18 08:27	02/20/18 10:45
Concentrate Thickener Feed	1800671-03	Other	02/19/18 08:59	02/20/18 10:45
Concentrate Thickener Underflow	1800671-04	Other	02/19/18 08:35	02/20/18 10:45
Concentrate Thickener Overflow	1800671-05	Other	02/19/18 08:44	02/20/18 10:45
Green Balls	1800671-06	Other	02/19/18 08:25	02/20/18 10:45
Scrubber Blowdown	1800671-07	Other	02/19/18 08:34	02/20/18 10:45
Tails Thickener Underflow	1800671-08	Wastewater	02/19/18 09:16	02/20/18 10:45
Finishers Concentrate Discharge	1800671-09	Wastewater	02/19/18 08:27	02/20/18 10:45
Concentrate Thickener Feed	1800671-10	Wastewater	02/19/18 08:59	02/20/18 10:45
Concentrate Thickener Underflow	1800671-11	Wastewater	02/19/18 08:35	02/20/18 10:45
Concentrate Thickener Overflow	1800671-12	Wastewater	02/19/18 08:44	02/20/18 10:45
Scrubber Blowdown	1800671-13	Wastewater	02/19/18 08:34	02/20/18 10:45

Shipping Container Information

Default Cooler Temperature (°C): 2.7

Received on ice: Yes
Received on melt water: Yes
Custody seals: No

Temperature blank was present
Ambient: No

Received on ice pack: No
Acceptable (IH/ISO only): No

Case Narrative:

The results are reported on an 'as received' basis for samples Finishers Concentrate Discharge and Concentrate Thickener Overflow due to limited sample.

Barr Engineering Co.
325 South Lake Avenue, Suite 700
Duluth, MN 55802

Project: 23691845
Project Number: 23691845.00 001 001
Project Manager: Mr. James E. Taraldsen

Work Order #: 1800671
Date Reported: 02/27/18

TOTAL MERCURY ANALYSIS
Legend Technical Services, Inc.

Analyte	Result	RL	MDL	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
Tails Thickener Underflow (1800671-01) Other Sampled: 02/19/18 09:16 Received: 02/20/18 10:45										
Mercury	**0.053**	0.050	0.0044	mg/kg dry	1	B8B2116	02/21/18	02/22/18	EPA 7473	
Finishers Concentrate Discharge (1800671-02) Other Sampled: 02/19/18 08:27 Received: 02/20/18 10:45										
Mercury	**0.050**	0.050	0.0044	mg/kg wet	1	B8B2116	02/21/18	02/22/18	EPA 7473	
Concentrate Thickener Feed (1800671-03) Other Sampled: 02/19/18 08:59 Received: 02/20/18 10:45										
Mercury	**0.044**	0.050	0.0044	mg/kg dry	1	B8B2116	02/21/18	02/22/18	EPA 7473	J
Concentrate Thickener Underflow (1800671-04) Other Sampled: 02/19/18 08:35 Received: 02/20/18 10:45										
Mercury	**0.014**	0.050	0.0044	mg/kg dry	1	B8B2116	02/21/18	02/22/18	EPA 7473	J
Concentrate Thickener Overflow (1800671-05) Other Sampled: 02/19/18 08:44 Received: 02/20/18 10:45										
Mercury	**0.035**	0.050	0.0044	mg/kg wet	1	B8B2116	02/21/18	02/22/18	EPA 7473	J
Green Balls (1800671-06) Other Sampled: 02/19/18 08:25 Received: 02/20/18 10:45										
Mercury	**0.0083**	0.050	0.0044	mg/kg dry	1	B8B2116	02/21/18	02/22/18	EPA 7473	J
Scrubber Blowdown (1800671-07) Other Sampled: 02/19/18 08:34 Received: 02/20/18 10:45										
Mercury	**0.41**	0.050	0.0044	mg/kg dry	1	B8B2116	02/21/18	02/22/18	EPA 7473	

Barr Engineering Co.	Project:	23691845		
325 South Lake Avenue, Suite 700	Project Number:	23691845.00 001 001	Work Order #:	1800671
Duluth, MN 55802	Project Manager:	Mr. James E. Taraldsen	Date Reported:	02/27/18

TOTAL METALS ANALYSIS
Legend Technical Services, Inc.

Analyte	Result	RL	MDL	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
Tails Thickener Underflow (1800671-08) Wastewater Sampled: 02/19/18 09:16 Received: 02/20/18 10:45										
Mercury	**0.30**	0.20	0.035	ug/L	1	B8B2609	02/26/18	02/26/18	EPA 200.8	
Finishers Concentrate Discharge (1800671-09) Wastewater Sampled: 02/19/18 08:27 Received: 02/20/18 10:45										
Mercury	**0.13**	0.20	0.035	ug/L	1	B8B2609	02/26/18	02/26/18	EPA 200.8	J
Concentrate Thickener Feed (1800671-10) Wastewater Sampled: 02/19/18 08:59 Received: 02/20/18 10:45										
Mercury	**0.083**	0.20	0.035	ug/L	1	B8B2609	02/26/18	02/26/18	EPA 200.8	J
Concentrate Thickener Underflow (1800671-11) Wastewater Sampled: 02/19/18 08:35 Received: 02/20/18 10:45										
Mercury	**0.061**	0.20	0.035	ug/L	1	B8B2609	02/26/18	02/26/18	EPA 200.8	J
Concentrate Thickener Overflow (1800671-12) Wastewater Sampled: 02/19/18 08:44 Received: 02/20/18 10:45										
Mercury	**0.051**	0.20	0.035	ug/L	1	B8B2609	02/26/18	02/26/18	EPA 200.8	J
Scrubber Blowdown (1800671-13) Wastewater Sampled: 02/19/18 08:34 Received: 02/20/18 10:45										
Mercury	**1.6**	0.20	0.035	ug/L	1	B8B2609	02/26/18	02/26/18	EPA 200.8	

Barr Engineering Co.	Project:	23691845	
325 South Lake Avenue, Suite 700	Project Number:	23691845.00 001 001	Work Order #: 1800671
Duluth, MN 55802	Project Manager:	Mr. James E. Taraldsen	Date Reported: 02/27/18

PERCENT SOLIDS
Legend Technical Services, Inc.

Analyte	Result	RL	MDL	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
Tails Thickener Underflow (1800671-01) Other Sampled: 02/19/18 09:16 Received: 02/20/18 10:45										
% Solids	**89**			%	1	B8B2703	02/27/18	02/27/18	% calculation	
Concentrate Thickener Feed (1800671-03) Other Sampled: 02/19/18 08:59 Received: 02/20/18 10:45										
% Solids	**89**			%	1	B8B2703	02/27/18	02/27/18	% calculation	
Concentrate Thickener Underflow (1800671-04) Other Sampled: 02/19/18 08:35 Received: 02/20/18 10:45										
% Solids	**87**			%	1	B8B2703	02/27/18	02/27/18	% calculation	
Green Balls (1800671-06) Other Sampled: 02/19/18 08:25 Received: 02/20/18 10:45										
% Solids	**91**			%	1	B8B2703	02/27/18	02/27/18	% calculation	
Scrubber Blowdown (1800671-07) Other Sampled: 02/19/18 08:34 Received: 02/20/18 10:45										
% Solids	**87**			%	1	B8B2703	02/27/18	02/27/18	% calculation	

Barr Engineering Co.	Project: 23691845		
325 South Lake Avenue, Suite 700	Project Number: 23691845.00 001 001	Work Order #:	1800671
Duluth, MN 55802	Project Manager: Mr. James E. Taraldsen	Date Reported:	02/27/18

TOTAL MERCURY ANALYSIS - Quality Control
Legend Technical Services, Inc.

Analyte	Result	RL	MDL	Units	Spike Level	Source Result	%REC	%REC Limits	%RPD	%RPD Limit	Notes
Batch B8B2116 - EPA 7473											
Blank (B8B2116-BLK1)					Prepared: 02/21/18	Analyzed: 02/22/18					
Mercury	< 0.0044	0.050	0.0044	mg/kg wet							
LCS (B8B2116-BS1)					Prepared: 02/21/18	Analyzed: 02/22/18					
Mercury	0.956	0.050	0.0044	mg/kg wet	1.00	<0.050	95.6	80-120			
LCS Dup (B8B2116-BSD1)					Prepared: 02/21/18	Analyzed: 02/22/18					
Mercury	0.941	0.050	0.0044	mg/kg wet	1.00	<0.050	94.1	80-120	1.58	20	
Matrix Spike (B8B2116-MS1)	**Source: 1800671-01**				Prepared: 02/21/18	Analyzed: 02/22/18					
Mercury	0.284	0.050	0.0044	mg/kg dry	0.235	0.0526	98.3	80-120			
Matrix Spike Dup (B8B2116-MSD1)	**Source: 1800671-01**				Prepared: 02/21/18	Analyzed: 02/22/18					
Mercury	0.269	0.050	0.0044	mg/kg dry	0.219	0.0526	98.6	80-120	5.41	20	

Barr Engineering Co.	Project: 23691845		
325 South Lake Avenue, Suite 700	Project Number: 23691845.00 001 001	Work Order #:	1800671
Duluth, MN 55802	Project Manager: Mr. James E. Taraldsen	Date Reported:	02/27/18

TOTAL METALS ANALYSIS - Quality Control
Legend Technical Services, Inc.

Analyte	Result	RL	MDL	Units	Spike Level	Source Result	%REC	%REC Limits	%RPD	%RPD Limit	Notes
Batch B8B2609 - EPA 200.8 Digestion											
Blank (B8B2609-BLK1)					Prepared & Analyzed: 02/26/18						
Mercury	< 0.035	0.20	0.035	ug/L							
LCS (B8B2609-BS1)					Prepared & Analyzed: 02/26/18						
Mercury	24.7	0.20	0.035	ug/L	25.0	<0.20	98.8	85-115			
LCS Dup (B8B2609-BSD1)					Prepared & Analyzed: 02/26/18						
Mercury	24.4	0.20	0.035	ug/L	25.0	<0.20	97.6	85-115	1.26	20	
Matrix Spike (B8B2609-MS1)	**Source: 1800671-08**				Prepared & Analyzed: 02/26/18						
Mercury	23.1	0.20	0.035	ug/L	25.0	0.299	91.2	75-125			
Matrix Spike (B8B2609-MS2)	**Source: 1800671-09**				Prepared & Analyzed: 02/26/18						
Mercury	22.9	0.20	0.035	ug/L	25.0	<0.20	91.2	75-125			

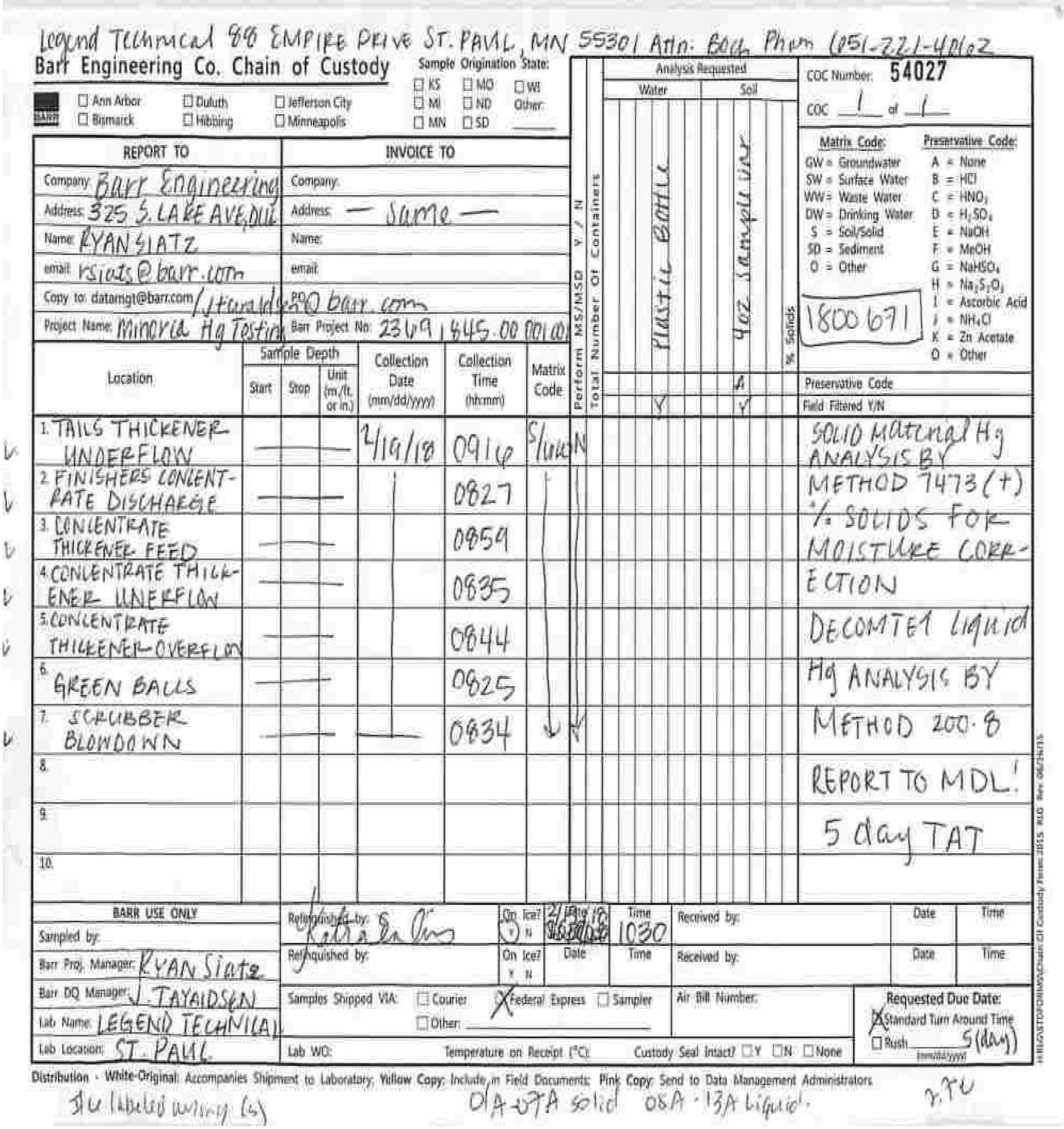
PERCENT SOLIDS - Quality Control
Legend Technical Services, Inc.

Analyte	Result	RL	MDL	Units	Spike Level	Source Result	%REC	%REC Limits	%RPD	%RPD Limit	Notes
Batch B8B2703 - General Preparation											
Duplicate (B8B2703-DUP1)	**Source: 1800671-06**			Prepared & Analyzed: 02/27/18							
% Solids	91.0			%		91.0			0.00	20	

Barr Engineering Co.	Project: 23691845		
325 South Lake Avenue, Suite 700	Project Number: 23691845.00 001 001	Work Order #:	1800671
Duluth, MN 55802	Project Manager: Mr. James E. Taraldsen	Date Reported:	02/27/18

Notes and Definitions

J	Parameter was present between the MDL and RL and should be considered an estimated value
<	Less than value listed
dry	Sample results reported on a dry weight basis
NA	Not applicable. The %RPD is not calculated from values less than the reporting limit.
MDL	Method Detection Limit; Equivalent to the method LOD (Limit of Detection)
RL	Reporting Limit
RPD	Relative Percent Difference
LCS	Laboratory Control Spike = Blank Spike (BS) = Laboratory Fortified Blank (LFB)
MS	Matrix Spike = Laboratory Fortified Matrix (LFM)



Legend Technical 88 EMPIRE DRIVE ST. PAUL, MN 55301 Attn: Bach Phone 651-221-4662

Barr Engineering Co. Chain of Custody

☐ Ann Arbor ☐ Duluth ☐ Jefferson City
☐ Bismarck ☐ Hibbing ☐ Minneapolis

Sample Origination State: ☐ KS ☐ MO ☐ WI ☐ MI ☐ ND Other: ___ ☐ MN ☐ SD

COC Number: **54027**
COC 1 of 1

REPORT TO		INVOICE TO	
Company:	Barr Engineering	Company:	
Address:	325 S. LAKE AVE, DUL	Address:	— Same —
Name:	RYAN SIATZ	Name:	
email:	rsiatz@barr.com	email:	
Copy to:	datamgt@barr.com / jtayaldsen@barr.com		
Project Name:	Minorca Hg Testing	Barr Project No:	23/69 / 845.00 001

Matrix Code:
GW = Groundwater
SW = Surface Water
WW = Waste Water
DW = Drinking Water
S = Soil/Solid
SD = Sediment
O = Other

Preservative Code:
A = None
B = HCl
C = HNO_3
D = H_2SO_4
E = NaOH
F = MeOH
G = $NaHSO_4$
H = $Na_2S_2O_3$
I = Ascorbic Acid
J = NH_4Cl
K = Zn Acetate
O = Other

1800671

Location	Sample Depth Start	Sample Depth Stop	Unit (m/ft. or in.)	Collection Date (mm/dd/yyyy)	Collection Time (hh:mm)	Matrix Code	Perform MS/MSD Y / N	Total Number Of Containers	Analysis Requested: Water: Plastic Bottle	Analysis Requested: Soil: 4oz Sample Jar	% Solids	
										A		Preservative Code
									Y	Y		Field Filtered Y/N
1. TAILS THICKENER UNDERFLOW	—	—		2/19/18	0916	S/ww	N					SOLID Material Hg ANALYSIS BY
2. FINISHERS CONCENTRATE DISCHARGE	—	—			0827							METHOD 7473 (+)
3. CONCENTRATE THICKENER FEED	—	—			0854							% SOLIDS FOR MOISTURE CORR-
4. CONCENTRATE THICKENER UNDERFLOW	—	—			0835							ECTION
5. CONCENTRATE THICKENER OVERFLOW	—	—			0844							DECOMTE1 liquid
6. GREEN BALLS	—	—			0825							Hg ANALYSIS BY
7. SCRUBBER BLOWDOWN	—	—		—	0834							METHOD 200.8
8.												REPORT TO MDL!
9.												5 day TAT
10.												

BARR USE ONLY		Relinquished by:	On Ice?	Date	Time	Received by:	Date	Time
Sampled by:		Katia Ra Oins	[✓ Y] N	2/20/18	1030			
Barr Proj. Manager:	RYAN Siatz	Relinquished by:	On Ice? Y N	Date	Time	Received by:	Date	Time
Barr DQ Manager:	J. TAYAIDSEN							
Lab Name:	LEGEND TECHNICAL							
Lab Location:	ST. PAUL							

Samples Shipped VIA: ☐ Courier ☒ Federal Express ☐ Sampler ☐ Other: ______

Air Bill Number:

Requested Due Date: ☒ Standard Turn Around Time ☐ Rush 5 (day) (mm/dd/yyyy)

Lab WO: Temperature on Receipt (°C): Custody Seal Intact? ☐ Y ☐ N ☐ None

Distribution - White-Original: Accompanies Shipment to Laboratory; Yellow Copy: Include in Field Documents; Pink Copy: Send to Data Management Administrators

HHEGISTDFORMS\Chain Of Custody Form 2015 RLG Rev 06/29/15

Jar labeled wrong (s)   01A-07A solid 08A-13A Liquid.   2.7U

LEGEND
Technical Services, Inc.

88 Empire Drive
St Paul, MN 55103
Tel: 651-642-1150
Fax: 651-642-1239

March 19, 2018

REVISION

Mr. James E. Taraldsen
Barr Engineering Co.
325 South Lake Avenue, Suite 700
Duluth, MN 55802

Work Order Number: 1800806
RE: 23691845

This is a revised report. The details of the revision are listed in the case narrative on the following page.

Enclosed are the results of analyses for samples received by the laboratory on 03/02/18. If you have any questions concerning this report, please feel free to contact me.

Results are not blank corrected unless noted within the report. Additionally, all QC results meet requirements unless noted.

All samples will be retained by Legend Technical Services, Inc., unless consumed in the analysis, at ambient conditions for 30 days from the date of this report and then discarded unless other arrangements are made. All samples were received in acceptable condition unless otherwise noted.

All test results and QC meet requirements of the 2003 NELAC standard.

MDH (NELAC) Accreditation #027-123-295

Prepared by,
LEGEND TECHNICAL SERVICES, INC

BACH PHAM

Bach Pham
Client Manager II
bpham@legend-group.com

LEGEND
Technical Services, Inc.

88 Empire Drive
St Paul, MN 55103
Tel: 651-642-1150
Fax: 651-642-1239

Barr Engineering Co.	Project:	23691845		
325 South Lake Avenue, Suite 700	Project Number:	23691845.00 001 001	Work Order #:	1800806
Duluth, MN 55802	Project Manager:	Mr. James E. Taraldsen	Date Reported:	03/19/18

ANALYTICAL REPORT FOR SAMPLES

Sample ID	Laboratory ID	Matrix	Date Sampled	Date Received
Tails Thickener Underflow	1800806-01	Soil	03/01/18 09:49	03/02/18 09:10
Finisher Concentrate Discharge	1800806-02	Soil	03/01/18 08:56	03/02/18 09:10
Concentrate Thickener Feed	1800806-03	Soil	03/01/18 09:34	03/02/18 09:10
Concentrate Thickener Underflow	1800806-04	Soil	03/01/18 09:06	03/02/18 09:10
Concentrate Thickener Overflow	1800806-05	Soil	03/01/18 09:15	03/02/18 09:10
Green Balls	1800806-06	Soil	03/01/18 08:17	03/02/18 09:10
Scrubber Blowdown	1800806-07	Soil	03/01/18 08:36	03/02/18 09:10
Tails Thickener Underflow	1800806-08	Wastewater	03/01/18 09:49	03/02/18 09:10
Finisher Concentrate Discharge	1800806-09	Wastewater	03/01/18 08:56	03/02/18 09:10
Concentrate Thickener Feed	1800806-10	Wastewater	03/01/18 09:34	03/02/18 09:10
Concentrate Thickener Underflow	1800806-11	Wastewater	03/01/18 09:06	03/02/18 09:10
Concentrate Thickener Overflow	1800806-12	Wastewater	03/01/18 09:15	03/02/18 09:10
Scrubber Blowdown	1800806-13	Wastewater	03/01/18 08:36	03/02/18 09:10

Shipping Container Information

Default Cooler Temperature (°C): 2.8

Received on ice: Yes
Received on melt water: Yes

Temperature blank was not present
Ambient: No

Received on ice pack: No
Acceptable (IH/ISO only): No

Custody seals: No

Case Narrative:

The results are reported on an 'as received' basis for sample Concentrate Thickener Overflow due to limited sample.

This report was revised on March 19, 2018 to include missing LCS data for 200.8 batch B8C0519. This report supersedes the report dated March 9, 2018.

Barr Engineering Co.
325 South Lake Avenue, Suite 700
Duluth, MN 55802

Project: 23691845
Project Number: 23691845.00 001 001
Project Manager: Mr. James E. Taraldsen

Work Order #: 1800806
Date Reported: 03/19/18

TOTAL MERCURY ANALYSIS
Legend Technical Services, Inc.

Analyte	Result	RL	MDL	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
Tails Thickener Underflow (1800806-01) Soil Sampled: 03/01/18 09:49 Received: 03/02/18 9:10										
Mercury	**0.062**	0.050	0.0044	mg/kg dry	1	B8C0508	03/05/18	03/05/18	EPA 7473	
Finisher Concentrate Discharge (1800806-02) Soil Sampled: 03/01/18 08:56 Received: 03/02/18 9:10										
Mercury	**0.023**	0.050	0.0044	mg/kg dry	1	B8C0508	03/05/18	03/05/18	EPA 7473	J
Concentrate Thickener Feed (1800806-03) Soil Sampled: 03/01/18 09:34 Received: 03/02/18 9:10										
Mercury	**0.018**	0.050	0.0044	mg/kg dry	1	B8C0508	03/05/18	03/05/18	EPA 7473	J
Concentrate Thickener Underflow (1800806-04) Soil Sampled: 03/01/18 09:06 Received: 03/02/18 9:10										
Mercury	**0.019**	0.050	0.0044	mg/kg dry	1	B8C0508	03/05/18	03/05/18	EPA 7473	J
Concentrate Thickener Overflow (1800806-05) Soil Sampled: 03/01/18 09:15 Received: 03/02/18 9:10										
Mercury	**0.046**	0.050	0.0044	mg/kg wet	1	B8C0508	03/05/18	03/05/18	EPA 7473	J
Green Balls (1800806-06) Soil Sampled: 03/01/18 08:17 Received: 03/02/18 9:10										
Mercury	**0.014**	0.050	0.0044	mg/kg dry	1	B8C0508	03/05/18	03/05/18	EPA 7473	J
Scrubber Blowdown (1800806-07) Soil Sampled: 03/01/18 08:36 Received: 03/02/18 9:10										
Mercury	**1.2**	0.050	0.0044	mg/kg dry	1	B8C0508	03/05/18	03/05/18	EPA 7473	

Barr Engineering Co.	Project:	23691845			
325 South Lake Avenue, Suite 700	Project Number:	23691845.00 001 001		Work Order #:	1800806
Duluth, MN 55802	Project Manager:	Mr. James E. Taraldsen		Date Reported:	03/19/18

TOTAL METALS ANALYSIS
Legend Technical Services, Inc.

Analyte	Result	RL	MDL	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
Tails Thickener Underflow (1800806-08) Wastewater Sampled: 03/01/18 09:49 Received: 03/02/18 9:10										
Mercury	**0.067**	0.20	0.035	ug/L	1	B8C0519	03/05/18	03/06/18	EPA 200.8	J
Finisher Concentrate Discharge (1800806-09) Wastewater Sampled: 03/01/18 08:56 Received: 03/02/18 9:10										
Mercury	**0.055**	0.20	0.035	ug/L	1	B8C0519	03/05/18	03/06/18	EPA 200.8	J
Concentrate Thickener Feed (1800806-10) Wastewater Sampled: 03/01/18 09:34 Received: 03/02/18 9:10										
Mercury	**0.036**	0.20	0.035	ug/L	1	B8C0519	03/05/18	03/06/18	EPA 200.8	J
Concentrate Thickener Underflow (1800806-11) Wastewater Sampled: 03/01/18 09:06 Received: 03/02/18 9:10										
Mercury	**0.045**	0.20	0.035	ug/L	1	B8C0519	03/05/18	03/06/18	EPA 200.8	J
Concentrate Thickener Overflow (1800806-12) Wastewater Sampled: 03/01/18 09:15 Received: 03/02/18 9:10										
Mercury	<0.035	0.20	0.035	ug/L	1	B8C0519	03/05/18	03/06/18	EPA 200.8	
Scrubber Blowdown (1800806-13) Wastewater Sampled: 03/01/18 08:36 Received: 03/02/18 9:10										
Mercury	**0.083**	0.20	0.035	ug/L	1	B8C0519	03/05/18	03/06/18	EPA 200.8	J

Barr Engineering Co.	Project: 23691845		
325 South Lake Avenue, Suite 700	Project Number: 23691845.00 001 001	Work Order #:	1800806
Duluth, MN 55802	Project Manager: Mr. James E. Taraldsen	Date Reported:	03/19/18

PERCENT SOLIDS
Legend Technical Services, Inc.

Analyte	Result	RL	MDL	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
Tails Thickener Underflow (1800806-01) Soil Sampled: 03/01/18 09:49 Received: 03/02/18 9:10										
% Solids	**78**			%	1	B8C0907	03/09/18	03/09/18	% calculation	
Finisher Concentrate Discharge (1800806-02) Soil Sampled: 03/01/18 08:56 Received: 03/02/18 9:10										
% Solids	**84**			%	1	B8C0907	03/09/18	03/09/18	% calculation	
Concentrate Thickener Feed (1800806-03) Soil Sampled: 03/01/18 09:34 Received: 03/02/18 9:10										
% Solids	**82**			%	1	B8C0907	03/09/18	03/09/18	% calculation	
Concentrate Thickener Underflow (1800806-04) Soil Sampled: 03/01/18 09:06 Received: 03/02/18 9:10										
% Solids	**85**			%	1	B8C0907	03/09/18	03/09/18	% calculation	
Green Balls (1800806-06) Soil Sampled: 03/01/18 08:17 Received: 03/02/18 9:10										
% Solids	**84**			%	1	B8C0907	03/09/18	03/09/18	% calculation	
Scrubber Blowdown (1800806-07) Soil Sampled: 03/01/18 08:36 Received: 03/02/18 9:10										
% Solids	**81**			%	1	B8C0907	03/09/18	03/09/18	% calculation	

88 Empire Drive
St Paul, MN 55103
Tel: 651-642-1150
Fax: 651-642-1239

Barr Engineering Co.	Project:	23691845		
325 South Lake Avenue, Suite 700	Project Number:	23691845.00 001 001	Work Order #:	1800806
Duluth, MN 55802	Project Manager:	Mr. James E. Taraldsen	Date Reported:	03/19/18

TOTAL MERCURY ANALYSIS - Quality Control
Legend Technical Services, Inc.

Analyte	Result	RL	MDL	Units	Spike Level	Source Result	%REC	%REC Limits	%RPD	%RPD Limit	Notes
Batch B8C0508 - EPA 7473											
Blank (B8C0508-BLK1)					Prepared & Analyzed: 03/05/18						
Mercury	< 0.0044	0.050	0.0044	mg/kg wet							
LCS (B8C0508-BS1)					Prepared & Analyzed: 03/05/18						
Mercury	0.910	0.050	0.0044	mg/kg wet	1.00	<0.050	91.0	80-120			
LCS Dup (B8C0508-BSD1)					Prepared & Analyzed: 03/05/18						
Mercury	0.976	0.050	0.0044	mg/kg wet	1.00	<0.050	97.6	80-120	7.03	20	
Matrix Spike (B8C0508-MS1)		**Source: 1800806-01**			Prepared & Analyzed: 03/05/18						
Mercury	0.419	0.050	0.0044	mg/kg dry	0.407	0.0623	87.5	80-120			
Matrix Spike Dup (B8C0508-MSD1)		**Source: 1800806-01**			Prepared & Analyzed: 03/05/18						
Mercury	0.353	0.050	0.0044	mg/kg dry	0.328	0.0623	88.6	80-120	17.1	20	

Barr Engineering Co.
325 South Lake Avenue, Suite 700
Duluth, MN 55802

Project: 23691845
Project Number: 23691845.00 001 001
Project Manager: Mr. James E. Taraldsen

Work Order #: 1800806
Date Reported: 03/19/18

TOTAL METALS ANALYSIS - Quality Control
Legend Technical Services, Inc.

Analyte	Result	RL	MDL	Units	Spike Level	Source Result	%REC	%REC Limits	%RPD	%RPD Limit	Notes
Batch B8C0519 - EPA 200.8 Digestion											
Blank (B8C0519-BLK1)					Prepared: 03/05/18 Analyzed: 03/06/18						
Mercury	< 0.035	0.20	0.035	ug/L							
LCS (B8C0519-BS1)					Prepared: 03/05/18 Analyzed: 03/06/18						
Mercury	25.9	0.20	0.035	ug/L	25.0	<0.20	104	85-115			
LCS Dup (B8C0519-BSD1)					Prepared: 03/05/18 Analyzed: 03/06/18						
Mercury	25.1	0.20	0.035	ug/L	25.0	<0.20	100	85-115	3.01	20	
Matrix Spike (B8C0519-MS1)		**Source: 1800779-01**			Prepared: 03/05/18 Analyzed: 03/06/18						
Mercury	23.7	0.20	0.035	ug/L	25.0	<0.20	94.2	75-125			
Matrix Spike Dup (B8C0519-MSD1)		**Source: 1800779-01**			Prepared: 03/05/18 Analyzed: 03/06/18						
Mercury	23.6	0.20	0.035	ug/L	25.0	<0.20	93.8	75-125	0.462	20	

Barr Engineering Co.	Project: 23691845		
325 South Lake Avenue, Suite 700	Project Number: 23691845.00 001 001	Work Order #:	1800806
Duluth, MN 55802	Project Manager: Mr. James E. Taraldsen	Date Reported:	03/19/18

PERCENT SOLIDS - Quality Control
Legend Technical Services, Inc.

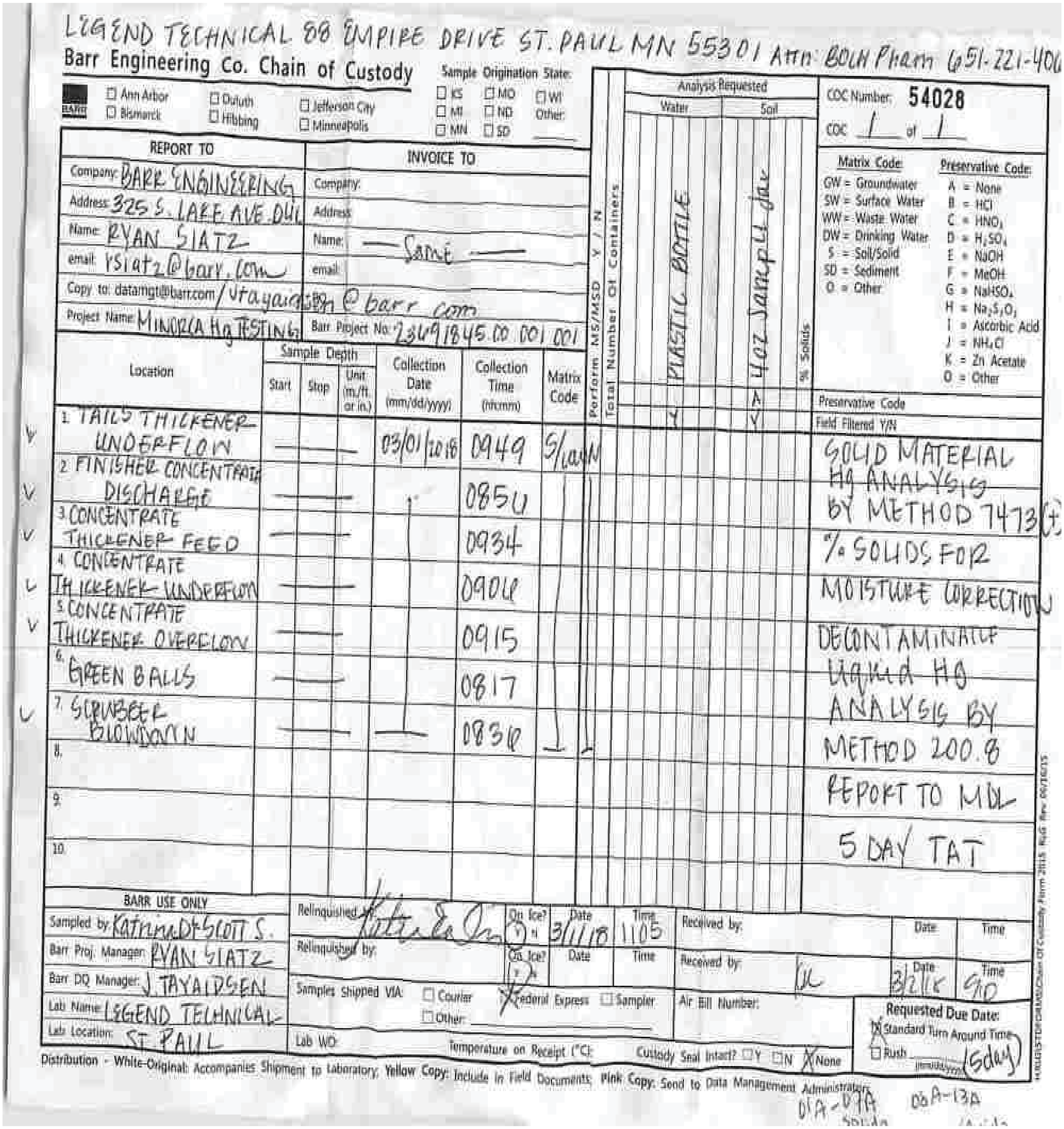
Analyte	Result	RL	MDL	Units	Spike Level	Source Result	%REC	%REC Limits	%RPD	%RPD Limit	Notes
Batch B8C0907 - General Preparation											
Duplicate (B8C0907-DUP1)	**Source: 1800806-06**			Prepared & Analyzed: 03/09/18							
% Solids	86.0			%		84.0			2.35	20	

The results in this report apply to the samples analyzed in accordance with the chain of custody document. This analytical report must be reproduced in its entirety.

Barr Engineering Co.	Project:	23691845			
325 South Lake Avenue, Suite 700	Project Number:	23691845.00 001 001		Work Order #:	1800806
Duluth, MN 55802	Project Manager:	Mr. James E. Taraldsen		Date Reported:	03/19/18

Notes and Definitions

J	Parameter was present between the MDL and RL and should be considered an estimated value
<	Less than value listed
dry	Sample results reported on a dry weight basis
NA	Not applicable. The %RPD is not calculated from values less than the reporting limit.
MDL	Method Detection Limit; Equivalent to the method LOD (Limit of Detection)
RL	Reporting Limit
RPD	Relative Percent Difference
LCS	Laboratory Control Spike = Blank Spike (BS) = Laboratory Fortified Blank (LFB)
MS	Matrix Spike = Laboratory Fortified Matrix (LFM)



LEGEND TECHNICAL 88 EMPIRE DRIVE ST. PAUL MN 55301 ATTN: BOUA Pharm 651-221-400

Barr Engineering Co. Chain of Custody

☐ Ann Arbor ☐ Bismarck ☐ Duluth ☐ Hibbing ☐ Jefferson City ☐ Minneapolis

Sample Origination State: ☐ KS ☐ MI ☐ MN ☐ MO ☐ ND ☐ SD ☐ WI Other: ____

COC Number: **54028**
COC 1 of 1

REPORT TO	INVOICE TO
Company: BARR ENGINEERING	Company:
Address: 325 S. LAKE AVE. DUL	Address:
Name: RYAN SIATZ	Name: — Same —
email: rsiatz@barr.com	email:
Copy to: datamgt@barr.com / Jtayaidsen@barr.com	
Project Name: MINORCA Hg TESTING	Barr Project No: 23691845.00 001 001

Analysis Requested: Water: PLASTIC BOTTLE — Soil: 4oz Sample jar — % Solids

Location	Sample Depth Start	Sample Depth Stop	Unit (m./ft. or in.)	Collection Date (mm/dd/yyyy)	Collection Time (hh:mm)	Matrix Code	Perform MS/MSD Y/N	Total Number Of Containers	PLASTIC BOTTLE	4oz Sample jar	% Solids
Preservative Code										A	
Field Filtered Y/N									Y	Y	
1. TAILS THICKENER UNDERFLOW	—	—		03/01/2018	0949	S/Law	N				
2. FINISHER CONCENTRATE DISCHARGE	—	—			0850						
3. CONCENTRATE THICKENER FEED	—	—			0934						
4. CONCENTRATE THICKENER UNDERFLOW	—	—			0906						
5. CONCENTRATE THICKENER OVERFLOW	—	—			0915						
6. GREEN BALLS	—	—			0817						
7. SCRUBBER BLOWDOWN	—	—			0836						
8.											
9.											
10.											

Matrix Code:
GW = Groundwater
SW = Surface Water
WW = Waste Water
DW = Drinking Water
S = Soil/Solid
SD = Sediment
O = Other

Preservative Code:
A = None
B = HCl
C = HNO_3
D = H_2SO_4
E = NaOH
F = MeOH
G = $NaHSO_4$
H = $Na_2S_2O_3$
I = Ascorbic Acid
J = NH_4Cl
K = Zn Acetate
O = Other

SOLID MATERIAL Hg ANALYSIS BY METHOD 7473(+)
% SOLIDS FOR MOISTURE CORRECTION
DECONTAMINATE liquid HG ANALYSIS BY METHOD 200.8
REPORT TO MDL
5 DAY TAT

BARR USE ONLY
Sampled by: Katrina D. & SCOTT S.
Barr Proj. Manager: RYAN SIATZ
Barr DQ Manager: J. TAYAIDSEN
Lab Name: LEGEND TECHNICAL
Lab Location: ST PAUL

Relinquished by:	On Ice?	Date	Time	Received by:	Date	Time
	Y	3/1/18	1105			
Relinquished by:	On Ice? Y	Date	Time	Received by:	3/2/18	910

Samples Shipped VIA: ☐ Courier ☒ Federal Express ☐ Sampler ☐ Other: ____
Air Bill Number:
Lab WO:
Temperature on Receipt (°C):
Custody Seal Intact? ☐ Y ☐ N ☒ None

Requested Due Date:
☒ Standard Turn Around Time (5day)
☐ Rush ____ (mm/dd/yyyy)

Distribution - White-Original: Accompanies Shipment to Laboratory; Yellow Copy: Include in Field Documents; Pink Copy: Send to Data Management Administrator

01A-07A
08A-13A

LEGEND
Technical Services, Inc.

88 Empire Drive
St Paul, MN 55103
Tel: 651-642-1150
Fax: 651-642-1239

March 14, 2018

Mr. James E. Taraldsen
Barr Engineering Co.
325 South Lake Avenue, Suite 700
Duluth, MN 55802

Work Order Number: 1800870
RE: 23691845

Enclosed are the results of analyses for samples received by the laboratory on 03/07/18. If you have any questions concerning this report, please feel free to contact me.

Results are not blank corrected unless noted within the report. Additionally, all QC results meet requirements unless noted.

All samples will be retained by Legend Technical Services, Inc., unless consumed in the analysis, at ambient conditions for 30 days from the date of this report and then discarded unless other arrangements are made.   All samples were received in acceptable condition unless otherwise noted.

All test results and QC meet requirements of the 2003 NELAC standard.

MDH (NELAP) Accreditation #027-123-295

Prepared by,
LEGEND TECHNICAL SERVICES, INC

Bach Pham

Bach Pham
Client Manager II
bpham@legend-group.com

Barr Engineering Co.	Project: 23691845		
325 South Lake Avenue, Suite 700	Project Number: 23691845.00 100 001	Work Order #:	1800870
Duluth, MN 55802	Project Manager: Mr. James E. Taraldsen	Date Reported:	03/14/18

ANALYTICAL REPORT FOR SAMPLES

Sample ID	Laboratory ID	Matrix	Date Sampled	Date Received
Tails Thickener Underflow	1800870-01	Other	03/06/18 09:14	03/07/18 16:25
Finishers Concentrate Discharge	1800870-02	Other	03/06/18 08:19	03/07/18 16:25
Concentrate Thickener Feed	1800870-03	Other	03/06/18 08:53	03/07/18 16:25
Concentrate Thickener Underflow	1800870-04	Other	03/06/18 08:28	03/07/18 16:25
Concentrate Thickener Overflow	1800870-05	Other	03/06/18 08:36	03/07/18 16:25
Green Balls	1800870-06	Other	03/06/18 08:16	03/07/18 16:25
Scrubber Blowdown	1800870-07	Other	03/06/18 08:25	03/07/18 16:25
Tails Thickener Underflow	1800870-08	Wastewater	03/06/18 09:14	03/07/18 16:25
Finishers Concentrate Discharge	1800870-09	Wastewater	03/06/18 08:19	03/07/18 16:25
Concentrate Thickener Feed	1800870-10	Wastewater	03/06/18 08:53	03/07/18 16:25
Concentrate Thickener Underflow	1800870-11	Wastewater	03/06/18 08:28	03/07/18 16:25
Concentrate Thickener Overflow	1800870-12	Wastewater	03/06/18 08:36	03/07/18 16:25
Scrubber Blowdown	1800870-13	Wastewater	03/06/18 08:25	03/07/18 16:25

Shipping Container Information

Default Cooler Temperature (°C): 1.2

Received on ice: Yes
Received on melt water: Yes
Custody seals: No

Temperature blank was not present
Ambient: No

Received on ice pack: No
Acceptable (IH/ISO only): No

Case Narrative:

The results in this report apply to the samples analyzed in accordance with the chain of custody document. This analytical report must be reproduced in its entirety.

Barr Engineering Co.
325 South Lake Avenue, Suite 700
Duluth, MN 55802

Project: 23691845
Project Number: 23691845.00 100 001
Project Manager: Mr. James E. Taraldsen

Work Order #: 1800870
Date Reported: 03/14/18

TOTAL MERCURY ANALYSIS
Legend Technical Services, Inc.

Analyte	Result	RL	MDL	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
Tails Thickener Underflow (1800870-01) Other Sampled: 03/06/18 09:14 Received: 03/07/18 16:25										
Mercury	**0.058**	0.050	0.0044	mg/kg dry	1	B8C0803	03/08/18	03/08/18	EPA 7473	
Finishers Concentrate Discharge (1800870-02) Other Sampled: 03/06/18 08:19 Received: 03/07/18 16:25										
Mercury	**0.013**	0.050	0.0044	mg/kg dry	1	B8C0803	03/08/18	03/08/18	EPA 7473	J
Concentrate Thickener Feed (1800870-03) Other Sampled: 03/06/18 08:53 Received: 03/07/18 16:25										
Mercury	**0.011**	0.050	0.0044	mg/kg dry	1	B8C0803	03/08/18	03/08/18	EPA 7473	J
Concentrate Thickener Underflow (1800870-04) Other Sampled: 03/06/18 08:28 Received: 03/07/18 16:25										
Mercury	**0.012**	0.050	0.0044	mg/kg dry	1	B8C0803	03/08/18	03/08/18	EPA 7473	J
Concentrate Thickener Overflow (1800870-05) Other Sampled: 03/06/18 08:36 Received: 03/07/18 16:25										
Mercury	**0.0097**	0.050	0.0044	mg/kg dry	1	B8C0803	03/08/18	03/08/18	EPA 7473	J
Green Balls (1800870-06) Other Sampled: 03/06/18 08:16 Received: 03/07/18 16:25										
Mercury	**0.010**	0.050	0.0044	mg/kg dry	1	B8C0803	03/08/18	03/08/18	EPA 7473	J
Scrubber Blowdown (1800870-07) Other Sampled: 03/06/18 08:25 Received: 03/07/18 16:25										
Mercury	**0.92**	0.050	0.0044	mg/kg dry	1	B8C0803	03/08/18	03/08/18	EPA 7473	

Barr Engineering Co.	Project: 23691845		
325 South Lake Avenue, Suite 700	Project Number: 23691845.00 100 001	Work Order #:	1800870
Duluth, MN 55802	Project Manager: Mr. James E. Taraldsen	Date Reported:	03/14/18

TOTAL METALS ANALYSIS
Legend Technical Services, Inc.

Analyte	Result	RL	MDL	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
Tails Thickener Underflow (1800870-08) Wastewater Sampled: 03/06/18 09:14 Received: 03/07/18 16:25										
Mercury	**0.17**	0.20	0.035	ug/L	1	B8C0909	03/09/18	03/09/18	EPA 200.8	J
Finishers Concentrate Discharge (1800870-09) Wastewater Sampled: 03/06/18 08:19 Received: 03/07/18 16:25										
Mercury	**0.11**	0.20	0.035	ug/L	1	B8C0909	03/09/18	03/09/18	EPA 200.8	J
Concentrate Thickener Feed (1800870-10) Wastewater Sampled: 03/06/18 08:53 Received: 03/07/18 16:25										
Mercury	**0.082**	0.20	0.035	ug/L	1	B8C0909	03/09/18	03/09/18	EPA 200.8	J
Concentrate Thickener Underflow (1800870-11) Wastewater Sampled: 03/06/18 08:28 Received: 03/07/18 16:25										
Mercury	**0.058**	0.20	0.035	ug/L	1	B8C0909	03/09/18	03/09/18	EPA 200.8	J
Concentrate Thickener Overflow (1800870-12) Wastewater Sampled: 03/06/18 08:36 Received: 03/07/18 16:25										
Mercury	**0.089**	0.20	0.035	ug/L	1	B8C0909	03/09/18	03/09/18	EPA 200.8	J
Scrubber Blowdown (1800870-13) Wastewater Sampled: 03/06/18 08:25 Received: 03/07/18 16:25										
Mercury	**1.7**	0.20	0.035	ug/L	1	B8C0909	03/09/18	03/09/18	EPA 200.8	

Barr Engineering Co.	Project: 23691845		
325 South Lake Avenue, Suite 700	Project Number: 23691845.00 100 001	Work Order #:	1800870
Duluth, MN 55802	Project Manager: Mr. James E. Taraldsen	Date Reported:	03/14/18

PERCENT SOLIDS
Legend Technical Services, Inc.

Analyte	Result	RL	MDL	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
Tails Thickener Underflow (1800870-01) Other Sampled: 03/06/18 09:14 Received: 03/07/18 16:25										
% Solids	**77**			%	1	B8C1409	03/14/18	03/14/18	% calculation	
Finishers Concentrate Discharge (1800870-02) Other Sampled: 03/06/18 08:19 Received: 03/07/18 16:25										
% Solids	**88**			%	1	B8C1409	03/14/18	03/14/18	% calculation	
Concentrate Thickener Feed (1800870-03) Other Sampled: 03/06/18 08:53 Received: 03/07/18 16:25										
% Solids	**87**			%	1	B8C1409	03/14/18	03/14/18	% calculation	
Concentrate Thickener Underflow (1800870-04) Other Sampled: 03/06/18 08:28 Received: 03/07/18 16:25										
% Solids	**87**			%	1	B8C1409	03/14/18	03/14/18	% calculation	
Concentrate Thickener Overflow (1800870-05) Other Sampled: 03/06/18 08:36 Received: 03/07/18 16:25										
% Solids	**80**			%	1	B8C1409	03/14/18	03/14/18	% calculation	
Green Balls (1800870-06) Other Sampled: 03/06/18 08:16 Received: 03/07/18 16:25										
% Solids	**91**			%	1	B8C1409	03/14/18	03/14/18	% calculation	
Scrubber Blowdown (1800870-07) Other Sampled: 03/06/18 08:25 Received: 03/07/18 16:25										
% Solids	**94**			%	1	B8C1409	03/14/18	03/14/18	% calculation	

TOTAL MERCURY ANALYSIS - Quality Control
Legend Technical Services, Inc.

Analyte	Result	RL	MDL	Units	Spike Level	Source Result	%REC	%REC Limits	%RPD	%RPD Limit	Notes
Batch B8C0803 - EPA 7473											
Blank (B8C0803-BLK1)					Prepared & Analyzed: 03/08/18						
Mercury	< 0.0044	0.050	0.0044	mg/kg wet							
LCS (B8C0803-BS1)					Prepared & Analyzed: 03/08/18						
Mercury	0.920	0.050	0.0044	mg/kg wet	1.00	<0.050	92.0	80-120			
LCS Dup (B8C0803-BSD1)					Prepared & Analyzed: 03/08/18						
Mercury	0.958	0.050	0.0044	mg/kg wet	1.00	<0.050	95.8	80-120	4.04	20	
Matrix Spike (B8C0803-MS1)	**Source: 1800870-01**				Prepared & Analyzed: 03/08/18						
Mercury	0.339	0.050	0.0044	mg/kg dry	0.269	0.0578	104	80-120			
Matrix Spike Dup (B8C0803-MSD1)	**Source: 1800870-01**				Prepared & Analyzed: 03/08/18						
Mercury	0.290	0.050	0.0044	mg/kg dry	0.288	0.0578	80.7	80-120	15.4	20	

TOTAL METALS ANALYSIS - Quality Control
Legend Technical Services, Inc.

Analyte	Result	RL	MDL	Units	Spike Level	Source Result	%REC	%REC Limits	%RPD	%RPD Limit	Notes
Batch B8C0909 - EPA 200.8 Digestion											
Blank (B8C0909-BLK1)					Prepared & Analyzed: 03/09/18						
Mercury	< 0.035	0.20	0.035	ug/L							
LCS (B8C0909-BS1)					Prepared & Analyzed: 03/09/18						
Mercury	26.0	0.20	0.035	ug/L	25.0	<0.20	104	85-115			
LCS Dup (B8C0909-BSD1)					Prepared & Analyzed: 03/09/18						
Mercury	26.7	0.20	0.035	ug/L	25.0	<0.20	107	85-115	2.66	20	
Matrix Spike (B8C0909-MS1)	**Source: 1800870-13**				Prepared & Analyzed: 03/09/18						
Mercury	26.4	0.20	0.035	ug/L	25.0	1.71	99.0	75-125			
Matrix Spike (B8C0909-MS2)	**Source: 1800870-09**				Prepared & Analyzed: 03/09/18						
Mercury	25.5	0.20	0.035	ug/L	25.0	<0.20	102	75-125			

Barr Engineering Co.	Project: 23691845	
325 South Lake Avenue, Suite 700	Project Number: 23691845.00 100 001	Work Order #: 1800870
Duluth, MN 55802	Project Manager: Mr. James E. Taraldsen	Date Reported: 03/14/18

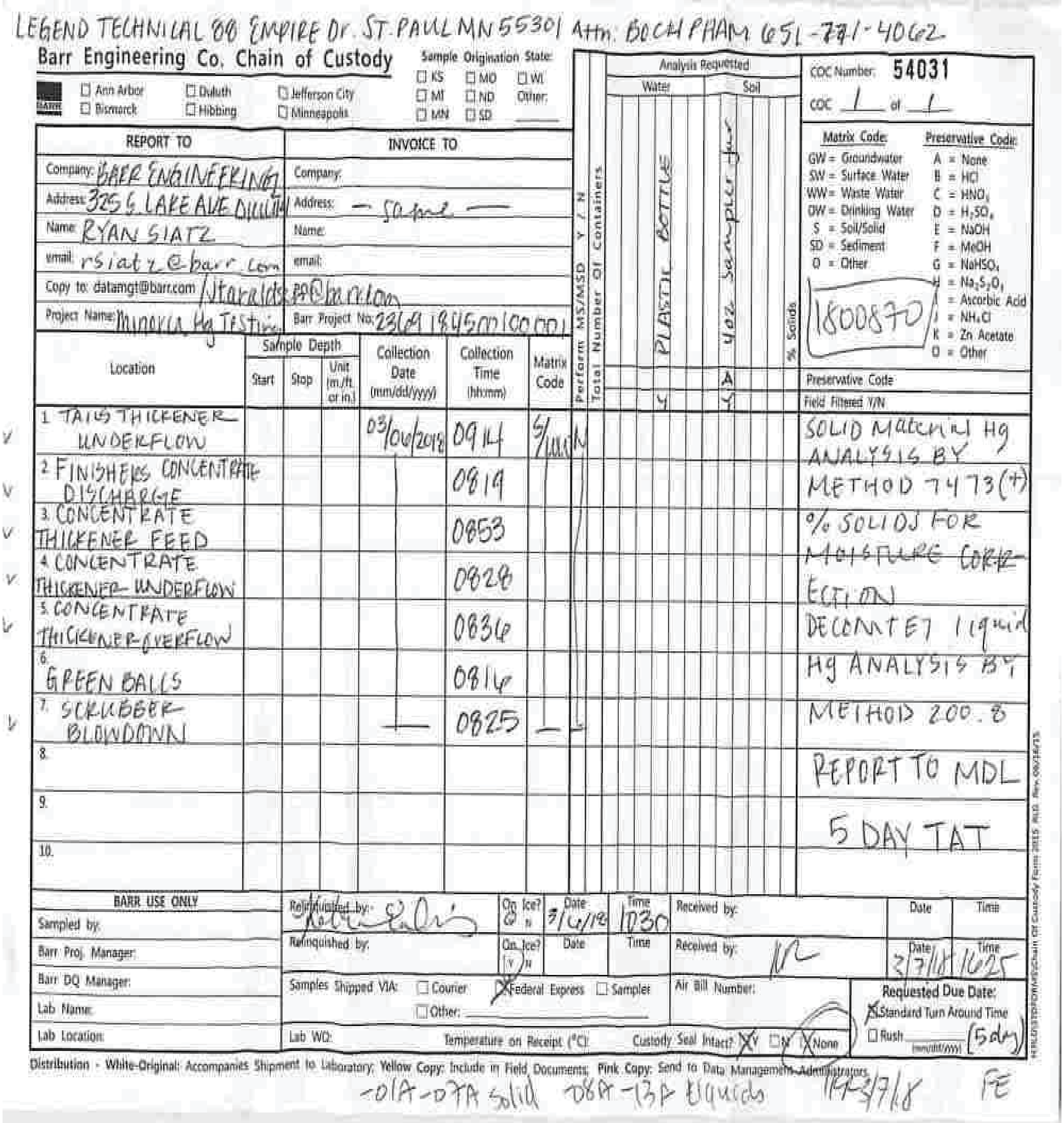
PERCENT SOLIDS - Quality Control
Legend Technical Services, Inc.

Analyte	Result	RL	MDL	Units	Spike Level	Source Result	%REC	%REC Limits	%RPD	%RPD Limit	Notes
Batch B8C1409 - General Preparation											
Duplicate (B8C1409-DUP1)	**Source: 1800948-06**			Prepared & Analyzed: 03/14/18							
% Solids	85.0			%		86.0			1.17	20	

The results in this report apply to the samples analyzed in accordance with the chain of custody document. This analytical report must be reproduced in its entirety.

Notes and Definitions

J	Parameter was present between the MDL and RL and should be considered an estimated value
<	Less than value listed
dry	Sample results reported on a dry weight basis
NA	Not applicable. The %RPD is not calculated from values less than the reporting limit.
MDL	Method Detection Limit; Equivalent to the method LOD (Limit of Detection)
RL	Reporting Limit
RPD	Relative Percent Difference
LCS	Laboratory Control Spike = Blank Spike (BS) = Laboratory Fortified Blank (LFB)
MS	Matrix Spike = Laboratory Fortified Matrix (LFM)



LEGEND TECHNICAL 88 EMPIRE Dr. ST. PAUL MN 55301 Attn: BOCH PHAM 651-771-4062

Barr Engineering Co. Chain of Custody

☐ Ann Arbor ☐ Bismarck ☐ Duluth ☐ Hibbing ☐ Jefferson City ☐ Minneapolis

Sample Origination State: ☐ KS ☐ MI ☐ MN ☐ MO ☐ ND ☐ SD ☐ WI Other: ____

COC Number: 54031
COC 1 of 1

REPORT TO	INVOICE TO
Company: BARR ENGINEERING	Company:
Address: 325 S. LAKE AVE DULUTH	Address: — same —
Name: RYAN SIATZ	Name:
email: rsiatz@barr.com	email:
Copy to: datamgt@barr.com / Jtaraldsen@barr.com	
Project Name: Minorca Hg Testing	Barr Project No: 23/69 1845001 0000

Matrix Code:
GW = Groundwater
SW = Surface Water
WW = Waste Water
DW = Drinking Water
S = Soil/Solid
SD = Sediment
O = Other

Preservative Code:
A = None
B = HCl
C = HNO_3
D = H_2SO_4
E = NaOH
F = MeOH
G = $NaHSO_4$
H = $Na_2S_2O_3$
I = Ascorbic Acid
J = NH_4Cl
K = Zn Acetate
O = Other

1800870

Analysis Requested: Water / Soil — PLASTIC BOTTLE; 4oz sampler jar; % Solids
Preservative Code: A (4oz sampler jar)
Field Filtered Y/N: Y (PLASTIC BOTTLE); Y (4oz sampler jar)

	Location	Sample Depth Start	Stop	Unit (m/ft or in)	Collection Date (mm/dd/yyyy)	Collection Time (hh:mm)	Matrix Code	Perform MS/MSD Y / N	Total Number Of Containers
✓	1 TAILS THICKENER UNDERFLOW				03/06/2018	0914	S/WW	N	
✓	2 FINISHERS CONCENTRATE DISCHARGE					0819			
✓	3 CONCENTRATE THICKENER FEED					0853			
✓	4 CONCENTRATE THICKENER UNDERFLOW					0828			
✓	5 CONCENTRATE THICKENER OVERFLOW					0836			
	6 GREEN BALLS					0816			
✓	7 SCRUBBER BLOWDOWN					0825			
	8.								
	9.								
	10.								

SOLID MATERIAL Hg ANALYSIS BY METHOD 7473(+)
% SOLIDS FOR MOISTURE CORRECTION
DECANTED liquid Hg ANALYSIS BY METHOD 200.8
REPORT TO MDL
5 DAY TAT

BARR USE ONLY								
Sampled by:	Relinquished by:	On Ice? Ⓨ N	Date 3/6/18	Time 1030	Received by:	Date	Time
Barr Proj. Manager:	Relinquished by:	On Ice? Ⓨ N	Date	Time	Received by:	Date 3/7/18	Time 1625
Barr DQ Manager:	Samples Shipped VIA: ☐ Courier ☒ Federal Express ☐ Sampler ☐ Other: ____				Air Bill Number:		
Lab Name:						Requested Due Date: ☒ Standard Turn Around Time ☐ Rush ____ (mm/dd/yyyy) (5 day)	
Lab Location:	Lab WO:	Temperature on Receipt (°C):		Custody Seal Intact? ☒ Y ☐ N ☒ None			

Distribution - White-Original: Accompanies Shipment to Laboratory; Yellow Copy: Include in Field Documents; Pink Copy: Send to Data Management Administrators

-01A -07A solid 08A -13A liquids 3/7/18 FE

The results in this report apply to the samples analyzed in accordance with the chain of custody document. This analytical report must be reproduced in its entirety.

LEGEND
Technical Services, Inc.

88 Empire Drive
St Paul, MN 55103
Tel: 651-642-1150
Fax: 651-642-1239

March 28, 2018

REVISION

Mr. James E. Taraldsen
Barr Engineering Co.
325 South Lake Avenue, Suite 700
Duluth, MN 55802

Work Order Number: 1800976
RE: 23691845

This is a revised report. The details of the revision are listed in the case narrative on the following page.

Enclosed are the results of analyses for samples received by the laboratory on 03/14/18. If you have any questions concerning this report, please feel free to contact me.

Results are not blank corrected unless noted within the report. Additionally, all QC results meet requirements unless noted.

All samples will be retained by Legend Technical Services, Inc., unless consumed in the analysis, at ambient conditions for 30 days from the date of this report and then discarded unless other arrangements are made.   All samples were received in acceptable condition unless otherwise noted.

All test results and QC meet requirements of the 2003 NELAC standard.

MDH (NELAC) Accreditation #027-123-295

Prepared by,
LEGEND TECHNICAL SERVICES, INC

BACH PHAM

Bach Pham
Client Manager II
bpham@legend-group.com

Barr Engineering Co.	Project:	23691845	
325 South Lake Avenue, Suite 700	Project Number:	23691845.00 001 001	Work Order #: 1800976
Duluth, MN 55802	Project Manager:	Mr. James E. Taraldsen	Date Reported: 03/28/18

ANALYTICAL REPORT FOR SAMPLES

Sample ID	Laboratory ID	Matrix	Date Sampled	Date Received
Tails Thickener Underflow	1800976-01	Other	03/13/18 09:27	03/14/18 09:30
Finishers Concentrate Discharge	1800976-02	Other	03/13/18 08:26	03/14/18 09:30
Concentrate Thickener Feed	1800976-03	Other	03/13/18 09:07	03/14/18 09:30
Concentrate Thickener Underflow	1800976-04	Other	03/13/18 08:35	03/14/18 09:30
Concentrate Thickener Overflow	1800976-05	Other	03/13/18 08:45	03/14/18 09:30
Green Balls	1800976-06	Other	03/13/18 08:27	03/14/18 09:30
Scrubber Blowdown	1800976-07	Other	03/13/18 08:36	03/14/18 09:30
Tails Thickener Underflow	1800976-08	Wastewater	03/13/18 09:27	03/14/18 09:30
Finishers Concentrate Discharge	1800976-09	Wastewater	03/13/18 08:26	03/14/18 09:30
Concentrate Thickener Feed	1800976-10	Wastewater	03/13/18 09:07	03/14/18 09:30
Concentrate Thickener Underflow	1800976-11	Wastewater	03/13/18 08:35	03/14/18 09:30
Concentrate Thickener Overflow	1800976-12	Wastewater	03/13/18 08:45	03/14/18 09:30
Scrubber Blowdown	1800976-13	Wastewater	03/13/18 08:36	03/14/18 09:30

Shipping Container Information

Default Cooler Temperature (°C): 2.4

Received on ice: Yes
Received on melt water: No
Custody seals: No

Temperature blank was not present
Ambient: No

Received on ice pack: No
Acceptable (IH/ISO only): No

Case Narrative:

The results are reported on an 'as received' basis for sample Concentrate Thickener Overflow due to limited sample.

The spike recoveries for mercury were below laboratory acceptance limits in the 7473 batch B8C1509 MS/MSD. All remaining spike recoveries were within acceptance limits in the batch LCS/LCSD. The MS/MSD source sample was Tails Thickener Underflow.

At the client's request, this report was revised on March 28, 2018 to change the project number. This report supersedes the report dated March 22, 2018.

Barr Engineering Co.
325 South Lake Avenue, Suite 700
Duluth, MN 55802

Project: 23691845
Project Number: 23691845.00 001 001
Project Manager: Mr. James E. Taraldsen

Work Order #: 1800976
Date Reported: 03/28/18

TOTAL MERCURY ANALYSIS
Legend Technical Services, Inc.

Analyte	Result	RL	MDL	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
Tails Thickener Underflow (1800976-01) Other Sampled: 03/13/18 09:27 Received: 03/14/18 9:30										
Mercury	**0.094**	0.050	0.0044	mg/kg dry	1	B8C1509	03/15/18	03/16/18	EPA 7473	M2
Finishers Concentrate Discharge (1800976-02) Other Sampled: 03/13/18 08:26 Received: 03/14/18 9:30										
Mercury	**0.021**	0.050	0.0044	mg/kg dry	1	B8C1509	03/15/18	03/16/18	EPA 7473	J
Concentrate Thickener Feed (1800976-03) Other Sampled: 03/13/18 09:07 Received: 03/14/18 9:30										
Mercury	**0.016**	0.050	0.0044	mg/kg dry	1	B8C1509	03/15/18	03/16/18	EPA 7473	J
Concentrate Thickener Underflow (1800976-04) Other Sampled: 03/13/18 08:35 Received: 03/14/18 9:30										
Mercury	**0.031**	0.050	0.0044	mg/kg dry	1	B8C1509	03/15/18	03/16/18	EPA 7473	J
Concentrate Thickener Overflow (1800976-05) Other Sampled: 03/13/18 08:45 Received: 03/14/18 9:30										
Mercury	**0.054**	0.050	0.0044	mg/kg wet	1	B8C1509	03/15/18	03/16/18	EPA 7473	
Green Balls (1800976-06) Other Sampled: 03/13/18 08:27 Received: 03/14/18 9:30										
Mercury	**0.0081**	0.050	0.0044	mg/kg dry	1	B8C1509	03/15/18	03/16/18	EPA 7473	J
Scrubber Blowdown (1800976-07) Other Sampled: 03/13/18 08:36 Received: 03/14/18 9:30										
Mercury	**1.3**	0.050	0.0044	mg/kg dry	1	B8C1509	03/15/18	03/16/18	EPA 7473	

Barr Engineering Co.	Project: 23691845	
325 South Lake Avenue, Suite 700	Project Number: 23691845.00 001 001	Work Order #: 1800976
Duluth, MN 55802	Project Manager: Mr. James E. Taraldsen	Date Reported: 03/28/18

TOTAL METALS ANALYSIS
Legend Technical Services, Inc.

Analyte	Result	RL	MDL	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
Tails Thickener Underflow (1800976-08) Wastewater Sampled: 03/13/18 09:27 Received: 03/14/18 9:30										
Mercury	**0.083**	0.20	0.035	ug/L	1	B8C1411	03/14/18	03/15/18	EPA 200.8	J
Finishers Concentrate Discharge (1800976-09) Wastewater Sampled: 03/13/18 08:26 Received: 03/14/18 9:30										
Mercury	**0.078**	0.20	0.035	ug/L	1	B8C1411	03/14/18	03/15/18	EPA 200.8	J
Concentrate Thickener Feed (1800976-10) Wastewater Sampled: 03/13/18 09:07 Received: 03/14/18 9:30										
Mercury	**0.077**	0.20	0.035	ug/L	1	B8C1411	03/14/18	03/15/18	EPA 200.8	J
Concentrate Thickener Underflow (1800976-11) Wastewater Sampled: 03/13/18 08:35 Received: 03/14/18 9:30										
Mercury	**0.053**	0.20	0.035	ug/L	1	B8C1411	03/14/18	03/15/18	EPA 200.8	J
Concentrate Thickener Overflow (1800976-12) Wastewater Sampled: 03/13/18 08:45 Received: 03/14/18 9:30										
Mercury	**0.047**	0.20	0.035	ug/L	1	B8C1411	03/14/18	03/15/18	EPA 200.8	J
Scrubber Blowdown (1800976-13) Wastewater Sampled: 03/13/18 08:36 Received: 03/14/18 9:30										
Mercury	**0.21**	0.20	0.035	ug/L	1	B8C1411	03/14/18	03/15/18	EPA 200.8	

Barr Engineering Co.	Project: 23691845		
325 South Lake Avenue, Suite 700	Project Number: 23691845.00 001 001	Work Order #:	1800976
Duluth, MN 55802	Project Manager: Mr. James E. Taraldsen	Date Reported:	03/28/18

PERCENT SOLIDS
Legend Technical Services, Inc.

Analyte	Result	RL	MDL	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
Tails Thickener Underflow (1800976-01) Other Sampled: 03/13/18 09:27 Received: 03/14/18 9:30										
% Solids	**77**			%	1	B8C2203	03/22/18	03/22/18	% calculation	
Finishers Concentrate Discharge (1800976-02) Other Sampled: 03/13/18 08:26 Received: 03/14/18 9:30										
% Solids	**87**			%	1	B8C2203	03/22/18	03/22/18	% calculation	
Concentrate Thickener Feed (1800976-03) Other Sampled: 03/13/18 09:07 Received: 03/14/18 9:30										
% Solids	**88**			%	1	B8C2203	03/22/18	03/22/18	% calculation	
Concentrate Thickener Underflow (1800976-04) Other Sampled: 03/13/18 08:35 Received: 03/14/18 9:30										
% Solids	**88**			%	1	B8C2203	03/22/18	03/22/18	% calculation	
Green Balls (1800976-06) Other Sampled: 03/13/18 08:27 Received: 03/14/18 9:30										
% Solids	**91**			%	1	B8C2203	03/22/18	03/22/18	% calculation	
Scrubber Blowdown (1800976-07) Other Sampled: 03/13/18 08:36 Received: 03/14/18 9:30										
% Solids	**91**			%	1	B8C2203	03/22/18	03/22/18	% calculation	

Barr Engineering Co.	Project:	23691845		
325 South Lake Avenue, Suite 700	Project Number:	23691845.00 001 001	Work Order #:	1800976
Duluth, MN 55802	Project Manager:	Mr. James E. Taraldsen	Date Reported:	03/28/18

TOTAL MERCURY ANALYSIS - Quality Control
Legend Technical Services, Inc.

Analyte	Result	RL	MDL	Units	Spike Level	Source Result	%REC	%REC Limits	%RPD	%RPD Limit	Notes
Batch B8C1509 - EPA 7473											
Blank (B8C1509-BLK1)					Prepared: 03/15/18 Analyzed: 03/16/18						
Mercury	< 0.0044	0.050	0.0044	mg/kg wet							
LCS (B8C1509-BS1)					Prepared: 03/15/18 Analyzed: 03/16/18						
Mercury	0.888	0.050	0.0044	mg/kg wet	1.00	<0.050	88.8	80-120			
LCS Dup (B8C1509-BSD1)					Prepared: 03/15/18 Analyzed: 03/16/18						
Mercury	0.929	0.050	0.0044	mg/kg wet	1.00	<0.050	92.9	80-120	4.56	20	
Matrix Spike (B8C1509-MS1)	**Source: 1800976-01**				Prepared: 03/15/18 Analyzed: 03/16/18						
Mercury	0.315	0.050	0.0044	mg/kg dry	0.298	0.0939	74.0	80-120			M2
Matrix Spike Dup (B8C1509-MSD1)	**Source: 1800976-01**				Prepared: 03/15/18 Analyzed: 03/16/18						
Mercury	0.327	0.050	0.0044	mg/kg dry	0.320	0.0939	73.0	80-120	4.01	20	M2

TOTAL METALS ANALYSIS - Quality Control
Legend Technical Services, Inc.

Analyte	Result	RL	MDL	Units	Spike Level	Source Result	%REC	%REC Limits	%RPD	%RPD Limit	Notes
Batch B8C1411 - EPA 200.8 Digestion											
Blank (B8C1411-BLK1)					Prepared: 03/14/18 Analyzed: 03/15/18						
Mercury	< 0.035	0.20	0.035	ug/L							
LCS (B8C1411-BS1)					Prepared: 03/14/18 Analyzed: 03/15/18						
Mercury	25.4	0.20	0.035	ug/L	25.0	<0.20	102	85-115			
LCS Dup (B8C1411-BSD1)					Prepared: 03/14/18 Analyzed: 03/15/18						
Mercury	25.9	0.20	0.035	ug/L	25.0	<0.20	104	85-115	2.00	20	
Matrix Spike (B8C1411-MS1)	**Source: 1800974-01**				Prepared: 03/14/18 Analyzed: 03/15/18						
Mercury	24.6	0.20	0.035	ug/L	25.0	<0.20	97.8	75-125			
Matrix Spike Dup (B8C1411-MSD1)	**Source: 1800974-01**				Prepared: 03/14/18 Analyzed: 03/15/18						
Mercury	24.6	0.20	0.035	ug/L	25.0	<0.20	97.8	75-125	0.00786	20	

PERCENT SOLIDS - Quality Control
Legend Technical Services, Inc.

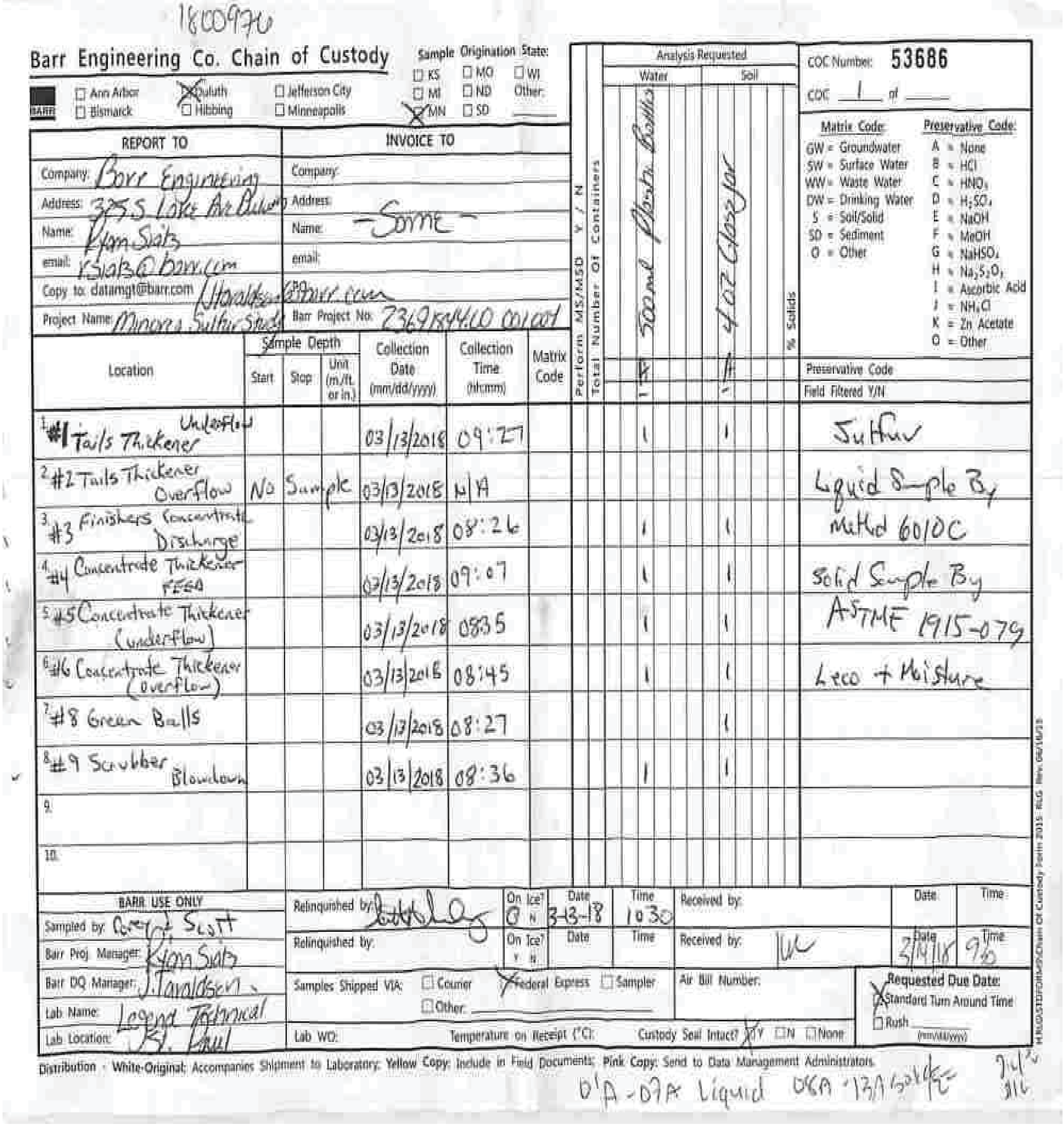
Analyte	Result	RL	MDL	Units	Spike Level	Source Result	%REC	%REC Limits	%RPD	%RPD Limit	Notes
Batch B8C2203 - General Preparation											
Duplicate (B8C2203-DUP1)	**Source: 1800976-06**				Prepared & Analyzed: 03/22/18						
% Solids	91.0			%		91.0			0.00	20	

The results in this report apply to the samples analyzed in accordance with the chain of custody document. This analytical report must be reproduced in its entirety.

Barr Engineering Co.	Project:	23691845			
325 South Lake Avenue, Suite 700	Project Number:	23691845.00 001 001		Work Order #:	1800976
Duluth, MN 55802	Project Manager:	Mr. James E. Taraldsen		Date Reported:	03/28/18

Notes and Definitions

M2	Matrix spike recovery was low, the associated blank spike recovery was acceptable.
J	Parameter was present between the MDL and RL and should be considered an estimated value
<	Less than value listed
dry	Sample results reported on a dry weight basis
NA	Not applicable. The %RPD is not calculated from values less than the reporting limit.
MDL	Method Detection Limit; Equivalent to the method LOD (Limit of Detection)
RL	Reporting Limit
RPD	Relative Percent Difference
LCS	Laboratory Control Spike = Blank Spike (BS) = Laboratory Fortified Blank (LFB)
MS	Matrix Spike = Laboratory Fortified Matrix (LFM)



1800970

Barr Engineering Co. Chain of Custody

BARR ☐ Ann Arbor ☐ Bismarck ☒ Duluth ☐ Hibbing ☐ Jefferson City ☐ Minneapolis

Sample Origination State: ☐ KS ☐ MI ☒ MN ☐ MO ☐ ND ☐ SD ☐ WI Other: ____

COC Number: **53686**

COC 1 of ____

REPORT TO	INVOICE TO
Company: Barr Engineering	Company:
Address: 325 S Lake Ave Duluth	Address:
Name: Ryan Siats	Name: – Same –
email: rsiats@barr.com	email:
Copy to: datamgt@barr.com JTavaldsen@barr.com	
Project Name: Minorca Sulfur Study	Barr Project No: 23691844.10 001 001

Matrix Code:
GW = Groundwater
SW = Surface Water
WW = Waste Water
DW = Drinking Water
S = Soil/Solid
SD = Sediment
O = Other

Preservative Code:
A = None
B = HCl
C = HNO_3
D = H_2SO_4
E = NaOH
F = MeOH
G = $NaHSO_4$
H = $Na_2S_2O_3$
I = Ascorbic Acid
J = NH_4Cl
K = Zn Acetate
O = Other

Location	Sample Depth Start	Sample Depth Stop	Sample Depth Unit (m./ft. or in.)	Collection Date (mm/dd/yyyy)	Collection Time (hh:mm)	Matrix Code	Perform MS/MSD Y / N	Total Number Of Containers	Analysis Requested Water: 500ml Plastic Bottles	Analysis Requested Soil: 4oz Glass Jar	% Solids	
Preservative Code									A	A		
Field Filtered Y/N									–	–		
1. #1 Tails Thickener Underflow				03/13/2018	09:27				1	1		Sulfur
2. #2 Tails Thickener Overflow	No	Sample		03/13/2018	N/A							Liquid Sample By
3. #3 Finishers Concentrate Discharge				03/13/2018	08:26				1	1		Method 6010C
4. #4 Concentrate Thickener Feed				03/13/2018	09:07				1	1		Solid Sample By
5. #5 Concentrate Thickener (underflow)				03/13/2018	0835				1	1		ASTME 1915-07a
6. #6 Concentrate Thickener (overflow)				03/13/2018	08:45				1	1		Leco + Moisture
7. #8 Green Balls				03/13/2018	08:27					1		
8. #9 Scrubber Blowdown				03/13/2018	08:36				1	1		
9.												
10.												

BARR USE ONLY
Sampled by: Corey J. Scott
Barr Proj. Manager: Ryan Siats
Barr DQ Manager: J. Tavaldsen
Lab Name: Legend Technical
Lab Location: St. Paul

Relinquished by:	On Ice?	Date	Time	Received by:	Date	Time
	[✓ Y] N	3-13-18	1030			
	Y N			LW	3/14/18	9:30

Samples Shipped VIA: ☐ Courier ☒ Federal Express ☐ Sampler ☐ Other: ____

Air Bill Number:

Requested Due Date: ☒ Standard Turn Around Time ☐ Rush ____ (mm/dd/yyyy)

Lab WO:

Temperature on Receipt (°C):

Custody Seal Intact? ☒ Y ☐ N ☐ None

Distribution - White-Original: Accompanies Shipment to Laboratory; Yellow Copy: Include in Field Documents; Pink Copy: Send to Data Management Administrators.

01A - 07A Liquid 08A - 13A Solid

[illegible]

H:\LOG\STD FORMS\Chain Of Custody Form 2015 BLG Rev. 06/16/15

LEGEND
Technical Services, Inc.

88 Empire Drive
St Paul, MN 55103
Tel: 651-642-1150
Fax: 651-642-1239

April 20, 2018

Mr. James E. Taraldsen
Barr Engineering Co.
325 South Lake Avenue, Suite 700
Duluth, MN 55802

Work Order Number: 1801391
RE: 23691981

Enclosed are the results of analyses for samples received by the laboratory on 04/12/18. If you have any questions concerning this report, please feel free to contact me.

Results are not blank corrected unless noted within the report. Additionally, all QC results meet requirements unless noted.

All samples will be retained by Legend Technical Services, Inc., unless consumed in the analysis, at ambient conditions for 30 days from the date of this report and then discarded unless other arrangements are made.   All samples were received in acceptable condition unless otherwise noted.

All test results and QC meet requirements of the 2003 NELAC standard.

MDH (NELAP) Accreditation #027-123-295

Prepared by,
LEGEND TECHNICAL SERVICES, INC

BACH PHAM

Bach Pham
Client Manager II
bpham@legend-group.com

Barr Engineering Co.
325 South Lake Avenue, Suite 700
Duluth, MN 55802

Project: 23691981
Project Number: 23691981
Project Manager: Mr. James E. Taraldsen

Work Order #: 1801391
Date Reported: 04/20/18

ANALYTICAL REPORT FOR SAMPLES

Sample ID	Laboratory ID	Matrix	Date Sampled	Date Received
Tails Thickener Underflow	1801391-01	Other	04/11/18 09:19	04/12/18 09:10
Concentrate Thickener Feed	1801391-02	Other	04/11/18 09:03	04/12/18 09:10
Concentrate Thickener Underflow	1801391-03	Other	04/11/18 08:35	04/12/18 09:10
Concentrate Thickener Overflow	1801391-04	Other	04/11/18 08:42	04/12/18 09:10
Green Balls	1801391-05	Other	04/11/18 08:27	04/12/18 09:10
Scrubber Blowdown	1801391-06	Other	04/11/18 08:30	04/12/18 09:10
Tails Thickener Underflow	1801391-07	Wastewater	04/11/18 09:19	04/12/18 09:10
Concentrate Thickener Feed	1801391-08	Wastewater	04/11/18 09:03	04/12/18 09:10
Concentrate Thickener Underflow	1801391-09	Wastewater	04/11/18 08:35	04/12/18 09:10
Concentrate Thickener Overflow	1801391-10	Wastewater	04/11/18 08:42	04/12/18 09:10
Scrubber Blowdown	1801391-11	Wastewater	04/11/18 08:30	04/12/18 09:10

Shipping Container Information

Default Cooler Temperature (°C):

Received on ice: Yes
Received on melt water: No
Custody seals: No

Temperature blank was not present
Ambient: No

Received on ice pack: No
Acceptable (IH/ISO only): No

Case Narrative:

The spike recovery for mercury was below laboratory acceptance limits in the 7473 batch B8D1810 MSD. All remaining spike recoveries were within acceptance limits in the batch LCS/LCSD/MS. The MS/MSD source sample was Tails Thickener Underflow.

The results are reported on an 'as received' basis for samples Concentrate Thickener Overflow and Scrubber Blowdown due to limited sample.

Barr Engineering Co.	Project: 23691981	
325 South Lake Avenue, Suite 700	Project Number: 23691981	Work Order #: 1801391
Duluth, MN 55802	Project Manager: Mr. James E. Taraldsen	Date Reported: 04/20/18

TOTAL MERCURY ANALYSIS
Legend Technical Services, Inc.

Analyte	Result	RL	MDL	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
Tails Thickener Underflow (1801391-01) Other Sampled: 04/11/18 09:19 Received: 04/12/18 9:10										
Mercury	**0.031**	0.050	0.0044	mg/kg dry	1	B8D1810	04/18/18	04/19/18	EPA 7473	M2, QR-04, J
Concentrate Thickener Feed (1801391-02) Other Sampled: 04/11/18 09:03 Received: 04/12/18 9:10										
Mercury	**0.0093**	0.050	0.0044	mg/kg dry	1	B8D1810	04/18/18	04/19/18	EPA 7473	J
Concentrate Thickener Underflow (1801391-03) Other Sampled: 04/11/18 08:35 Received: 04/12/18 9:10										
Mercury	**0.014**	0.050	0.0044	mg/kg dry	1	B8D1810	04/18/18	04/19/18	EPA 7473	J
Concentrate Thickener Overflow (1801391-04) Other Sampled: 04/11/18 08:42 Received: 04/12/18 9:10										
Mercury	**0.030**	0.050	0.0044	mg/kg wet	1	B8D1810	04/18/18	04/19/18	EPA 7473	J
Green Balls (1801391-05) Other Sampled: 04/11/18 08:27 Received: 04/12/18 9:10										
Mercury	**0.0095**	0.050	0.0044	mg/kg dry	1	B8D1810	04/18/18	04/19/18	EPA 7473	J
Scrubber Blowdown (1801391-06) Other Sampled: 04/11/18 08:30 Received: 04/12/18 9:10										
Mercury	**1.4**	0.050	0.0044	mg/kg wet	1	B8D1810	04/18/18	04/19/18	EPA 7473	

Barr Engineering Co.	Project: 23691981	
325 South Lake Avenue, Suite 700	Project Number: 23691981	Work Order #: 1801391
Duluth, MN 55802	Project Manager: Mr. James E. Taraldsen	Date Reported: 04/20/18

TOTAL METALS ANALYSIS
Legend Technical Services, Inc.

Analyte	Result	RL	MDL	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
Tails Thickener Underflow (1801391-07) Wastewater Sampled: 04/11/18 09:19 Received: 04/12/18 9:10										
Mercury	**0.11**	0.20	0.035	ug/L	1	B8D1303	04/13/18	04/16/18	EPA 200.8	J
Concentrate Thickener Feed (1801391-08) Wastewater Sampled: 04/11/18 09:03 Received: 04/12/18 9:10										
Mercury	**0.074**	0.20	0.035	ug/L	1	B8D1303	04/13/18	04/16/18	EPA 200.8	J
Concentrate Thickener Underflow (1801391-09) Wastewater Sampled: 04/11/18 08:35 Received: 04/12/18 9:10										
Mercury	**0.064**	0.20	0.035	ug/L	1	B8D1303	04/13/18	04/16/18	EPA 200.8	J
Concentrate Thickener Overflow (1801391-10) Wastewater Sampled: 04/11/18 08:42 Received: 04/12/18 9:10										
Mercury	**0.081**	0.20	0.035	ug/L	1	B8D1303	04/13/18	04/16/18	EPA 200.8	J
Scrubber Blowdown (1801391-11) Wastewater Sampled: 04/11/18 08:30 Received: 04/12/18 9:10										
Mercury	**0.26**	0.20	0.035	ug/L	1	B8D1303	04/13/18	04/16/18	EPA 200.8	

Barr Engineering Co.
325 South Lake Avenue, Suite 700
Duluth, MN 55802

Project: 23691981
Project Number: 23691981
Project Manager: Mr. James E. Taraldsen

Work Order #: 1801391
Date Reported: 04/20/18

PERCENT SOLIDS
Legend Technical Services, Inc.

Analyte	Result	RL	MDL	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
Tails Thickener Underflow (1801391-01) Other Sampled: 04/11/18 09:19 Received: 04/12/18 9:10										
% Solids	**80**			%	1	B8D1903	04/19/18	04/19/18	% calculation	
Concentrate Thickener Feed (1801391-02) Other Sampled: 04/11/18 09:03 Received: 04/12/18 9:10										
% Solids	**86**			%	1	B8D1903	04/19/18	04/19/18	% calculation	
Concentrate Thickener Underflow (1801391-03) Other Sampled: 04/11/18 08:35 Received: 04/12/18 9:10										
% Solids	**86**			%	1	B8D1903	04/19/18	04/19/18	% calculation	
Green Balls (1801391-05) Other Sampled: 04/11/18 08:27 Received: 04/12/18 9:10										
% Solids	**91**			%	1	B8D1903	04/19/18	04/19/18	% calculation	

Barr Engineering Co.	Project: 23691981		
325 South Lake Avenue, Suite 700	Project Number: 23691981	Work Order #:	1801391
Duluth, MN 55802	Project Manager: Mr. James E. Taraldsen	Date Reported:	04/20/18

TOTAL MERCURY ANALYSIS - Quality Control
Legend Technical Services, Inc.

Analyte	Result	RL	MDL	Units	Spike Level	Source Result	%REC	%REC Limits	%RPD	%RPD Limit	Notes
Batch B8D1810 - EPA 7473											
Blank (B8D1810-BLK1)					Prepared: 04/18/18	Analyzed: 04/19/18					
Mercury	< 0.0044	0.050	0.0044	mg/kg wet							
LCS (B8D1810-BS1)					Prepared: 04/18/18	Analyzed: 04/19/18					
Mercury	0.891	0.050	0.0044	mg/kg wet	1.00	<0.050	89.1	80-120			
LCS Dup (B8D1810-BSD1)					Prepared: 04/18/18	Analyzed: 04/19/18					
Mercury	0.955	0.050	0.0044	mg/kg wet	1.00	<0.050	95.5	80-120	6.93	20	
Matrix Spike (B8D1810-MS1)	**Source: 1801391-01**				Prepared: 04/18/18	Analyzed: 04/19/18					
Mercury	0.349	0.050	0.0044	mg/kg dry	0.357	<0.050	89.0	80-120			
Matrix Spike Dup (B8D1810-MSD1)	**Source: 1801391-01**				Prepared: 04/18/18	Analyzed: 04/19/18					
Mercury	0.253	0.050	0.0044	mg/kg dry	0.310	<0.050	71.8	80-120	31.7	20	M2, QR-04

Barr Engineering Co.	Project:	23691981		
325 South Lake Avenue, Suite 700	Project Number:	23691981	Work Order #:	1801391
Duluth, MN 55802	Project Manager:	Mr. James E. Taraldsen	Date Reported:	04/20/18

TOTAL METALS ANALYSIS - Quality Control
Legend Technical Services, Inc.

Analyte	Result	RL	MDL	Units	Spike Level	Source Result	%REC	%REC Limits	%RPD	%RPD Limit	Notes
Batch B8D1303 - EPA 200.8 Digestion											
Blank (B8D1303-BLK1)					Prepared: 04/13/18	Analyzed: 04/16/18					
Mercury	< 0.035	0.20	0.035	ug/L							
LCS (B8D1303-BS1)					Prepared: 04/13/18	Analyzed: 04/16/18					
Mercury	25.2	0.20	0.035	ug/L	25.0	<0.20	101	85-115			
LCS Dup (B8D1303-BSD1)					Prepared: 04/13/18	Analyzed: 04/16/18					
Mercury	24.7	0.20	0.035	ug/L	25.0	<0.20	98.9	85-115	1.75	20	
Matrix Spike (B8D1303-MS1)	**Source: 1801323-01**				Prepared: 04/13/18	Analyzed: 04/16/18					
Mercury	24.2	0.20	0.035	ug/L	25.0	<0.20	96.6	75-125			
Matrix Spike Dup (B8D1303-MSD1)	**Source: 1801323-01**				Prepared: 04/13/18	Analyzed: 04/16/18					
Mercury	23.7	0.20	0.035	ug/L	25.0	<0.20	94.6	75-125	2.10	20	

PERCENT SOLIDS - Quality Control
Legend Technical Services, Inc.

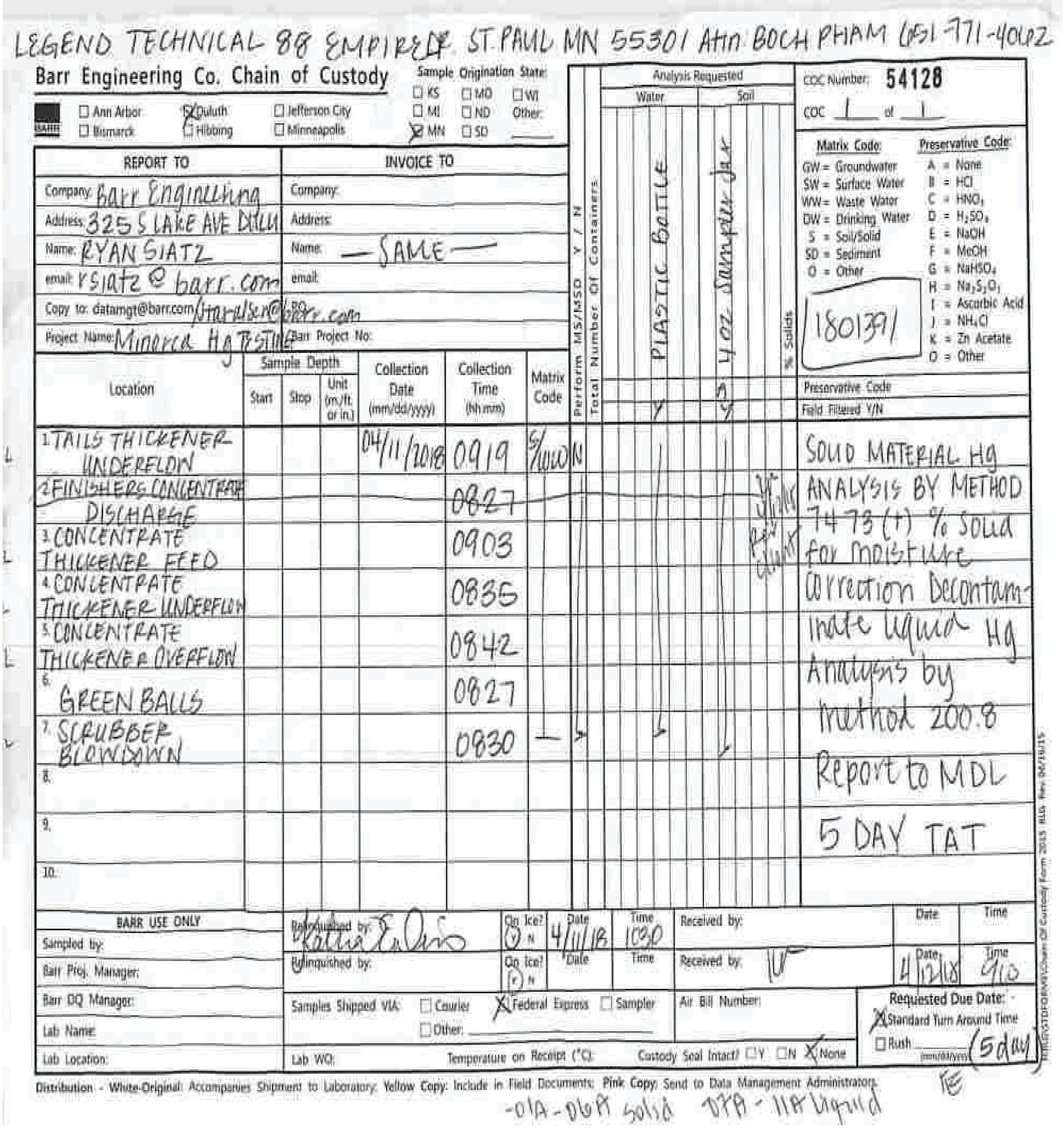
Analyte	Result	RL	MDL	Units	Spike Level	Source Result	%REC	%REC Limits	%RPD	%RPD Limit	Notes
Batch B8D1903 - General Preparation											
Duplicate (B8D1903-DUP1)	**Source: 1801391-05**				Prepared & Analyzed: 04/19/18						
% Solids	90.0			%		91.0			1.10	20	

Barr Engineering Co.	Project: 23691981		
325 South Lake Avenue, Suite 700	Project Number: 23691981	Work Order #:	1801391
Duluth, MN 55802	Project Manager: Mr. James E. Taraldsen	Date Reported:	04/20/18

Notes and Definitions

QR-04	The RPD value for the MS/MSD was outside of QC acceptance limits. Data was accepted based on LCS and/or LCSD recovery and/or RPD values.
M2	Matrix spike recovery was low, the associated blank spike recovery was acceptable.
J	Parameter was present between the MDL and RL and should be considered an estimated value
<	Less than value listed
dry	Sample results reported on a dry weight basis
NA	Not applicable. The %RPD is not calculated from values less than the reporting limit.
MDL	Method Detection Limit; Equivalent to the method LOD (Limit of Detection)
RL	Reporting Limit
RPD	Relative Percent Difference
LCS	Laboratory Control Spike = Blank Spike (BS) = Laboratory Fortified Blank (LFB)
MS	Matrix Spike = Laboratory Fortified Matrix (LFM)

88 Empire Drive
St Paul, MN 55103
Tel: 651-642-1150
Fax: 651-642-1239



LEGEND TECHNICAL 88 EMPIRE DR ST. PAUL MN 55301 Attn BOCH PHAM 651-771-4062

Barr Engineering Co. Chain of Custody

☐ Ann Arbor ☐ Bismarck ☒ Duluth ☐ Hibbing ☐ Jefferson City ☐ Minneapolis

Sample Origination State: ☐ KS ☐ MI ☒ MN ☐ MO ☐ ND ☐ SD ☐ WI Other: ____

COC Number: **54128**

COC 1 of 1

REPORT TO	INVOICE TO
Company: Barr Engineering	Company:
Address: 325 S LAKE AVE DULU	Address:
Name: RYAN SIATZ	Name: — SAME —
email: rsiatz@barr.com	email:
Copy to: datamgt@barr.com / jtaralsen@barr.com	
Project Name: Minorca Hg Testing	Barr Project No:

Analysis Requested: Water: PLASTIC BOTTLE; Soil: 4 oz Sampler Jar; % Solids

Matrix Code:
GW = Groundwater
SW = Surface Water
WW = Waste Water
DW = Drinking Water
S = Soil/Solid
SD = Sediment
O = Other

Preservative Code:
A = None
B = HCl
C = HNO_3
D = H_2SO_4
E = NaOH
F = MeOH
G = $NaHSO_4$
H = $Na_2S_2O_3$
I = Ascorbic Acid
J = NH_4Cl
K = Zn Acetate
O = Other

1801391

	Location	Sample Depth Start	Sample Depth Stop	Unit (m/ft. or in.)	Collection Date (mm/dd/yyyy)	Collection Time (hh:mm)	Matrix Code	Perform MS/MSD Y/N	Total Number Of Containers	PLASTIC BOTTLE	4 oz Sampler Jar	% Solids
	Preservative Code										A	
	Field Filtered Y/N									Y	Y	
L	1. TAILS THICKENER UNDERFLOW				04/11/2018	0919	S/WW	N				
	2. FINISHERS CONCENTRATE DISCHARGE					0827						Y Only Per client
L	3. CONCENTRATE THICKENER FEED					0903						
L	4. CONCENTRATE THICKENER UNDERFLOW					0835						
L	5. CONCENTRATE THICKENER OVERFLOW					0842						
	6. GREEN BALLS					0827						
L	7. SCRUBBER BLOWDOWN					0830						
	8.											
	9.											
	10.											

SOLID MATERIAL Hg ANALYSIS BY METHOD 7473 (+) % Solid for moisture correction Decontaminate Liquid Hg Analysis by method 200.8

Report to MDL

5 DAY TAT

BARR USE ONLY		On Ice?	Date	Time		Date	Time
Sampled by:	Relinquished by: Katie Evans	[✓ Y] N	4/11/18	1030	Received by:		
Barr Proj. Manager:	Relinquished by:	[✓ Y] N			Received by:	4/12/18	910
Barr DQ Manager:	Samples Shipped VIA: ☐ Courier ☒ Federal Express ☐ Sampler ☐ Other: ____				Air Bill Number:		
Lab Name:							
Lab Location:	Lab WO:	Temperature on Receipt (°C):			Custody Seal Intact? ☐ Y ☐ N ☒ None		

Requested Due Date: ☒ Standard Turn Around Time ☐ Rush ____ (mm/dd/yyyy) (5 day)

Distribution - **White-Original:** Accompanies Shipment to Laboratory; **Yellow Copy:** Include in Field Documents; **Pink Copy:** Send to Data Management Administrator.

-01A - 06A solid 07A - 11A liquid

Chain Of Custody Form 2015 RLS Rev. 06/18/15

North Shore
Analytical, Inc.
4511 W. 1st St., Suite #1, Duluth, MN 55807

MDH Lab # 027-137-389
WDNR Lab # 399017190

Analytical Report

Project: Minorca Hg Testing

Barr Engineering
ATTN: Jim Taraldsen
325 S Lake Ave, Suite 700
Duluth MN 55802

jtaraldsen@barr.com

Chain of Custody # 21682

Report Date: 2/5/2018

Sample Receipt Date: 1/25/2018

EPA Method 1631E

Method Blanks (ng/L): < 0.100, < 0.100, < 0.100

Sample #	Client Sample ID / (dilution factor)	Mercury (ng/L)	Collection Date	Collection Time	Sampled By	Date Analyzed	Analyzed by	MDL (ng/L)
89239	Scrubber Blowdown (100X)	1510	1/23/2018	8:33		2/2/2018	LC	10
89240	Make-up-water	0.563	1/23/2018	8:45		2/2/2018	LC	0.10
89241	Field Blank	< 0.500	1/23/2018	8:35		2/2/2018	LC	0.10

Reported by: ____________

Reviewed by: ____________

If you have any questions or feedback please call

Chris Gross or Linda Christensen at 218-729-4658.

7

ship to:

North Shore Analytical, Inc.
4511 W. 1st St., Suite #1
Duluth, MN 55807
Phone (218) 729-4658
Fax (218) 729-4659

Record # : 21682

STF-COC-001
Revision Number: 6
Revision Date: 06/30/2014

Chain of Custody

Client Name: Barr Engineering
Address: 325 S. Lake Ave. Suite 700
City: Duluth
State: MN
Zip: 55802
Report to: Jim Toraldsen, Ryan Siats
Phone: 218-529-7138
~~Fax:~~ jtoraldsen@barr.com, rsiats@barr.com
Sampled by:
Project: Minorca Hg Testing

NSA Lab #	Bottle #	Client Sample Identification	Date Collected	Time Collected	Matrix	Sample Type Grab	Sample Type Composite	Container/ Preservation	Analysis Requested
89239	1.41	Scrubber Blowdown	1/23/18	0833	WW	X		NA	LLHg - 1631E
89240	310.75	Make-up-water	⊥	0845	WW	X		NA	LLHg - 1631E
89241	1039.4	FIELD BLANK		0835	WW	X		NA	LLHg - 1631E

Transfer #	Relinquished By	Date	Time	Accepted By	Date	Time	Condition
1	Katria Endres	1/23/18	1033	KR	1/24/18	950	ice, no temp.
2							
3							
4	KR	1/24/18	1430		1-25-18	10:15	ok

F.E.

ADDITIONAL COMMENTS:

Logged In 1-25-18 LH

Low-level mercury bottles supplied by North Shore Analytical? Y N

KEY:

Lab use only

Matrix:
SW = Surface Water
WW = Wastewater
P = Precipitation
DI = Deionized water
GW = Ground Water
DW = Drinking Water
S = Solid/sediment/soil

Containers:
P = Plastic
T = Teflon/Fluoropolymer
G = Glass
B = Plastic Bag

Preservation:
NA = None Added
H = Hydrochloric Acid
I = ice
B = Bromine Monochloride

North Shore
Analytical, Inc.
4511 W. 1st St., Suite #1, Duluth, MN 55807

MDH Lab # 027-137-389
WDNR Lab # 399017190

Analytical Report

Project: Minorca Hg Testing

Barr Engineering
ATTN: Jim Taraldsen
325 S Lake Ave, Suite 700
Duluth MN 55802

jtaraldsen@barr.com

Chain of Custody # 21703

Report Date: 2/8/2018

Sample Receipt Date: 1/31/2018

EPA Method 1631E

Method Blanks (ng/L): < 0.100, < 0.100, < 0.100

Sample #	Client Sample ID / (dilution factor)	Mercury (ng/L)	Collection Date	Collection Time	Sampled By	Date Analyzed	Analyzed by	MDL (ng/L)
89317	Make-Up-Water	0.615	1/30/2018	8:51		2/7/2018	LC	0.10
89318	Tails Thickener-Over	1.43	1/30/2018	9:08		2/7/2018	LC	0.10
89319	Field Blank	< 0.500	1/30/2018	9:10		2/7/2018	LC	0.10

Reported by: ____________________

Reviewed by: ____________________

If you have any questions or feedback please call

Chris Gross or Linda Christensen at 218-729-4658.

7

ship to:

North Shore Analytical, Inc.
4511 W. 1st St., Suite #1
Duluth, MN 55807
Phone (218) 729-4658
Fax (218) 729-4659

Record # : 21703

STF-COC-001
Revision Number: 6
Revision Date: 06/30/2014

Chain of Custody

Client Name: Barr Engineering
Address: 325 S. Lake Ave. Suite 700
City: Duluth
State: MN
Zip: 55802

Report to: Jim Toraldsen
Ryan Siats
Phone: 218-529-7138
Fax: jtoraldsen@barr.com
rsiats@barr.com

Sampled by:

Project: Minorca Hg Testing

NSA Lab #	Bottle #	Client Sample Identification	Date Collected	Time Collected	Matrix	Sample Type: Grab	Sample Type: Composite	Container/ Preservation	Analysis Requested
		~~Scrubber Blowdown~~			~~WW~~	~~X~~		~~NA~~	~~LLHg - 1631E~~
89317		Make-up-water	1/30/18	0851	WW	X		NA	LLHg - 1631E
89318		TAILS THICKENER-OVER		0908	WW	X		NA	LLHg - 1631E
89319		FIELD BLANK		0910	WW	X		NA	LLHg - 1631E

Transfer #	Relinquished By	Date	Time	Accepted By	Date	Time	Condition
1	Katra Ealvs	1/30/18	1030		1-31-18	10:44	OK
2							
3							
4							

ADDITIONAL COMMENTS:

Logged In 1-31-18 LH

Low-level mercury bottles supplied by North Shore Analytical? Y N

KEY:

Matrix:
SW = Surface Water
WW = Wastewater
P = Precipitation
DI = Deionized water
GW = Ground Water
DW = Drinking Water
S = Solid/sediment/soil

Containers:
P = Plastic
T = Teflon/Fluoropolymer
G = Glass
B = Plastic Bag

Preservation:
NA = None Added
H = Hydrochloric Acid
I = ice
B = Bromine Monochloride

North Shore
Analytical, Inc.
4511 W. 1st St., Suite #1, Duluth, MN 55807

MDH Lab # 027-137-389
WDNR Lab # 399017190

Analytical Report

Project: Minorca Hg Testing

Barr Engineering
ATTN: Jim Taraldsen
325 S Lake Ave, Suite 700
Duluth MN 55802

jtaraldsen@barr.com

Chain of Custody # 21754

Report Date: 2/28/2018

Sample Receipt Date: 2/20/2018

EPA Method 1631E

Method Blanks (ng/L): < 0.100, < 0.100, < 0.100

Sample #	Client Sample ID / (dilution factor)	Mercury (ng/L)	Collection Date	Collection Time	Sampled By	Date Analyzed	Analyzed by	MDL (ng/L)
89504	Make Up Water	0.628	2/19/2018	8:50		2/27/2018	LC	0.10
89505	Tails Thickener Over	1.82	2/19/2018	9:08		2/27/2018	LC	0.10
89506	Field Blank	< 0.500	2/19/2018	9:10		2/27/2018	LC	0.10

Reported by: ____________

Reviewed by: ____________

If you have any questions or feedback please call

Chris Gross or Linda Christensen at 218-729-4658.

North Shore Analytical, Inc.
4511 W. 1st St., Suite #1
Duluth, MN 55807
Phone (218) 729-4658
Fax (218) 729-4659

Ship to

Record # : 21754

7

STF-COC-001
Revision Number: 7
Revision Date: 01/31/2017

Chain of Custody

Client Name: Barr Engineering
Address: 325 S. LAKE AVE Suite 700
City: DULUTH
State: MN
Zip: 55802
Report to: JIM TORALDSEN RYAN SIATZ
Phone: 218-529-7198
Email: JTORALDSON@barr rsiatz@barr
Sampled by:
Project: Minorca Hg Test

NSA Lab #	Bottle #	Client Sample Identification	Date Collected	Time Collected	Matrix	Sample Type: Grab	Sample Type: Composite	Container/ Preservation	Analysis Requested*
89504	724.75	MAKE UP WATER	2/19/18	0850	WW	X		NA	LLHg-1631E
89505	125.42	TAILS THICKENER OVER	|	0908	WW	X		NA	LLHg-1631E
89506	136.42	FIELD BLANK	|	0910	WW	X		NA	LLHg-1631E
	JET-Barr 2/21/18								

Transfer #	Relinquished By	Date	Time	Accepted By	Date	Time	Condition
1	Katra Ewers	2/19/18	1030		2-20-18	11:24	OK
2							
3							

Lab use | Logged in by (Initial): LH | 2-21-18 | 11:10 | Filtered by (Initial): | Lot #:

ADDITIONAL COMMENTS:
* Sampres came in with no Bottle #'s assigned - called Jim from Barr came in to assign

* "LLHg," "mercury," or "Low-level mercury" = USEPA Method 1631E

Low-level mercury bottles supplied by North Shore Analytical? Y N

KEY:

Lab use only

Matrix:
SW = Surface Water
WW = Wastewater
P = Precipitation
DI = Deionized water
GW = Ground Water
DW = Drinking Water
S = Solid/sediment/soil

Containers:
P = Plastic
T = Teflon/Fluoropolymer
G = Glass
B = Plastic Bag

Preservation:
NA = None Added
H = Hydrochloric Acid
I = ice
B = Bromine Monochloride

North Shore
Analytical, Inc.
4511 W. 1st St., Suite #1, Duluth, MN 55807

MDH Lab # 027-137-389
WDNR Lab # 399017190

Analytical Report

Project: Minorca Hg Test

Barr Engineering
ATTN: Jim Taraldsen
325 S Lake Ave, Suite 700
Duluth MN 55802

jtaraldsen@barr.com

Chain of Custody # 21787

Report Date: 3/13/2018

Sample Receipt Date: 3/2/2018

EPA Method 1631E

Method Blanks (ng/L): < 0.100, < 0.100, < 0.100

Sample #	Client Sample ID / (dilution factor)	Mercury (ng/L)	Collection Date	Collection Time	Sampled By	Date Analyzed	Analyzed by	MDL (ng/L)
89635	Make Up Water	2.13	3/1/2018	9:24	Katrina D/Scott S	3/12/2018	LC	0.10
89636	Tails Thickener Over	4.25	3/1/2018	9:42	Kartina D/Scott S	3/12/2018	LC	0.10
89637	Field Blank	< 0.500	3/1/2018	9:25	Katrina D/Scott S	3/12/2018	LC	0.10

Reported by: ____________________

Reviewed by: ____________________

If you have any questions or feedback please call
Chris Gross or Linda Christensen at 218-729-4658.

7

North Shore Analytical, Inc.
4511 W. 1st St., Suite #1
Duluth, MN 55807
Phone (218) 729-4658
Fax (218) 729-4659

Record # : 21787

STF-COC-001
Revision Number: 7
Revision Date: 01/31/2017

Chain of Custody

Client Name: BARR ENGINEERING
Address: 325 S. LAKE AVE SUITE 700
City: DULUTH
State: MN
Zip: 55802
Report to: JIM TORALDSON
RYAN SIATZ
Phone: 218-529-7138
Email: JTORALDSON @ BARR
rsiatz@barr
Sampled by: KATRINA.D & SCOTT.S.
Project: MINORCA Hg TEST

NSA Lab #	Bottle #	Client Sample Identification	Date Collected	Time Collected	Matrix	Sample Type: Grab	Sample Type: Composite	Container/ Preservation	Analysis Requested*
89635	736.75	MAKE UP WATER	3/1/18	0924	WW	X		NA	LLHg-1631E
896136	137.42	TAILS THICKENER OVER	L	0942	WW	X		NA	LLHg-1631
89637	138.42	FIELD BLANK		0925	WW	X		NA	LLHg-1631

Transfer #	Relinquished By	Date	Time	Accepted By	Date	Time	Condition
1		3/1/18	1105		3-2-18	9:49	OK
2							on ice
3							

Lab use | Logged in by (Initial): LH | 3-2-18 | 10:37 | Filtered by (Initial): | Lot #:

ADDITIONAL COMMENTS:

*** "LLHg," "mercury," or "Low-level mercury" = USEPA Method 1631E**

Low-level mercury bottles supplied by North Shore Analytical? Y N

KEY:
Lab use only

Matrix:
SW = Surface Water
WW = Wastewater
P = Precipitation
DI = Deionized water
GW = Ground Water
DW = Drinking Water
S = Solid/sediment/soil

Containers:
P = Plastic
T = Teflon/Fluoropolymer
G = Glass
B = Plastic Bag

Preservation:
NA = None Added
H = Hydrochloric Acid
B = Bromine Monochloride
I = ice

North Shore Analytical, Inc.
4511 W. 1st St., Suite #1, Duluth, MN 55807

MDH Lab # 027-137-389
WDNR Lab # 399017190

Analytical Report

Project: Minorca Hg Test

Barr Engineering
ATTN: Jim Taraldsen
325 S Lake Ave, Suite 700
Duluth MN 55802

jtaraldsen@barr.com

Chain of Custody # 21798

Report Date: 3/14/2018

Sample Receipt Date: 3/7/2018

EPA Method 1631E

Method Blanks (ng/L): < 0.100, < 0.100, < 0.100

Sample #	Client Sample ID / (dilution factor)	Mercury (ng/L)	Collection Date	Collection Time	Sampled By	Date Analyzed	Analyzed by	MDL (ng/L)
89683	Make Up Water	1.27	3/6/2018	8:44		3/13/2018	LC	0.10
89684	Tails Thickener Over	4.85	3/6/2018	9:00		3/13/2018	LC	0.10
89685	Field Blank	< 0.500	3/6/2018	9:05		3/13/2018	LC	0.10

Reported by: ____________

Reviewed by: ____________

If you have any questions or feedback please call
Chris Gross or Linda Christensen at 218-729-4658.

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North Shore Analytical, Inc.
4511 W. 1st St., Suite #1
Duluth, MN 55807
Phone (218) 729-4658
Fax (218) 729-4659

ship to

Record # : 21798

STF-COC-001
Revision Number: 7
Revision Date: 01/31/2017

Chain of Custody

Client Name: BARR ENGINEERING
Address: 325 S LAKE AVE SUITE 700
City: DULUTH
State: MN
Zip: 55802
Report to: JIM TORALDSON
RYAN SIATZ
Phone: 218 529 7138
Email: JTORALDSON@barr
rsiatz@bar
Sampled by:
Project: Minorca Hg test

NSA Lab #	Bottle #	Client Sample Identification	Date Collected	Time Collected	Matrix	Sample Type		Container/ Preservation	Analysis Requested*
						Grab	Composite		
89683	732.75	Make up water	3/6/18	0844	WW	X		NA	LLHg-1631E
89684	141.42	TAILS THICKENER OVER		0900	WW	X		NA	LLHg-1631E
89685	142.42	FIELD BLANK		0905	WW	X		NA	LLHg-1631E

Transfer #	Relinquished By	Date	Time	Accepted By	Date	Time	Condition
1		3/6/18	1030		3-7-18	10:43	ok
2							
3							

Lab use | Logged in by (Initial): LH | 3-7-18 | 11:14 | Filtered by (Initial): | Lot #:

ADDITIONAL COMMENTS:

*** "LLHg," "mercury," or "Low-level mercury" = USEPA Method 1631E**

Low-level mercury bottles supplied by North Shore Analytical? Y N

KEY:

Matrix:
SW = Surface Water
WW = Wastewater
P = Precipitation
DI = Deionized water
GW = Ground Water
DW = Drinking Water
S = Solid/sediment/soil

Containers:
P = Plastic
G = Glass
B = Plastic Bag
T = Teflon/Fluoropolymer

Preservation:
NA = None Added
H = Hydrochloric Acid
B = Bromine Monochloride
I = ice

Lab use only

North Shore
Analytical, Inc.

4511 W. 1st St., Suite #1, Duluth, MN 55807

MDH Lab # 027-137-389
WDNR Lab # 399017190

Analytical Report

Project: Minorca Scrubber Solid Hg Reduction

Barr Engineering
ATTN: Jim Taraldsen
325 S Lake Ave, Suite 700
Duluth MN 55802

jtaraldsen@barr.com

Chain of Custody # 21830

Report Date: 3/20/2018

Sample Receipt Date: 3/14/2018

EPA Method 1631E

Method Blanks (ng/L): < 0.100, < 0.100, < 0.100

Sample #	Client Sample ID / (dilution factor)	Mercury (ng/L)	Collection Date	Collection Time	Sampled By	Date Analyzed	Analyzed by	MDL (ng/L)
89803	#2 Tails Thickner Overflow	5.59	3/13/2018	9:17	CA/SS	3/19/2018	LC	0.10
89804	Field Blank	< 0.500	3/13/2018	8:54	CA/SS	3/19/2018	LC	0.10
89805	#10 Make Up H2O	1.01	3/13/2018	8:56	CA/SS	3/19/2018	LC	0.10

Reported by: ______

Reviewed by: ______

If you have any questions or feedback please call

Chris Gross or Linda Christensen at 218-729-4658.

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North Shore Analytical, Inc.
4511 W. 1st St., Suite #1
Duluth, MN 55807
Phone (218) 729-4658
Fax (218) 729-4659

Record # : 2R30

STF-COC-001
Revision Number: 7
Revision Date: 01/31/2017

Chain of Custody

Client Name: Barr Engineering
Address: 325 South Lake Avenue
City: Duluth
State: MN
Zip:
Report to: Ryan Siats
Phone:
Email: rsiats@barr.com
Sampled by: CA/SS
Project: Minorca Scrubber Solid Hg Reduction

NSA Lab #	Bottle #	Client Sample Identification	Date Collected	Time Collected	Matrix	Sample Type: Grab	Sample Type: Composite	Container/ Preservation	Analysis Requested*
89803	135.42	#2 Tails Thickner OverFlow	3-13-18	0917	W	~~X~~	X	NA	LL Hg 1631E
89804	129.42	Field Blank		0854	W	X			LL Hg 1631E
89805	100546	#10 Makeup H2O		0856	W		X		LL Hg 1631E

Transfer #	Relinquished By	Date	Time	Accepted By	Date	Time	Condition
1	-NTS	3-13-18	1030		3/14/18	1015	ok
2							
3							

Lab use | Logged in by (Initial): he 3/15/18 | Filtered by (Initial): | Lot #:

ADDITIONAL COMMENTS: Shipped Out By Fed Ex

* "LLHg," "mercury," or "Low-level mercury" = USEPA Method 1631E

Low-level mercury bottles supplied by North Shore Analytical? 135-42 129-42 [✓ Y] [✓ N] 100846

KEY:

Lab use only

Matrix:
SW = Surface Water
WW = Wastewater
P = Precipitation
DI = Deionized water
GW = Ground Water
DW = Drinking Water
S = Solid/sediment/soil

Containers:
P = Plastic
G = Glass
B = Plastic Bag
T = Teflon/Fluoropolymer

Preservation:
NA = None Added
H = Hydrochloric Acid
B = Bromine Monochloride
I = ice

North Shore
Analytical, Inc.
4511 W. 1st St., Suite #1, Duluth, MN 55807

MDH Lab # 027-137-389
WDNR Lab # 399017190

Analytical Report

Project: Minorca Hg Test

Barr Engineering
ATTN: Jim Taraldsen
325 S Lake Ave, Suite 700
Duluth MN 55802

jtaraldsen@barr.com

Chain of Custody # 21929

Report Date: 4/19/2018

Sample Receipt Date: 4/11/2018

EPA Method 1631E

Method Blanks (ng/L): < 0.100, < 0.100, < 0.100

Sample #	Client Sample ID / (dilution factor)	Mercury (ng/L)	Collection Date	Collection Time	Sampled By	Date Analyzed	Analyzed by	MDL (ng/L)
90186	Make Up Water	0.530	4/11/2018	8:50	NTS/Minorca	4/19/2018	LC	0.10
90187	Trails Thickener Over	2.08	4/11/2018	9:11	NTS/Minorca	4/19/2018	LC	0.10
90188	Field Blank	< 0.500	4/11/2018	8:55	NTS/Minorca	4/19/2018	LC	0.10

Reported by: ______________________

Reviewed by: ______________________

If you have any questions or feedback please call
Chris Gross or Linda Christensen at 218-729-4658.

7

North Shore Analytical, Inc.
4511 W. 1st St., Suite #1
Duluth, MN 55807
Phone (218) 729-4658
Fax (218) 729-4659

Ship to:

Record # : 21929

STF-COC-001
Revision Number: 7
Revision Date: 01/31/2017

Chain of Custody

Client Name: Barr Engineering
Address: 325 S Lake Ave Suite 700
City: Duluth
State: MN
Zip: 55802
Report to: JIM TORALDSON RYAN SIATZ
Phone: 218 529 7138
Email:
Sampled by: NTS/MINORCA
Project: MINORCA Hg Test

NSA Lab #	Bottle #	Client Sample Identification	Date Collected	Time Collected	Matrix	Sample Type: Grab	Sample Type: Composite	Container/ Preservation	Analysis Requested*
90186	120.43	MAKE UP WATER	4/11/18	0850	WW	X		NA	LL Hg - 1631E
90187	119.43	TAILS THICKENER OVER	|	0911	WW	X		|	|
90188	122.43	FIELD BLANK	|	0855	WW	X		|	|

Transfer #	Relinquished By	Date	Time	Accepted By	Date	Time	Condition
1	Katrina E.	4/11/18	1502		4/11/18	1505	ok
2							
3							

Lab use Logged in by (Initial): LH 4-12-18 9:08 Filtered by (Initial): Lot #:

ADDITIONAL COMMENTS:

*** "LLHg," "mercury," or "Low-level mercury" = USEPA Method 1631E**

Low-level mercury bottles supplied by North Shore Analytical? [✓ Y] N

KEY:
Lab use only

Matrix:
SW = Surface Water
WW = Wastewater
P = Precipitation
DI = Deionized water
GW = Ground Water
DW = Drinking Water
S = Solid/sediment/soil

Containers:
P = Plastic
G = Glass
B = Plastic Bag
T = Teflon/Fluoropolymer

Preservation:
NA = None Added
H = Hydrochloric Acid
B = Bromine Monochloride
I = ice

Appendix B-5-4

Summary of Emissions Speciation Change on Potential Mercury Loading to Northeast Minnesota

December 14, 2018

resourceful. naturally.
engineering and environmental consultants
BARR

Technical Memorandum

To: Minnesota Taconite Industry
From: Cliff Twaroski
Subject: Summary of emissions speciation change on potential mercury loading to northeast Minnesota
Date: December 14, 2018
Project: 23692040.00
c: Ryan Siats, Paul Taylor, Keith Hanson, Todd Fasking

Executive Summary

The effects of long-term application of activated carbon injection and halide injection with existing wet scrubbers on taconite furnaces were evaluated for overall reductions in mercury air emissions and related changes in speciation that could result in more local deposition. Important findings include:

- Both long-term activated carbon injection and halide injection resulted in reductions in the mass of mercury emissions, with an average reduction of about 20% and 27%, respectively, from existing conditions.
- Long-term application of activated carbon injection resulted in increased particle-bound mercury emissions, on both a percentage and mass basis.
- Long-term application of halide injection resulted in increased emissions of both oxidized and particle-bound mercury. Both species increased on a percentage and mass basis.

Given the propensity for particle-bound and/or oxidized mercury to deposit near an emission point, the increase in mass of oxidized and particle-bound mercury emissions is expected to result in more local deposition (i.e., increased loading of mercury) near an emission source and most certainly within northeast Minnesota. An increase in mercury loading to northeast Minnesota is inconsistent with the Statewide Mercury Total Maximum Daily Load (TMDL) study that requires a reduction in loading in order to reduce fish tissue mercury concentrations. The relatively small reduction in total mercury emissions and the increased local deposition of oxidized and/or particle-bound mercury and the bioavailability of those species indicate that adverse local/regional environmental impacts would be expected. Therefore, neither activated carbon injection nor halide injection with existing wet scrubbers should be considered applicable control technologies for the taconite industry.

Introduction

This memorandum is an evaluation of the potential change in mercury loading to the local environment due to a change in speciation of air emissions when using certain emission reduction control technologies. The information presented below pertains to the injection of 1) activated carbon and 2) halides (as dissolved calcium bromide, $CaBr_2$) into the waste gas stream of an indurating furnace and the resulting change in mercury speciation. The discussion and screening calculations presented in this technical memorandum are generally relevant to other technologies that would shift speciated mercury emissions toward a greater percentage of particle-bound and/or oxidized mercury.

This assessment relies on information from the Statewide Mercury Total Maximum Daily Load (TMDL) study because it provides the Minnesota Pollution Control Agency's (MPCA) rationale regarding the linkage of mercury air emissions and atmospheric loading to Minnesota's water bodies and the potential atmospheric loading of mercury to Minnesota's environment after controls are implemented by various industry sectors (MPCA 2007).

The TMDL-related information (MPCA 2007) is used to evaluate whether use of activated carbon injection (ACI) or halide injection with the existing scrubbers produce results that are consistent with the TMDL's goals with respect to 1) reducing mercury air emissions from in-state sources, and 2) reducing mercury atmospheric loading to Minnesota's environment.

Mercury Speciation and Relationship to Local Deposition

Mercury air emissions generally exist as one of three species: elemental, ionic or oxidized, and particle-bound. Understanding which species are present is the key to determining mercury's atmospheric pathway, transport, and fate. As summarized by the Arctic Monitoring and Assessment Program/United Nations Environment Programme (AMAP/UNEP 2013, at P. 38), the majority of anthropogenic mercury emissions and the most common species present in the atmosphere is gaseous elemental mercury. Elemental mercury has an atmospheric lifetime of several months to a year and is transported great distances. Elemental mercury when emitted to the atmosphere can readily travel for hundreds to thousands of miles (Florida DEP 2013, at P. 16). Due to its elemental properties and slow reaction with common atmospheric oxidants, very little if any gaseous elemental mercury is deposited to the earth's surface (AMAP/UNEP 2013, at P. 38). It should be noted that the deposition of elemental mercury is more important in the Arctic regions. Obrist et al. (2017) identified most of the mercury (~70%) in the interior Arctic tundra is derived from the atmospheric deposition of gaseous elemental mercury and has resulted in elevated mercury concentrations in surface soils. However, in the temperate zone, which encompasses Minnesota, studies to date indicate that direct gaseous elemental mercury deposition is not a major contributor to total mercury deposition. However, deposition of elemental mercury to terrestrial forested systems does occur via stomatal uptake by trees (Grigal 2003) with a small portion of that elemental mercury ultimately being sequestered in the soil. The calculations in the MPCA's Mercury Risk Estimation Method (MMREM, MPCA 2006a) indirectly account for local deposition of elemental mercury. Therefore, as shown later in this technical memorandum, a small amount of elemental mercury emissions has been estimated to be locally deposited to reflect the potential uptake of elemental mercury by forest vegetation and deposition via litterfall (Grigal 2003).

Mercury deposition to land and water is predominantly in the form of oxidized mercury compounds, gaseous oxidized mercury or oxidized mercury attached to particles, both of which are due to the direct deposition of gas phase species, and through wet deposition of oxidized mercury in precipitation (AMAP/UNEP 2013, at P. 38). Ionic mercury, as a large ion, readily binds to other materials from associated emissions and as well as other materials in the atmosphere (Florida DEP 2013, at P. 16). Further, gaseous oxidized mercury is highly reactive with other environmental constituents and is deposited within a few miles of its emission point (Florida DEP 2013, at P. 16). Particle-bound mercury has a short atmospheric life due its physical characteristics (mass, increased wind resistance, interaction with precipitation) and is thought to be deposited in a range of 30-50 miles from the emission point (Florida DEP 2013, at P. 16).

In the Statewide Mercury TMDL study (MPCA 2007) and TMDL Implementation Plan (MPCA 2009), during development of the 2014 Minnesota Mercury Rule (MPCA 2013), and in other mercury-related supporting documents, the MPCA has acknowledged that about 90% of the mercury deposition in the state originates from other international and regional sources. Therefore, only about 10% of the mercury deposition in the state originates from Minnesota sources (MPCA 2007). Because elemental mercury has a long atmospheric lifetime and is transported great distances, it is likely that it constitutes most of the mercury derived from international and regional sources. MPCA (2007) further stated that no "hot-spots" of deposition had been identified based on their review and assessment of available data used to develop the TMDL.

The MPCA (2006b) identified mercury speciation for the Minnesota taconite industry as follows: 93% elemental, 6% oxidized, and 1% particle-bound. The emphasis here is on the small percent of oxidized and particle-bound mercury associated with the current (i.e. existing conditions) taconite industry emissions. Speciation of emissions for the Minnesota taconite industry based on more recent stack testing data is provided in Table 1 and is similar to that estimated by the MPCA (2006b).

Emission Speciation Change with Control Technology Application

During recent, long-term testing at the taconite facilities where ACI or halide injection was applied prior to the furnace exhaust gas entering the existing wet scrubbers, a relatively small reduction in total mercury emissions was found. Average total mercury emissions reductions were approximately 20% for ACI (range of 0% to 40% reduction) (Barr Eng. 2018a, 2018b) and about 27% for halide injection (range of approximately 22% to 33%; UTAC 2018; Barr Eng. 2018a, 2018c). However, for both control technologies, there was a large change in mercury speciation as compared to existing conditions.

Table 1 Comparison of mercury emissions speciation for the taconite industry.

Source of Mercury Emissions Speciation	**Elemental**	**Oxidized**	**Particle-bound**
Existing Conditions: MPCA (2006b)[1]	93%	6%	1%
Existing Conditions: Industry Average, MN [2]	87%	11%	2%
Average Conditions: MPCA and Industry	90%	8.5%	1.5%
Application of Control Technology			
Activated carbon injection [3]	60%	7%	33%
Halide injection – long-term testing			
Ontario Hydro Results [4]			
Hibtac	21%	72%	7%
Minntac	83%	16%	1%
Average	52%	44%	4%
Method 29 Results [4]			
UTAC	--	--	8%
Halide injection – short-term testing, average [5]	--	41%	--

[1] Mercury speciation data for the taconite industry was provided to Barr Engineering Company by the MPCA (2006b): 93% elemental, 6% oxidized, and 1% particle-bound.

[2] For the Minnesota taconite industry, representative mercury speciation for existing conditions is based on Ontario Hydro stack test data for:
Hibtac, Line 2, Ontario Hydro Method, 2016 (September); 89% elemental, 11% oxidized, <1% particle-bound (Barr Eng. 2018a)
Hibtac, Line 2, Ontario Hydro Method, 2017 (September); 88% elemental, 12% oxidized, <1% particle-bound (Barr Eng. 2018a)
Minntac, Line 6, Ontario Hydro Method, 2018 (April); 85% elemental, 10% oxidized, 5% particle-bound (Barr Eng. 2018b)
Stack test results were averaged for the two facilities.

[3] For the Minnesota taconite industry, representative mercury speciation associated with the activated carbon injection control technology was based on stack test data for:
Hibtac, Line 2, ACI rate = 1 lb/mmacf, Ontario Hydro Method, October 2016; 43% elemental, 4% oxidized, 54% particle-bound (Barr Eng. 2018a)
Hibtac, Line 2, ACI Rate = 1 lb/mmacf, Ontario Hydro Method, November 2016; 83% elemental, 7% oxidized, 10% particle-bound (Barr Eng. 2018a)
ArcelorMittal Minorca Mine Inc., Line 1, ACI rate = 1 lb/mm acf, Ontario Hydro Method, 2017 (February); 55% elemental, 11% oxidized, 34% particle-bound (Barr Eng. 2018c)
Stack test results were averaged for the two facilities for application of activated carbon.

[4] For the Minnesota taconite industry, speciation associated with the halide injection control technology (dissolved calcium bromide ($CaBr_2$)) was based on stack test data for:
Hibtac, Line 2, Ontario Hydro Method, October/November 2017.
Change in emissions speciation with long-term testing:

Test Condition	Injection Rate (gallons/hour)	Injection Location	Elemental	Oxidized	Particle-Bound
Baseline	N/a	N/a	87.5%	11.6%	0.5%
Long-term	2	Preheat zone	20.6%	71.9%	7.1%

Minntac, Line 6, Ontario Hydro Method, Baseline, April 2018; Long-term test, June/July/August 2018.
Change in emissions speciation with long-term testing:

Test Condition	Injection Rate (gallons/hour)	Injection Location	Elemental	Oxidized	Particle-Bound
Baseline	N/a	N/a	85.2%	10.0%	4.8%
Long-term	0.75	Initial down draft drying zone (DDD1)	83.1%	15.5%	1.4%

UTAC, Stack 2A, Method 29, Baseline, November 2017; Long-term test, December 2017/January 2018.
Change in particle-bound mercury emissions speciation with long-term testing of halide injection. Halide injection occurred in the transition zone between the grate and the kiln. This data is to provide additional support that halide injection results in more particle-bound mercury emissions in addition to more oxidized mercury emissions.

Halide Test Date	Pellet Production	Test Condition	Injection rate (gallons/ hour)	Elemental	Oxidized	Particle-Bound
December 2017/ January 2018	Standard, Recycle Scrubber Solids	Baseline	N/a	--	--	0.5%
		Long-term	4.5	--	--	7.8%

[5] Change in oxidized mercury (percentage basis) during short-term testing conducted in 2007 to 2009 by the MNDNR (2011). Testing used a continuous emission monitoring system (CEMS). Company names as used in Table 1 of the MDNR (2011) report.

Test Condition	Keewatin Taconite	Hibbing Taconite (Line 3)	Minntac (Line 3)	ArcelorMittal	United Taconite (Line 2, Stack A)	United Taconite (Line 2, Stack B)	Average
Type of Pelletizer	Grate kiln	Straight grate	Grate kiln	Straight grate	Grate kiln		
Baseline, Oxidized	20%	19%	12%	14%	13%	22%	17%
Halide injection 1. gallons/hour 2. pounds/hour (dry weight basis)	24	60	3.6	5.4	36-48	36-48	-- --
Location of Injection	Flame end of kiln	Second "down comer" location above preheat zone	Flame end of kiln	Second "down comer" location above preheat zone	Flame end of kiln	Flame end of kiln	
Test, Oxidized	54%	NA	36%	25%	46%	44%	41%

During the long-term ACI testing with a low application rate (one pound per million actual cubic feet of air; 1 lb/mmacf), the percentage of particle-bound mercury emissions increased from ~2% to 33% of the total mercury emitted (Table 1). For Hibbing Taconite Company (Hibtac), ACI resulted in approximately a factor of 90 increase in the mass of particle-bound mercury emissions (Barr Eng. 2018a).

During the long-term halide injection testing, a significant increase in the average oxidized speciation percentage was also observed (from ~11% to 44%) along with a smaller increase in the average particle-bound speciation (from ~2% to 4%) (Table 1). It is noted that both Hibtac and United Taconite (UTAC) found an increase in the percentage of particle-bound mercury emissions from 0.5% to about 7 to 8%, respectively, providing additional evidence that halide injection likely significantly increases particle-bound mercury speciation (Table 1, Footnote 4). For oxidized mercury speciation, United States Steel Corporation, Minnesota Ore Operations - Minntac (Minntac), observed a smaller increase during its long-term halide testing than what was measured during Hibtac's long-term halide test. Minntac also observed a smaller change in oxidized mercury speciation from what had been previously observed during short-term testing conducted from 2007 to 2009 at several taconite facilities (Minntac; Hibtac; ArcelorMittal Minorca Mine (Minorca); UTAC, and United States Steel Corporation, Minnesota Ore Operations – Keetac (Keetac)) as reported by the MDNR (2011). However, as shown in Table 1, the average percentage increase in oxidized mercury speciation during halide testing is significant with a smaller but notable increase in particle-bound mercury speciation when including the changes observed during UTAC's testing (Table 1, Footnote 4).

Overall, the mercury emission speciation data for the ACI and halide injection control technologies presented in Table 1 are considered to represent the range of potential values that taconite facilities would expect to experience if they were to use these technologies. The weight-of-evidence in the available literature is that ACI results in significantly more particle-bound mercury speciation and that halide injection results in a significant increase in oxidized mercury speciation from combustion processes (e.g., MDNR 2011; MDNR 2012). The expectation is that taconite facilities would experience a similar significant increase in emissions of particle-bound and/or oxidized mercury (MDNR 2007). The potential increase in particle-bound mercury speciation when applying ACI to the taconite industry is expected to be similar to the average for the long-term testing (Table 1). Similarly, the potential increase in oxidized mercury speciation when applying halide technology to the taconite industry, in general, is expected to be similar to the average for the long-term testing (~44%) shown in Table 1, with a potential increase in oxidized mercury speciation as high as observed at Hibtac (72%). As shown for ACI and for both short-term (MDNR 2011) and long-term halide injection testing (Table 1), the control technologies result in an increased percentage of particle-bound and/or oxidized mercury emissions. This increase in the percentage of particle-bound and/or oxidized mercury results in an overall increase in the mass of those mercury species emitted to the air (Barr Eng. 2018a, 2018b, 2018c, 2018d). The changes in speciated mercury mass emission rates and deposition from using activated carbon injection and halide injection technologies on taconite furnaces are further discussed below.

Activated Carbon Injection and Potential for Increased Local Mercury Deposition

Data from Albemarle (2018) indicates that for HPAC (high temperature brominated powdered activated carbon) and BPAC (brominated powdered activated carbon), the mean particle size for coconut-based carbon is 17.3 microns (distribution range (in microns): D10 = 2.7, D50 = 14.2, D90 = 35.4). The interpretation is that the carbon particles are "large".

The settling velocity of a particle increases with size, and, therefore, larger (coarse) particles, typically greater than 10 microns, settle out of the air relatively quickly. These coarse particles tend to deposit locally, with the larger particles (greater than 20 microns) depositing relatively close to an emission source (U.S. Environmental Protection Agency, (USEPA) 1995; USEPA 2004; Pederson 2006). The overall conclusion from the literature is that the larger the particle, the higher the settling velocity and the less travel distance, resulting in more particle deposition closer to the emission source. While dry activated carbon particles prior to injection have a lower density (typical particle density of <1 gram per cubic centimeter; g/cm^3) than do mineral particles (typical value for silicate minerals = 2.7 g/cm^3), the larger size (mean = 17.3 microns) increases the potential for deposition closer to an emission source. The addition of adsorbed moisture and mercury sorbed after injection increases the mass of the carbon particles, thereby also increasing the potential for the particles to settle out of the atmosphere faster and therefore, closer to an emission source.

In previous assessments of potential mercury loading to nearby lakes from new or expanding sources (e.g., Essar Steel), the deposition (settling) velocity assigned to particle-bound mercury was 0.05 centimeters per second (cm/sec) (MPCA 2006a), which is indicative of fine particles (2.5 microns and smaller). For Best Available Retrofit Technology (BART) modeling, coarse particles (>2.5 microns, but <10 microns) were assigned a settling velocity of 1.67 cm/sec (VISTAS 2005). Based on the work of Lim et al. (2006), the potential settling velocity for an activated carbon particle can be estimated from a similar sized mineral particle[1]. A typical PM_{10} mineral particle from taconite processing has an estimated settling velocity of 1.67 cm/sec and a density of 2.7 g/cm^3. On that basis, the settling velocity of a similar-sized activated carbon particle with a density of ~ 1.0 g/cm^3 (potentially accounts for moisture and adsorbed mercury) is estimated to be ~0.6 cm/sec. Larger mineral particles (15 to 20 microns in size) would have a settling velocity greater than 1.67 cm/sec, and likely greater than 2.0 cm/sec (Zhang and He 2014). The potential deposition velocity of larger carbon particles, based on a mineral particle deposition velocity of 2.0 cm/sec, would be approximately 0.7 cm/sec.

When assessing the potential for local deposition, the change in only the settling velocity for particle-bound mercury from 0.05 cm/sec to 0.6 to 0.7 cm/sec (or higher) to account for larger activated carbon particles, could increase loading by a factor of 10 or more. In general, deposition velocity, directly related to loading, increases logarithmically with particle size (Piskunov 2009; Zhang et al. 2001) and suggests a potential increase in particle-bound mercury emissions could increase local deposition by more than a factor of 10. Therefore, when assessing the potential for local mercury deposition (loading), a change in the particle size to greater than 10 microns and the associated increase in settling velocity would be significant with regard to overall mercury loading.

It is also important to recognize that the increase in particle-bound mercury identified in Table 1 (see footnote 3) was associated with a low application rate of ACI, 1 lb/mmacf with existing wet scrubbers. A higher application rate of ACI with the existing wet scrubbers further increased the mass of particulate emissions out of the stack and thus increased the particulate bound mercury emissions as well (Barr Eng. 2018a; 2018b). Therefore, a higher rate of ACI injection with the existing wet scrubbers does not alleviate the problem of increased future particle-bound mercury emissions from taconite furnace and increased deposition to northeast Minnesota.

Halide Injection and Potential for Increased Local Mercury Deposition

As shown in Table 1, halide injection with the existing wet scrubbers resulted in a significant change in emissions speciation for Hibtac, with gas-phase oxidized mercury as the predominant species with a

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[1] Estimated settling velocity of a PM_{10} activated carbon particle = 1.67 cm/sec * 1.0 g/cm^3 / 2.7 g/cm^3 = 0.6 cm/sec
Estimated settling velocity of a PM_{10} activated carbon particle = 2.0 cm/sec * 1.0 g/cm^3 / 2.7 g/cm^3 = 0.7 cm/sec

smaller but notable (and unexpected) increase in particle-bound mercury (from 0.5% to about 7%). Stack testing data from UTAC (2018) also indicates a notable increase in particle-bound mercury (from 0.5% to about 8%) (Table 1, Footnote 4).

Oxidized mercury is water-soluble and is deposited readily through precipitation at the local level (local in this case is within 10, and up to 100 kilometers of, the emission point; USEPA 2006). The local deposition of oxidized mercury and its role in elevated fish tissue mercury concentrations has been documented in several regions of the U.S., for example in the southeast (Florida DEP 2003, Chapter 4) and in New England (Evers et al. 2007; King et al. 2008). In the evaluation by Florida DEP (2003), oxidized mercury accounted for more than 50% of the emissions from the facilities being evaluated. King et al. (2008) found that local mercury deposition due to emissions of oxidized mercury was a factor of 4 to 10 times greater than rural background deposition. Associated with increased local deposition of mercury, fish tissue mercury concentrations were elevated in nearby water bodies (Florida DEP 2003; King et al. 2008). The available literature clearly concludes that an increase in oxidized mercury air emissions will result in increased local mercury deposition.

The discussion of increased particle-bound mercury emissions resulting in increased local/regional deposition related to use of ACI also applies to halide injection. As discussed above, fine sized particles (2.5 micron and smaller) are estimated to have a settling velocity of 0.05 cm/sec (MPCA 2006a) while coarse particles (>2.5 microns, but <10 microns) are estimated to have a settling velocity of 1.67 cm/sec (VISTAS 2005). Both settling velocities, 0.05 cm/sec for fine particles and 1.67 cm/sec for coarse particles, are applicable to the mineral particles emitted from taconite furnaces with halide injection, signaling that some of the fine mineral particles and all of the coarse particles would be likely to settle near the emission source. Therefore, halide injection, with an increase in oxidized and particle-bound mercury emissions, also increases local/regional deposition of both oxidized and particle-bound mercury.

Implications for the Statewide Mercury TMDL Study

An important component of the Statewide Mercury TMDL study (MPCA 2007) was the assumption of proportionality between atmospheric loading (deposition) and fish tissue mercury concentrations. Specifically, the assumption was that an increase in atmospheric mercury loading (deposition) proportionately increases fish tissue mercury concentrations. MPCA's Response to Comments (2014, at P, 16) emphasized that because all forms of mercury cycle in the environment, all forms of mercury, including mercury in its particulate form, represent environmental concerns. Therefore, any increase in mercury loading (deposition) to Minnesota, whether from oxidized or particle-bound mercury, is expected to increase fish tissue mercury concentrations.

The application of ACI with the existing wet scrubbers has been shown to increase the emissions of particle-bound mercury (Barr Eng. 2018a; 2018b). Earlier discussion on the increased settling velocity of large particles and acknowledgement of published literature (e.g., Florida DEP 2003; Evers et al. 2007) that particle-bound mercury is expected to deposit within 30 to 50 miles of the emission source indicates that using ACI technology with existing wet scrubbers on the taconite furnaces will increase local mercury deposition and thereby result in an increase in fish tissue mercury concentrations, which contradicts the stated intent of the Statewide Mercury TMDL study (MPCA 2007).

The application of halide injection with the existing wet scrubbers increased oxidized mercury speciation in both short-term (MDNR 2011) and long-term testing (average of 44% in Table 1), with a significant increase in oxidized mercury emissions on a percentage basis (from 12% to 72%, Table 1) and mass basis (300% increase, Barr Eng. 2018a) from the Hibtac pelletizing process. Long-term testing at Hibtac and UTAC also found a notable increase in particle-bound mercury, from 0.5% to about 8% (Table 1). As previously discussed above, the weight-of-evidence in published literature (e.g., Florida DEP 2003; Evers et al. 2007) concurs that particle-bound and oxidized mercury air emissions are expected to be deposited within miles of the emission source. Local mercury deposition will increase, thereby increasing fish tissue mercury concentrations. Therefore, the expected increase in local mercury deposition associated with the use of halide injection with existing wet scrubbers also contradicts the stated intent of the Statewide Mercury TMDL study (MPCA 2007).

Screening Mercury Mass Loading Calculations - Summary

When estimating Minnesota's contribution to mercury loading (deposition) as part of the Statewide Mercury TMDL study, the MPCA (2007) separated the state into a Northeast Region (which includes the Minnesota taconite facilities) and a Southwest Region (Figure 1). The MPCA (2007) further assumed that in-state emissions disperse across both TMDL regions. However, for this assessment, screening calculations were formulated to estimate the potential atmospheric loading of mercury from the taconite industry to only the Northeast Region because it is most likely to experience increased loading due to more particle-bound mercury with the application of ACI and both more oxidized and particle-bound mercury speciation due to halide injection.

Input data and critical assumptions for the screening calculations are as follow for existing conditions:

1. 1990 mercury emissions
    a. Statewide = 11,271 lbs/yr (~5113.9 kilograms per year, kg/yr)
    b. Taconite industry = 724 lbs/yr (~328 kg/yr).
    Taconite industry emissions ~6.4% of statewide emissions (MPCA 2007, Figure 13).
2. Statewide loading: 1990 atmospheric mercury loading (assumed uniform across the state, MPCA 2007) = 12.5 micrograms per square meter per year (μg/m^2/yr)
    a. 10% of the atmospheric loading due to in-state sources = 1.25 μg/m^2/yr
    b. In-state atmospheric source load (area of both TMDL Regions, 219,825 km^2)
    Load In-State = 1.25 μg/m2/yr * 219,825 km^2 * Conversion Factor (0.001) = 274.8 kg/yr
3. Taconite industry loading, 1990: based on total mercury emissions of 724 lbs/year (328.5 kg/yr), and speciation of those emissions from MPCA (2006b): 93% elemental, 6% oxidized, and 1% particle-bound.
    a. Emissions: estimate of speciated emissions

        i. Elemental = 328.5 kg/yr * 0.93 = 305.5 kg/yr
        ii. Oxidized = 328.5 kg/yr * 0.06 = 19.7 kg/yr
        iii. Particle-bound = 328.5 kg/yr * 0.01 = 3.3 kg/yr
    b. Loading: estimated loading based on emissions speciation
        i. Elemental, some deposits = 1.5 kg/yr
        ii. Oxidized, all deposits = 19.7 kg/yr
        iii. Particle-bound, all deposits = 3.3 kg/yr
        Sum = 24.5 kg/yr
    c. Ratio of MN Taconite industry loading to emissions: 24.5 kg/yr / 328 kg/yr = 0.07

4. TMDL Northeast Region loading
    a. In-state atmospheric source load to Northeast Region (90,151 km^2)
       Load = 1.25 µg/m^2/yr * 90,151 km^2 * Conversion Factor (0.001) = 112.7 kg/yr
    b. Load from taconite industry to Northeast Region = 24.5 kg/yr
       (0.5% of elemental mercury emissions and all (100%) oxidized and particle-bound mercury emissions deposit locally; i.e., within the TMDL Northeast Region)
    c. Ratio of MN Taconite industry loading to in-state loading = 24.5 kg/yr / 112.7 kg/yr = 0.2

For this assessment, potential local deposition of elemental mercury has been estimated for existing conditions as well as the future scenarios (Table 2). USEPA (2005) has stated that vapor-phase elemental mercury is deposited from the air very slowly and may be ignored when considering local deposition. However, as previously discussed, elemental mercury can be taken up by trees via stomatal openings in leaves and the mercury incorporated into those leaves can reach the forest floor where a small amount can become sequestered in soil (Grigal 2003). MPCA's local mercury deposition calculations (MMREM, MPCA 2006a) also estimate a small amount of elemental mercury depositing within 20 kilometers of an emission source (~0.03 to 0.05%). Therefore, even though the estimated potential deposition of elemental mercury is "essentially zero" or deminimis compared to oxidized and particle-bound mercury deposition, Table 2 provides conservative estimates of a small amount of elemental mercury depositing to the TMDL Northeast Region (about 0.5% of elemental mercury emissions). Other factors that limit the local deposition of elemental mercury are taconite furnace stack heights and exhaust gas temperatures that provide "lift" to the emissions plume (i.e., a buoyant plume) to elevate it above the vegetated landscape and provide for good dispersion away from the emission point. Therefore, the estimated 0.5% of elemental mercury emissions potentially depositing to the TMDL Northeast Region is a conservative assumption and likely overestimates potential loading.

Application of ACI or halide injection and the use of existing scrubbers to reduce total mercury emissions potentially changes speciated mercury mass loading (deposition) as summarized in Table 2. Estimated speciated mercury loading for four scenarios are shown in Table 2, the existing conditions scenario (previously described) and three potential scenarios: future TMDL scenario based on calculations from the Statewide Mercury TMDL study (MPCA 2007), future with ACI, and future with halide injection.

Table 2 Summary of potential changes in atmospheric loading of mercury to the TMDL Northeast Region as estimated by the MPCA (2007) and if the taconite industry uses activated carbon injection (ACI) or halide injection as a mercury control technology.

Parameter	Existing Conditions	TMDL Future Assumption	Potential Future (ACI)	Potential Future (halide injection)
MN Taconite Industry: Total Mercury Emissions [1]	724 lbs/yr (328 kg/yr)	138 lbs/yr (63 kg/yr)	579 lbs/yr (263 kg/yr)	529 lbs/yr (240 kg/yr)
Ratio of MN Taconite Mercury Emissions to Total In-State Emissions[1]	0.064	0.17	0.73	0.67
Speciation of Mercury Emissions[2]				
Elemental	93%	93%	60%	52%
Oxidized	6%	6%	7%	44%
Particle-bound	1%	1%	33%	4%
Emissions by Species[2]				
Elemental	305.5 kg/yr	58.2 kg/yr	157.7 kg/yr	124.7 kg/yr
Oxidized	19.7 kg/yr	3.8 kg/yr	18.4 kg/yr	105.5 kg/yr
Particle-bound	3.3 kg/yr	0.63 kg/yr	86.7 kg/yr	9.6 kg/yr
Total Mercury Loading from MN Taconite Industry to TMDL Northeast Region [3]				
Elemental, 0.5% deposits locally	1.5 kg/yr	0.3 kg/yr	0.8 kg/yr	0.6 kg/yr
Oxidized, 100% deposits locally	19.7 kg/yr	3.8 kg/yr	18.4 kg/yr	105.5 kg/yr
Particle-bound, 100% deposits locally	3.3 kg/yr	0.6 kg/yr	86.7 kg/yr	9.6 kg/yr
SUM	24.5 kg/yr	4.7 kg/yr	105.9 kg/yr	115.7 kg/yr
Change in Total Mercury Load from Existing Conditions				
Percentage basis	--	-81%	332%	372%
Factor change	--	0.19	4.32	4.72
Ratio of MN Taconite Industry Mercury Loading to Emissions	0.075	0.075	0.40	0.48
Potential "Net Loading" of Mercury, MN Taconite Industry				
(Net loading represents the % of Total Loading that is potentially bioavailable) [4]	21.3 kg/yr	4.1 kg/yr	20.0 kg/yr	106.2 kg/yr
100% elemental; 100% oxidized; 1% of particle-bound bioavailable	21.6 kg/yr	4.1 kg/yr	27.8 kg/yr	107.1 kg/yr
100% elemental; 100% oxidized; 10% of particle-bound bioavailable	22.1 kg/yr	4.2 kg/yr	40.9 kg/yr	108.5 kg/yr
100% elemental; 100% oxidized; 25% of particle-bound bioavailable	22.9 kg/yr	4.4 kg/yr	62.5 kg/yr	110.9 kg/yr
100% elemental; 100% oxidized; 50% of particle-bound bioavailable				
TMDL, Northeast Region Mercury Load Allocation (LA)[5]				
Total LA (MPCA 2007, Table ES-1)		399.1 kg/yr	399.1 kg/yr	399.1 kg/yr
In-State Contribution (MPCA 2007, Table ES-1)		57.0 kg/yr	57.0 kg/yr	57.0 kg/yr
MN Taconite Industry (estimated)		4,7 kg/yr	4.7 kg/yr	4.7 kg/yr

[1] Estimate of Minnesota taconite industry emissions (rounded to nearest pound or kilogram):

a. Existing conditions emissions for the MN Taconite Industry, approximately 724 pounds per year (lbs/yr) for 1990, are from the Statewide Mercury TMDL study (MPCA 2007). The ratio of MN Taconite industry emissions to total in-state emissions is based on information from Table 12 of the TMDL study (MPCA 2007). All in-state source emissions in 1990 = 11,272 lbs/yr.

b. Future TMDL Scenario: The future TMDL scenario is based on Table 12 of the TMDL study (MPCA's 2007) that estimates reductions in emissions from approximately 723 lbs/yr (1990) to 138 lbs/yr (Target 3) for the Material Processing sector (i.e., taconite processing). The TMDL scenario assumes there is no change in mercury speciation of air emissions that would change the potential atmospheric loading to the TMDL Northeast Region; ratio of loading to air emissions for the TMDL scenario is the same as for existing conditions and atmospheric loading is primarily from oxidized mercury. For the ratio of MN Taconite Industry emissions to all in-state source emissions (Target #3), in-state source emissions for Target #3 = 789 lbs/yr (MPCA 2007, Table 12).

c. Future emissions using ACI with the existing wet scrubbers: estimate of potential future emissions based on an average reduction of 20% for all Hg from stack testing conducted at Hibtac, Line 2, 2016 (Sept., Oct., and Nov.; 40% reduction; details in Barr Eng. 2018a) and Minorca, 2017 (February; 0% reduction; details in Barr Eng. 2018b). Speciation is based on the average for the industry as shown in Table 1. For the ratio of MN Taconite Industry emissions to all in-state source emissions, the in-state emissions for Target #3 of the Statewide TMDL study are used: in-state source emissions for Target #3 = 789 lbs/yr (MPCA 2007, Table 12).

d. Future emissions using halide injection with the existing wet scrubbers: estimate of potential future emissions based on an average total mercury reduction of approximately 27% from testing conducted at Hibtac (Line 2, October/November 2017; ~33% reduction; details in Barr Eng. 2018a), Minntac (July 2018; ~25% reduction; details in Barr Eng. 2018c), and UTAC (2018 testing; 22% reduction; details in UTAC 2018). Speciation is based on the average for the industry as shown in Table 1. For the ratio of MN Taconite Industry emissions to all in-state source emissions, the in-state emissions for Target #3 of the Statewide TMDL study are used: in-state source emissions for Target #3 = 789 lbs/yr (MPCA 2007, Table 12).

[2] Mercury emissions speciation is from Table 1 of this technical memorandum. For existing conditions (as of 1990) and the TMDL Future Assumption scenarios, the speciation is based on information from the MPCA (2006b). Due to rounding of taconite industry total mercury emissions, speciated emissions may not sum to the total mercury emissions estimate.

[3] Speciation of loading to watersheds in the TMDL Northeast Region is based on the following: a) a small amount (about 0.5%) of elemental mercury is estimated to deposit locally/regionally due to stomatal uptake by forest vegetation and subsequent litterfall to the forest floor where a small portion of the mercury is sequestered in the soil (Grigal 2003); b) 100% of oxidized mercury deposits locally based on data and conclusions from the Florida DEP (2013) and AMAP/UNEP (2013); and c) 100% of particle-bound mercury emissions are estimated to deposit locally/regionally based on data and conclusions from the Florida DEP (2013) and AMAP/UNEP (2013).

4] For this assessment, 100% of the elemental mercury deposited via litterfall has the potential to be bioavailable as leaf/litter decomposition is microbially mediated (Fleck et al. 1999); 100% of the oxidized mercury deposited in the TMDL Northeast Region has the potential to be bioavailable. The estimated percent of particle-bound mercury that has the potential to be bioavailable is based on information from the following literature sources.
1% bioavailable, based on Pavlish et al. (2003).
10% bioavailable due to potentially more acidic environmental conditions and biological activity (Gagnon and Fisher 1997; Psarska et al. 2016).
25% and 50% bioavailability: The assumption that 25% to 50% of the mercury associated with atmospherically deposited activated carbon particles could be bioavailable is based on the potential ingestion of particles by biota (Gagnon and Fisher 1997; Psarska et al. 2016), with 50% being considered a reasonable estimate of potential bioavailability.

[5] Load Allocation (LA) is the atmospheric load estimated from in-state and out-of-state sources after implementation of the TMDL study (MPCA 2007, Table ES-1). The in-state source LA = 0.143 * 399.1 kg/yr = 57.0 kg/yr.
For this assessment, the potential allowable LA from the Minnesota taconite industry is estimated by assuming that the future proportion of mercury deposition from speciated taconite mercury emissions is the same as for existing conditions; a ratio of 0.075. The estimated in-state contribution from the taconite industry in the future = 0.075 * 63 kg/yr = 4.7 kg/yr (after control technology applied).

The TMDL scenario in Table 2 is based on MPCA's (2007) estimate that mercury emissions from taconite processing could be reduced from 723 to about 138 lbs/yr (MPCA 2007, Table 12). Further, the TMDL scenario assumed that the application of control technology would result in the same emissions speciation as existing conditions (~93% elemental, ~6% oxidized, and 1% particle-bound), and that atmospheric loading would be primarily from oxidized and particle-bound mercury. Stack testing data collected from ACI and halide injection testing conducted at taconite facilities since 2007clearly shows that the TMDL reduction goal formulated by MPCA (2007) for this sector did not account for changes in mercury speciation caused by the application of certain control technologies and the associated increase in local deposition.

As shown in Table 2, the estimated potential future emissions scenario using ACI with existing wet scrubbers correlates to an estimated reduction in taconite industry total mercury emissions from about 328 kg/yr (existing conditions) to about 263 kg/yr (~20% reduction). However, there would be an estimated increase in atmospheric loading to the TMDL Northeast Region due to the shift towards more particle-bound mercury emissions with the application of ACI with the existing scrubbers. The potential increase in atmospheric loading (local mercury deposition) with the application of ACI (105.9 kg/yr) is estimated to be 4.3 times greater (i.e., an increase of 332%) than estimated for existing conditions (24.5 kg/yr) (Table 2, Footnote 2), due to the increase in particle-bound mercury that would be deposited closer to the emission source. This shift in mercury speciation due to ACI would significantly increase the ratio of deposition to emissions for taconite furnaces from 0.07 under existing conditions to 0.4 (i.e., approximately 40% of emissions would deposit to the TMDL Northeast Region compared to about 7% under existing conditions).

As shown in Table 2, the estimated potential future emissions scenario using halide injection with existing wet scrubbers correlates to an estimated reduction in taconite industry total mercury emissions from about 328 kg/yr (existing conditions) to 240 kg/yr (~27% reduction). However, there would be an estimated increase in atmospheric loading to the TMDL Northeast Region due to the shift towards more oxidized and particle-bound mercury. The potential increase in atmospheric loading (local mercury deposition) with the application of the halide injection control technology (115.7 kg/yr) is estimated to be 4.7 times greater than estimated for existing conditions (24.5 kg/yr) (Table 2). This shift in mercury speciation due to halide injection would significantly increase the ratio of deposition to emissions from 0.07 under existing conditions to 0.48 (approximately 48% of mercury emissions would deposit to the TMDL Northeast Region in the future scenario compared to about 7% under existing conditions).

Due to the emissions speciation change to more particle-bound mercury with ACI and more oxidized mercury with halide injection, the estimated future atmospheric mercury loading from the taconite industry (105.9 and 115.7 kg/yr, respectively; Table 2) would be greater than the TMDL Load Allocation (LA) for the Northeast Region (57 kg/yr; MPCA 2007). MPCA (2007) estimated a total LA for the TMDL Northeast Region (57 kg/yr), but did not allocate load by industry sector. For this assessment, an estimated LA for the taconite industry of 4.7 kg/yr (after controls) was based on the assumption (future TMDL scenario) that the deposition of mercury emissions from taconite processing to the TMDL Northeast Region would be reduced from current deposition rates in proportion to the reduction in total mercury emissions (Table 2, footnote 5). The estimated LA of 4.7 kg/yr for the taconite industry (after control) provides a relative measure to compare potential atmospheric loading from the application of the activated carbon control technology and the halide injection control technology to existing conditions and to the anticipated reductions estimated for taconite processing in the TMDL study (MPCA 2007; Table 12). As shown in Table 2, the potential atmospheric loading of 105.9 kg/yr from the application of the activated carbon control technology and the 115.7 kg/yr from the application of halide injection would be well above the estimated TMDL future goal LA of 4.7 kg/yr.

For the potential future scenarios with application of ACI or halide injection with the existing scrubbers, when applying the proportionality concept advocated by the MPCA in conducting the TMDL study (MPCA 2007; MPCA 2014), the estimated increased loading associated with the increase in particle-bound and oxidized mercury emissions (Table 2) would result in an increase in fish tissue mercury concentrations.

Bioavailability of Mercury: Oxidized, and Adsorbed to Activated Carbon Particles

As discussed by Evers et al. (2007), once mercury is emitted to the atmosphere and deposited to the landscape, the potential for biological uptake of that mercury depends on several factors, including the rate of deposition, site-specific characteristics such as landscape sensitivity (e.g., presence of methylation sites such as wetlands) and water level fluctuations in waterbodies including wetlands.

In the case of oxidized mercury associated with halide injection, the potential future deposition is higher than estimated for existing conditions by a factor of 4.9 (Table 2). With regard to landscape sensitivity, Evers et al. (2007) states that landscapes with shallow hydrologic flow paths (e.g., shallow soil over bedrock), the presence of wetlands, and unproductive surface waters facilitate the transport, methylation, and bioconcentration of mercury in surface waters. All of these landscape features are present in the TMDL Northeast Region, which makes northern Minnesota a “sensitive landscape” according to the criteria in Evers et al. (2007). When a potential increase in oxidized mercury emissions is coupled with deposition to a sensitive landscape, there is a high probability that increased mercury cycling in the food chain will occur (Florida DEP 2003; Evers et al. 2007). Atmospheric loading of oxidized mercury near emission sources has been documented to directly affect fish tissue mercury concentrations (USEPA 1997; Florida DEP 2003; Evers et al. 2007; King et al. 2008).

While the increase in mercury bioavailability associated with oxidized mercury has been documented, the potential increased bioavailability of mercury bound to activated carbon particles is uncertain. The environment tends to sequester mercury such that mercury associated with particles in general is subject to several loss mechanisms that result in only a small portion of the mercury becoming bioavailable. An important loss mechanism is burial in terrestrial and aquatic systems where Brigham (1992), Engstrom and Swain (1997), Watras et al. (2000), Engstrom et al. (2007) and Watras and Morrison (2008) found that most (~90%) of the atmospheric load of mercury (including particle-bound mercury) deposited to a lake system is sequestered by the sediments. For mercury deposited to watersheds (upland/wetland environments), forest and wetland soils are net accumulators of atmospherically deposited particles (Grigal 2002; Grigal 2003). On a watershed basis, mass balance calculations by Grigal (2002) indicate that about 90% (range of 84% to 97%) of the atmospheric mercury load is not available for cycling due to volatilization loss or sequestering in soil, with only about 10% (range of ~3% to 16%) being potentially available for cycling and methylation in the environment.

In wetlands, an additional post-depositional loss of mercury sometimes occurs due to water level fluctuations that move atmospherically deposited mercury (e.g., particle-bound mercury) downward in the soil profile where anaerobic conditions persist (i.e., oxygen is limited; Haberer et al. 2011) and particle weathering is severely limited (Rausch et al. 2005a). However, in some cases, mineral particle weathering can occur relatively quickly, even though the time period is short (Rausch et al. 2005b; Hansson et al. 2014). It is uncertain if activated carbon particles would weather similar to the mineral particles assessed by Rausch et al. (2005a; 2005b).

In upland soils, the forest floor (organic layer overlying the mineral soil) and the upper 12 inches of the mineral soil are considered an oxygenated environment (Pritchett 1979) and any particles atmospherically deposited would have the potential to weather for longer periods of time (months to years).

Pavlish et al. (2003) found that mercury was adsorbed tightly to activated carbon particles and that less than 1% of the mercury was released during leaching tests conducted at pH 5.0. It is uncertain if acidic conditions (pH 3.5 to 4 in coniferous bogs to pH 5.5 in typical surface mineral soils) and the presence of soluble organic compounds with reduced sulfur groups (Xia et al. 1999; Skyllberg et al. 2000) would result in more mercury release from activated carbon particles. Mercury in both upland and wetland soils is mainly bound to reduced sulfur groups in soil humic substances (Xia et al. 1999; Skyllberg et al. 2000). The binding constants for mercury and reduced sulfur groups (log K_{Hg} ranges from 32 to 38, Skyllberg et al. 2000) are many orders of magnitude higher than those for mercury with other organic functional groups. This suggests that organic sulfur groups present in soil organic matter may complex mercury bound to activated carbon particles and simply out-compete the activated carbon-mercury bonds to remove mercury from the activated carbon surface. Mercury originally bound to activated carbon particles may, over time, migrate to reduced sulfur groups in both humic (solid phase) and fulvic (soluble) organic substances, thus enhancing the potential for release of mercury from activated carbon particles and its incorporation into the aquatic mercury cycle.

Biological activity in soil and sediment is also expected to release some of the particle-bound mercury. While the binding of mercury to particles is typically strong (Pavlish et al. 2003; Gagnon and Fisher 1997), Gagnon and Fisher (1997) also found that ingestion of particles by benthic organisms resulted in a higher exposure to mercury and elevated mercury concentrations within the test organisms. Similar to sediments, the biological cycling of mercury in soils is also important. Psarska et al. (2016) estimated that in northern Minnesota soils, earthworms consuming forest floor organic matter had increased exposure to mercury and that an additional 35% to 65% of the forest floor mercury was added to the upper mineral soil. It is possible that biota in the surface soil (organic layer and upper portion of the mineral soil) could ingest activated carbon particles and thereby release some of the bound mercury to participate in the geochemical cycling of mercury in surface soil. Therefore, while mercury may be strongly adsorbed to activated carbon particles or other particles in the environment, there is a potential for that mercury to be released through ingestion of particles by soil or sediment-dwelling organisms and then become part of the aquatic mercury cycle (USEPA 1997).

The available literature does not support an assumption of 100% bioavailability of the mercury bound to activated carbon particles. However, there is likely to be some release of the particle-bound mercury and some portion would become bioavailable. For the current calculations, a range of potential bioavailability was used: 1%, 10%, 25%, and 50%. The assumption that 1%, 10%, 25%, and 50% of the mercury associated with atmospherically deposited activated carbon particles could be bioavailable is based on the potential ingestion of particles by biota. In addition to ingestion by biota, mercury bioavailability may increase because of the high affinity of mercury for reduced sulfur and other functional groups on soil organic matter as described above. This affinity could result in mercury being extracted from the activated carbon particles, making it more bioavailable than currently estimated. Therefore, the estimate of 50% of the particle-bound mercury being bioavailable in this assessment is considered reasonable and conservative, but at the same time it may also underestimate potential bioavailability of the particle-bound mercury.

As shown in Table 2 (Potential Future (ACI)), if most of the mercury remains adsorbed to activated carbon particles (only 1% potentially bioavailable), then the potential future "net loading" associated with ACI would remain essentially neutral compared to loading from existing conditions (elemental + oxidized + particle-bound in existing conditions = 21.3 kg/yr versus 20.0 kg/yr for the future condition). However, if only a relatively small percent (~10% to 25%) of the mercury associated with activated carbon particles were to become bioavailable, the potential "net loading" from the taconite industry (~28 to 41 kg/yr, respectively) to the TMDL Northeast Region would increase above existing conditions (Table 2). Under the assumption that 50% of the mercury associated with activated carbon particles becomes bioavailable, then the estimated potential "net loading" from the taconite industry would be a factor of about 3 greater than the loading of existing conditions (a potential future load of ~62.5 kg/yr versus estimated existing conditions loading of ~22.9 kg/yr) (Table 2). Based on the assumption of proportionality (MPCA 2007), this potential change in mercury loading from particle-bound mercury would be expected to increase fish tissue mercury concentrations.

Summary

Screening calculations were conducted to identify if a change in speciation of mercury emissions to more particle-bound or oxidized mercury would increase mercury deposition to aquatic and terrestrial ecosystems. The input data used for the screening calculations are derived from the Statewide Mercury TMDL study (MPCA 2007), the assumption of proportionality between mercury emissions and atmospheric loading (deposition), and industry stack test data (Ontario Hydro method) that demonstrates the change in mercury emissions speciation with the application of ACI or halide injection with existing scrubbers.

Based on the input values, the results of the screening calculations indicate that the long-term application of ACI prior to furnace exhaust gas entering the existing wet scrubbers as a mercury control technology would likely result in increased atmospheric loading of mercury to the TMDL Northeast Region (increased local deposition) (Table 2). Based on the principle of proportionality (MPCA 2007), an increase in mercury loading would thereby increase fish tissue mercury concentrations. The screening calculations also indicate that the long-term application of halide injection prior to furnace exhaust gas entering the existing wet scrubbers would likely result in increased atmospheric loading to the TMDL Northeast Region (increased local deposition) (Table 2). As previously discussed, increased local deposition due to emissions of oxidized mercury has been demonstrated to increase fish tissue mercury concentrations.

Overall, the application of ACI or halide injection reduces total mercury emissions from baseline conditions, with an average reduction of about 20% and 27%, respectively. However, these estimated reductions in total mercury emissions are well below the estimated reductions for the taconite industry emissions used by the MPCA for future conditions in the Statewide Mercury TMDL study (MPCA 2007, Table 12; reduction from 723 lbs/yr (1990) to 138 lbs/yr (Target #3)). Further, and perhaps most significant, the propensity for particle-bound and/or oxidized mercury to deposit near an emission point (AMAP/UNEP 2013; Florida DEP 2013) and the increase in emissions of the particle-bound and/or oxidized mercury fraction will result in an increase in local mercury deposition that is not offset by the expected decrease in total mercury emissions. The expected increase in mercury loading to the TMDL Northeast Region due to changes in speciation caused by the use of either ACI or halide injection (Table 2) is inconsistent with the Statewide Mercury TMDL study (MPCA 2007) that requires a reduction in loading in order to reduce fish tissue mercury concentrations. The relatively small reduction in total mercury emissions and the potential for increased local deposition of oxidized and/or particle-bound mercury indicate that neither ACI nor halide injection with existing wet scrubbers should be considered applicable control technologies for the taconite industry.

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This technical memorandum was provided to Dr. David Grigal (Professor Emeritus, University of Minnesota) and Dr. Edward Nater (Professor, University of Minnesota) for their critical review. Dr. Nater summed up the overall peer review findings as follows:

> While we all agree it would be beneficial to reduce or eliminate mercury emissions, reducing gaseous elemental mercury emissions while simultaneously increasing oxidized mercury (reactive mercury) and/or particulate mercury emissions is not a desirable outcome.

The collective comments and observations by Drs. Grigal and Nater regarding the information presented in this technical memorandum are greatly appreciated by Barr Engineering Company and the taconite industry.

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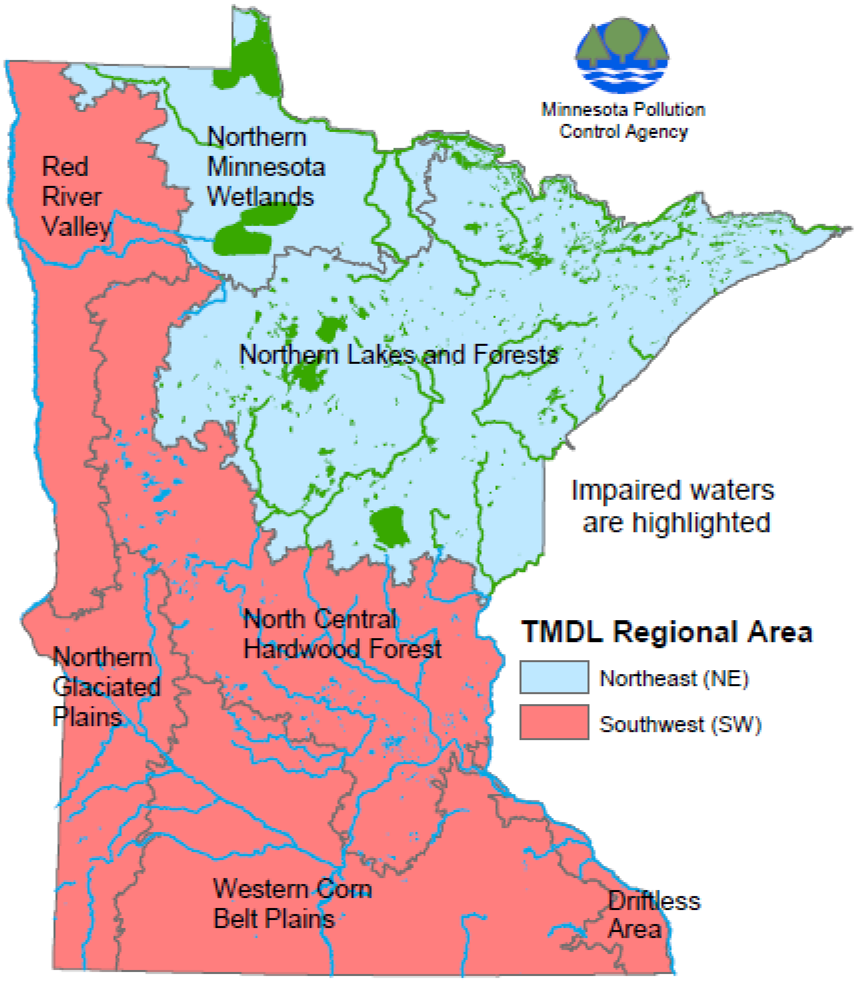

Figure 1 Statewide Mercury Total Maximum Daily Load (TMDL) Regional Areas (from MPCA 2007)