Source Test Report

Billerud Escanaba, LLC
7100 County Road 426
Escanaba, Michigan 49829

Source Tested: Boiler 11
Test Date: September 12, 2024

Project No. AST-2024-3909

Prepared By
Alliance Technical Group, LLC
20 Parkway View Drive
Pittsburgh, Pennsylvania 15205

Regulatory Information

ROP No. MI-ROP-A0884-2021b

Source Information

Source Name	*Source ID*	*Target Parameters*
Boiler 11	EU11B68	PM, CO, HCl, Hg

Contact Information

Test Location
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7100 County Road 426
Escanaba, Michigan 49829

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Alliance Technical Group, LLC (Alliance) has completed the source testing as described in this report. Results apply only to the source(s) tested and operating condition(s) for the specific test date(s) and time(s) identified within this report. All results are intended to be considered in their entirety, and Alliance is not responsible for use of less than the complete test report without written consent. This report shall not be reproduced in full or in part without written approval from the customer.

To the best of my knowledge and abilities, all information, facts and test data are correct. Data presented in this report has been checked for completeness and is accurate, error-free and legible. Onsite testing was conducted in accordance with approved internal Standard Operating Procedures. Any deviations or problems are detailed in the relevant sections in the test report.

This report is only considered valid once an authorized representative of Alliance has signed in the space provided below; any other version is considered draft. This document was prepared in portable document format (.pdf) and contains pages as identified in the bottom footer of this document.

Kenji Kinoshita **Project Manager** **Alliance Technical Group, LLC**	11/5/2024 Date

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APPENDICES

Introduction

1.0 Introduction

Alliance Technical Group, LLC (Alliance) was retained by Apex Companies, LLC, on behalf of, Billerud Escanaba, LLC (Billerud), to conduct compliance testing at the Escanaba, Michigan facility. The facility operates under Michigan Department of Environment, Great Lakes, and Energy (EGLE) Renewable Operating Permit (ROP) number MI-ROP-A0884-2021b. Testing was conducted to determine the emission rates of particulate matter (PM), carbon monoxide (CO), hydrogen chloride (HCl), and mercury (Hg) at the exhaust of Boiler 11.

1.1 Source Description

Boiler 11 (EU11B68) was installed in 1981 and modified in 1986. It is an ABB Combustion Engineering combination fuel boiler (Boiler 11) rated for 750,000 pounds of steam per hour (approximately 1,040 million Btu per hour heat input) that provides steam for mill processes and steam turbine-generators for producing electricity. Boiler 11 is a hybrid suspension grate burner designed to burn wet biomass/bio-based solid fuel. Boiler 11 burns natural gas and solid fuels, which may include pulverized coal, wood residue, wastewater treatment plant residuals, tire-derived fuel, and non-hazardous secondary material (NHSM) pellets.

Emissions from Boiler 11 are controlled by an over-fired air system, multi-clone dust collector, and electrostatic precipitator.

1.2 Project Team

Personnel involved in this project are identified in the following table.

Table 1-1: Project Team

Regulatory Personnel	Jeremy Howe Michael Conklin Joseph Scanlan
Facility Personnel	Amanda Freele
Apex Personnel	Dr. Derek Wong, P.E.
Alliance Personnel	Justin Bernard Matthew Fulton Dennis Haynes Alexander Schutters

1.3 Site Specific Test Plan and Notification

Testing was conducted in accordance with the Site-Specific Test Plan (SSTP) submitted to EGLE on August 9, 2024, with the following exception: testing was conducted on September 12, 2024 rather than the proposed date of September 10, 2024 because the boiler was down. Ms. Amanda Freele, with Billerud, notified Mr. Joseph Scanlan, with EGLE, of the change.

1.4 Test Program Notes

No technical difficulties or protocol deviations were encountered during this test program.

Summary of Results

2.0 Summary of Results

Alliance conducted compliance testing at the Billerud facility in Escanaba, Michigan, on September 12, 2024. Testing consisted of determining the emission rates of PM, CO, HCl, and Hg at the exhaust of Boiler 11, while firing wood, natural gas, and wastewater treatment plant residue (WWTPR).

The purpose of the test program is to demonstrate that No. 11 Power Boiler is compliant with the Hg, HCl, PM, and CO applicable emission limits under National Emission Standards for Hazardous Air Pollutants for Major Sources: Industrial, Commercial, and Institutional Boilers and Process Heaters promulgated at 40 CFR Part 63, Subpart DDDDD Table 2 subcategory 13 for hybrid suspension grate units designed to burn biomass/bio-based solids. Testing also serves as compliance with PM and CO emission limits under the facility's Title V permit.

Table 2-1 provides a summary of the emission testing results with comparisons to the applicable permit limits. Any difference between the summary results listed in the following table and the detailed results contained in appendices is due to rounding for presentation.

Table 2-1: Summary of Results – Boiler 11

Emissions Data				
Run Number	**Run 1**	**Run 2**	**Run 3**	**Average**
Date	**9/12/24**	**9/12/24**	**9/12/24**	**--**
Particulate Matter				
Emission Factor, lb/MMBtu (O_2)	0.0038	0.0052	0.0032	0.0041
40 CFR Part 60, D Limit, lb/MMBtu (O_2)	--	--	--	0.06
Percent of Limit, %	--	--	--	**6.76 %**
40 CFR Part 63, DDDDD Limit, lb/MMBtu	--	--	--	0.44
Percent of Limit, %	--	--	--	**0.92 %**
Hydrogen Chloride				
Emission Factor, lb/MMBtu (O_2)	3.39E-05	2.84E-05	3.05E-05	3.09E-05
40 CFR Part 63, DDDDD Limit, lb/MMBtu (O_2)	--	--	--	0.02
Percent of Limit, %	--	--	--	**0.15 %**
Mercury				
Emission Rate, lb/MMBtu (O_2)	5.98E-07	6.19E-07	6.00E07	6.06E-07
40 CFR Part 63, DDDDD Limit, lb/MMBtu (O_2)	--	--	--	5.40E-06
Percent of Limit, %	--	--	--	**11 %**
Carbon Monoxide				
Concentration, ppmvd @ 3% O_2	32.9	22.2	29.3	28.1
40 CFR Part 63, DDDDD Limit, ppmvd @ 3% O2	--	--	--	3,500
Percent of Limit, %	--	--	--	**1 %**
Emission Rate, lb/MMBtu (O_2d)	0.026	0.017	0.023	0.022
Permit Limit, lb/MMBtu (O_2d)	--	--	--	0.5
Percent of Limit, %	--	--	--	**4 %**

Testing Methodology

3.0 Testing Methodology

The emission testing program was conducted in accordance with the test methods listed in Table 3-1. Method descriptions are provided below while quality assurance/quality control data is provided in Appendix D.

Table 3-1: Source Testing Methodology

Parameter	U.S. EPA Reference Test Methods	Notes/Remarks
Volumetric Flow Rate	1 and 2	Full Velocity Traverses
Oxygen/Carbon Dioxide	3A	Instrumental Analysis
Moisture Content	4	Gravimetric Analysis
Particulate Matter	5	Isokinetic Sampling
Carbon Monoxide	10	Instrumental Analysis
Hydrogen Chloride	26A	Isokinetic Sampling
Mercury	30B	Sorbent Traps
Gas Dilution System Certification	205	---

3.1 U.S. EPA Reference Test Methods 1 and 2 – Volumetric Flow Rate

The sampling location and number of traverse (sampling) points were selected in accordance with U.S. EPA Reference Test Method 1. To determine the minimum number of traverse points, the upstream and downstream distances were expressed in equivalent diameters and compared to Figure 1-1 in U.S. EPA Reference Test Method 1.

Full velocity traverses were conducted in accordance with U.S. EPA Reference Test Method 2 to determine the average stack gas velocity pressure, static pressure and temperature. The velocity and static pressure measurement system consisted of a pitot tube and inclined manometer. The stack gas temperature was measured with a K-type thermocouple and pyrometer.

Stack gas velocity pressure and temperature readings were recorded during each test run. The data collected was utilized to calculate the volumetric flow rate in accordance with U.S. EPA Reference Test Method 2.

3.2 U.S. EPA Reference Test Method 3A – Oxygen/Carbon Dioxide

The oxygen (O_2) and carbon dioxide (CO_2) testing was conducted in accordance with U.S. EPA Reference Test Method 3A. Data was collected online and reported in one-minute averages. The sampling system consisted of a stainless-steel probe, Teflon sample line(s), gas conditioning system and the identified gas analyzer. The gas conditioning system was a non-contact condenser used to remove moisture from the stack gas. If an unheated Teflon sample line was used, then a portable non-contact condenser was placed in the system directly after the probe. Otherwise, a heated Teflon sample line was used. The quality control measures are described in Section 3.9.

3.3 U.S. EPA Reference Test Method 4 – Moisture Content

The stack gas moisture content (BWS) was determined in accordance with U.S. EPA Reference Test Method 4. The gas conditioning train consisted of a series of chilled impingers. Prior to testing, each impinger was filled with a known quantity of water or silica gel. Each impinger was weighed before and after each test run on the same balance to determine the amount of moisture condensed.

3.4 U.S. EPA Reference Test Method 5 – Particulate Matter

The filterable particulate matter testing was conducted accordance with U.S. EPA Reference Test Method 5. The complete sampling system consisted of a glass nozzle, heated glass-lined probe, pre-weighed heated quartz filter, gas conditioning train, pump and calibrated dry gas meter. The gas conditioning train consisted of four chilled impingers – the first and second containing 100 mL of H_2O, an empty third impinger and the fourth containing 200-300 grams of silica gel. The probe liner and filter heating systems were maintained at a temperature of 120 ± 14°C (248 ±25°F) and the impinger temperature was maintained at 20°C (68°F) or less throughout the testing.

Following the completion of each test run, the sampling train was leak checked at a vacuum pressure greater than or equal to the highest vacuum pressure observed during the run, and the contents of the impingers were measured for moisture gain. The probe and nozzle were rinsed and brushed three times with acetone to remove adhering particulate matter. This rinse was recovered in container 2. The front half of the filter holder was rinsed three times with acetone and this rinse was added to container 2. The pre-weighed quartz filter was carefully removed and placed in container 1. All containers were sealed, labeled and liquid levels marked for transport to the laboratory.

3.5 U.S. EPA Reference Test Method 10 – Carbon Monoxide

The carbon monoxide (CO) testing was conducted in accordance with U.S. EPA Reference Test Method 10. Data was collected online and reported in one-minute averages. The sampling system consisted of a stainless-steel probe, Teflon sample line(s), gas conditioning system, and the identified gas analyzer. The length of the probe was fourteen feet. The gas conditioning system was a non-contact condenser used to remove moisture from the gas. If an unheated Teflon sample line was used, then a portable non-contact condenser was placed in the system directly after the probe. Otherwise, a heated Teflon sample line was used. The quality control measures are described in Section 3.9.

3.6 U.S. EPA Reference Test Method 26A – Hydrogen Chloride

The hydrogen chloride (HCl) testing was conducted in accordance with U.S. EPA Reference Test Method 26A. The complete sampling system consisted of a glass nozzle, heated glass-lined probe, heated Teflon filter, gas conditioning train, pump and calibrated dry gas meter. The gas conditioning train consisted of four chilled impingers. The first and second impingers contained 100 mL of 0.1 N H_2SO_4, the third was initially empty and the fourth contained 200-300 grams of silica gel. The probe liner and filter heating systems were maintained at 248-273°F, and the impinger temperature was maintained at 20°C (68°F) or less throughout the testing.

Following the completion of each test run, the sampling train was leak checked at a vacuum pressure greater than or equal to the highest vacuum pressure observed during the run and the contents of the impingers were measured for moisture gain. The absorbing solution (0.1 N H_2SO_4) from the first and second impingers was placed into sample container 3. The back-half of the filter holder, first, second and third impingers and all glassware leading to the outlet of the third impinger were rinsed with de-ionized (DI) water. These rinses were also placed in container 3. All containers were sealed, labeled and liquid levels marked for transport to the identified laboratory for analysis.

3.7 U.S. EPA Reference Test Method 30B – Mercury

The total vapor phase mercury (Hg) testing was conducted in accordance with U.S. EPA Reference Test Method 30B. The complete sampling system consisted of a heated pair of in-stack sorbent traps, stainless steel-lined probe, gas conditioning train, pump and calibrated dry gas meter. The length of the probe was ten feet. Sample gas was withdrawn through the paired sorbent traps at a pre-determined sampling rate during each test run. A field recovery test was conducted during three of the test runs in which a known mass of mercury was pre-spiked onto one of the paired sorbent traps.

Prior to starting each test run, the sampling train was leak checked at a vacuum pressure of fifteen inches of mercury. Following the completion of each test run, the sampling train was leak checked at the highest vacuum pressure observed during the test run. Each sorbent trap was removed from the sample probe and sealed to prevent contamination. All samples were sealed and labeled for transport to the identified laboratory for analysis.

3.8 U.S. EPA Reference Test Method 205 – Gas Dilution System Certification

A calibration gas dilution system field check was conducted in accordance with U.S. EPA Reference Method 205. Multiple dilution rates and total gas flow rates were utilized to force the dilution system to perform two dilutions on each mass flow controller. The diluted calibration gases were sent directly to the analyzer, and the analyzer response recorded in an electronic field data sheet. The analyzer response agreed within 2% of the actual diluted gas concentration. A second Protocol 1 calibration gas, with a cylinder concentration within 10% of one of the gas divider settings described above, was introduced directly to the analyzer, and the analyzer response recorded in an electronic field data sheet. The cylinder concentration and the analyzer response agreed within 2%. These steps were repeated three times. Copies of the Method 205 data can be found in the Quality Assurance/Quality Control Appendix.

3.9 Quality Assurance/Quality Control – U.S. EPA Reference Test Methods 3A and 10

Cylinder calibration gases used met EPA Protocol 1 (±- 2%) standards. Copies of all calibration gas certificates are included in the Quality Assurance/Quality Control Appendix.

Low-Level gas was introduced directly to the analyzer. After adjusting the analyzer to the Low-Level gas concentration and once the analyzer reading was stable, the analyzer value was recorded. This process was repeated for the High-Level gas. For the Calibration Error Test, Low-, Mid-, and High-Level calibration gases were sequentially introduced directly to the analyzer. All values were within 2.0% of the Calibration Span or 0.5 ppmv/% absolute difference.

High- or Mid-Level gas (whichever was closer to the stack gas concentration) was introduced at the probe and the time required for the analyzer reading to reach 95% or 0.5 ppmv/% (whichever was less restrictive) of the gas concentration was recorded. The analyzer reading was observed until it reached a stable value, and this value was recorded. Next, Low-Level gas was introduced at the probe and the time required for the analyzer reading to decrease to a value within 5.0% or 0.5 ppmv/% (whichever was less restrictive) was recorded. If the Low-Level gas was zero gas, the response was 0.5 ppmv/% or 5.0% of the upscale gas concentration (whichever was less restrictive). The analyzer reading was observed until it reached a stable value and this value was recorded. The measurement system response time and initial system bias were determined from these data. The System Bias was within 5.0% of the Calibration Span or 0.5 ppmv/% absolute difference.

High- or Mid-Level gas (whichever was closer to the stack gas concentration) was introduced at the probe. After the analyzer response was stable, the value was recorded. Next, Low-Level gas was introduced at the probe, and the analyzer value recorded once it reached a stable response. The System Bias was within 5.0% of the Calibration Span or 0.5 ppmv/% absolute difference or the data was invalidated, and the Calibration Error Test and System Bias were repeated.

Drift between pre- and post-run System Bias was within 3% of the Calibration Span or 0.5 ppmv/% absolute difference. If the drift exceeded 3% or 0.5 ppmv/%, the Calibration Error Test and System Bias were repeated.

To determine the number of sampling points, a gas stratification check was conducted prior to initiating testing. The pollutant concentrations were measured at three points. Each traverse point was sampled for a minimum of twice the system response time.

If the pollutant concentration at each traverse point did not differ more than 5% or 0.5 ppmv/0.3% (whichever was less restrictive) of the average pollutant concentration, then single point sampling was conducted during the test runs. If the pollutant concentration did not meet these specifications but differed less than 10% or 1.0 ppmv/0.5% from the average concentration, then three point sampling was conducted (stacks less than 7.8 feet in diameter - 16.7, 50.0, and 83.3% of the measurement line; stacks greater than 7.8 feet in diameter – 0.4, 1.0, and 2.0 meters from the stack wall). If the pollutant concentration differed by more than 10% or 1.0 ppmv/0.5% from the average concentration, then sampling was conducted at a minimum of twelve traverse points. Copies of stratification check data can be found in the Quality Assurance/Quality Control Appendix.

A Data Acquisition System with battery backup was used to record the instrument response in one minute averages. The data was continuously stored as a *.CSV file in Excel format on the hard drive of a computer. At the completion of testing, the data was also saved to the Alliance server. All data was reviewed by the Field Team Leader before leaving the facility. Once arriving at Alliance's office, all written and electronic data was relinquished to the report coordinator and then a final review was performed by the Project Manager.

Appendix A

Alliance
TECHNICAL GROUP

Location:	Billerud Escanaba, Inc. - Escanaba, MI
Source:	Boiler 11 (EU11B68) CO (Method 10)
Project No.:	AST-2024-3909
Run No. /Method	Run 1 / Method 3A

O_2 - Outlet Concentration (C_{O_2}), % dry

$$C_{O_2} = (C_{obs} - C_0) \times \left(\frac{C_{MA}}{(C_M - C_0)} \right)$$

where,

C_{obs}	4.34	= average analyzer value during test, % dry
C_o	0.04	= average of pretest & posttest zero responses, % dry
C_{MA}	10.98	= actual concentration of calibration gas, % dry
C_M	10.73	= average of pretest & posttest calibration responses, % dry
C_{O_2}	4.42	= O_2 Concentration, % dry

Alliance
TECHNICAL GROUP

Location: Billerud Escanaba, Inc. - Escanaba, MI
Source: Boiler 11 (EU11B68) CO (Method 10)
Project No.: AST-2024-3909
Run No. /Method Run 1 / Method 3A

CO_2 - Outlet Concentration (C_{CO_2}), % dry

$$C_{CO_2} = (C_{obs} - C_0) \times \left(\frac{C_{MA}}{(C_M - C_0)} \right)$$

where,

C_{obs}	12.01	= average analyzer value during test, % dry
C_o	0.14	= average of pretest & posttest zero responses, % dry
C_{MA}	10.90	= actual concentration of calibration gas, % dry
C_M	10.58	= average of pretest & posttest calibration responses, % dry
C_{CO_2}	12.39	= CO_2 Concentration, % dry

TECHNICAL GROUP

Location: Billerud Escanaba, Inc. - Escanaba, MI
Source: Boiler 11 (EU11B68) CO (Method 10)
Project No.: AST-2024-3909
Run No. /Method Run 1 / Method 10

CO - Outlet Concentration (C_{CO}), ppmvd

$$C_{CO} = (C_{obs} - C_0) \times \left(\frac{C_{MA}}{(C_M - C_0)}\right)$$

where,

C_{obs}	29.02	= average analyzer value during test, ppmvd
C_o	0.94	= average of pretest & posttest zero responses, ppmvd
C_{MA}	50.00	= actual concentration of calibration gas, ppmvd
C_M	47.24	= average of pretest & posttest calibration responses, ppmvd
C_{CO}	30.33	= CO Concentration, ppmvd

CO - Outlet Concentration (C_{COc3}), ppmvd @ 3% O_2

$$C_{COc3} = C_{CO} \times \left(\frac{20.9 - 3}{20.9 - O_2}\right)$$

where,

C_{CO}	30.33	= CO - Outlet Concentration, ppmvd
C_{O_2}	4.42	= oxygen concentration, %
C_{COc3}	32.95	= ppmvd @3% O_2

CO - Outlet Emission Rate (ER_{CO}), lb/hr

$$ER_{CO} = \frac{C_{CO} \times MW \times Qs \times 60\ \frac{min}{hr} \times 28.32\ \frac{L}{ft^3}}{24.04\ \frac{L}{g-mole} \times 1.0E06 \times 453.592\ \frac{g}{lb}}$$

where,

C_{CO}	30.33	= CO - Outlet Concentration, ppmvd
MW	28.01	= CO molecular weight, g/g-mole
Qs	149944	= stack gas volumetric flow rate at standard conditions, dscfm
ER_{CO}	19.85	= lb/hr

CO - Outlet Emission Factor (EF_{COHI}), lb/MMBtu

$$EF_{COHI} = \frac{ER_{CO}}{HI}$$

where,

ER_{CO}	19.85	= CO - Outlet Emission Rate, lb/hr
HI	698.00	= Heat Input, MMBtu/hr
EF_{COHI}	0.028	= lb/MMBtu

CO - Outlet Emission Factor (EF_{COO_2d}), lb/MMBtu

$$EF_{COO_2d} = ER_{CO} \times K \times Fd \times \left(\frac{20.9}{20.9 - C_{O_2}}\right)$$

where,

C_{CO}	30.3	= CO - Outlet Concentration, ppmvd
K	7.27E-08	= constant, lb/dscf · ppmvd
F_d	9,130	= fuel factor, dscf/MMBtu
C_{O_2}	4.42	= oxygen concentration, %
EF_{COO_2d}	0.026	= lb/MMBtu

Alliance
TECHNICAL GROUP

Example Calculations

Location: Billerud Escanaba, Inc. - Escanaba, MI
Source: Boiler 11 (EU11B68)
Project No.: AST-2024-3909
Method/Run No.: Method 30B/Run 1

Standard Meter Volume (Vmstd), dsL

$$Vmstd = \frac{17.636 \text{ x } Vm \text{ x } Pm \text{ x } Y}{Tm}$$

where,

Y	0.992	= meter correction factor
Vm	36.057	= meter volume, L
Pm	29.25	= absolute meter pressure, in. Hg
Tm	520.7	= absolute meter temperature, °R
Vmstd	35.448	= dsL

Standard Meter Volume (Vmstd), dscf

$$Vmstd = \frac{Vmstd}{1000\frac{L}{m^3} \times 0.02834\frac{m^3}{ft^3}}$$

where,

Vmstd	35.448	= dsL
Vmstd	1.252	= dscm

Mercury Concentration (unspiked) (Ca), ug/dscm

$$C_a = \frac{m_u \times 1.0E+03}{Vmstd_{DGM1} \times 1.0E+03}$$

where,

m_u	29.22	= mercury mass (unspiked), ng
Vmstd	35.4483469	= standard meter volume (unspiked), dsL
Ca	0.82	= ug/dscm

Mercury Mass (without spike) (mb), ng

$$m_b = m_s - m_{spiked}$$

where,

m_s	39.73	= mercury mass (with spike), ng
m_{spiked}	10	= spike mass, ng
m_b	29.73	= ng

Mercury Concentration (C_{Hg}), ug/dscm

$$C_{Hg} = \frac{Ca + Cb}{2}$$

where,

Ca	0.82	= mercury concentration (unspiked), ug/dscm
Cb	0.83	= mercury concentration (duplicate/spiked), ug/dscm
C_{Hg}	0.83	= ug/dscm

Example Calculations

Location: Billerud Escanaba, Inc. - Escanaba, MI
Source: Boiler 11 (EU11B68)
Project No.: AST-2024-3909
Method/Run No.: Method 30B/Run 1

Mercury Mass (M_{Hg}), lb

$$M_{Hg-a} = \frac{m_u}{1000\frac{ng}{ug}} \times \frac{10^{-6}}{453.6\frac{grams}{lb}}$$

where,

m_u 29.22 = mercury mass, ng
M_{Hg-a} 6.4E-11 = mercury mass, lb

Mercury Mass (M_{Hg}), lb

$$M_{Hg} = \frac{M_{Hg-a} + M_{Hg-b}}{2}$$

where,

M_{Hg-a} 6.4E-11 = mercury mass (unspiked), lb
M_{Hg-b} 6.6E-11 = mercury mass (duplicate/spiked), lb
M_{Hg} 6.5E-11 = mercury mass, lb

Mercury Emission Rate (ER_{Hg}), lb/hr

$$ER_{Hg} = \frac{M_{Hg-a}}{Vmstd} \times 60\frac{mins}{hr} \times Qs$$

where,

M_{Hg} 6.44E-11 = mercury concentration dry, ug/dscm
Qs 149,944 = average stack gas flow at standard conditions, dscfm
ER_{Hg} 4.6E-04 = lb/hr

Mercury Emission Rate (ER_{Hg}), lb/hr

$$ER_{Hg} = \frac{ER_{Hg-a} + ER_{Hg-b}}{2}$$

where,

ER_{Hg-a} 4.6E-04 = mercury emission rate (unspiked), lb/hr
ER_{Hg-b} 4.7E-04 = mercury emission rate (duplicate/spiked), lb/hr
ER_{Hg} 4.6E-04 = mercury emission rate, lb/hr

Alliance TECHNICAL GROUP

Example Calculations

Location:	**Billerud Escanaba, Inc. - Escanaba, MI**
Source:	**Boiler 11 (EU11B68)**
Project No.:	**AST-2024-3909**
Method/Run No.:	**Method 30B/Run 1**

Mercury Emission Factor (EF_{Hg}), lb/Mmbtu

$$EF_{Hg} = \frac{ER_{Hg}}{HI}$$

where,

ER_{Hg}	4.6E-04	= mercury emission rate, lb/hr
HI	693	= heat input, MMBtu/hr
EF_{Hg}	6.7E-07	= lb/MMBtu

Mercury Emission Factor ($EF_{Hg\,O2d}$), lb/MMBtu

$$EF_{HgO2d} = \frac{M_{Hg}}{Vmstd} \times Fd \times \frac{20.9}{20.9 - O_2}$$

where,

M_{Hg}	6.44E-11	= mercury mass, lb
Vmstd	1.252	= dscm
Fd	9,126	= oxygen based fuel factor, dscf/MMBtu
O_2	4.42	= oxygen concentration, %
$EF_{Hg\,O2d}$	6.0E-07	= lb/MMBtu

Mercury Emission factor (ERHg), lb/MMbtu

$$EF_{Hg} = \frac{EF_{Hg-a} + EF_{Hg-b}}{2}$$

where,

EF_{Hg-a}	6.0E-07	= mercury emission factor (unspiked), lb/MMbtu
EF_{Hg-b}	6.0E-07	= mercury emission factor (duplicate/spiked), lb/MMbtu
EF_{Hg}	6.0E-07	= mercury emission factor, lb/MMbtu

ALLIANCE TECHNICAL GROUP

Location: Billerud Escanaba, Inc. - Escanaba, MI
Source: Boiler 11 (EU11B68)
Project No.: AST-2024-3909
Run No.: 1
Parameter: PM, HCl Methods 5-26A

Meter Pressure (Pm), in. Hg

$$Pm = Pb + \frac{\Delta H}{13.6}$$

where,

Pb	29.40	= barometric pressure, in. Hg
ΔH	1.875	= pressure differential of orifice, in H_2O
Pm	29.54	= in. Hg

Absolute Stack Gas Pressure (Ps), in. Hg

$$Ps = Pb + \frac{Pg}{13.6}$$

where,

Pb	29.40	= barometric pressure, in. Hg
Pg	-0.63	= static pressure, in. H_2O
Ps	29.35	= in. Hg

Standard Meter Volume (Vmstd), dscf

$$Vmstd = \frac{17.636 \times Y \times Vm \times Pm}{Tm}$$

where,

Y	0.987	= meter correction factor
Vm	47.665	= meter volume, cf
Pm	29.54	= absolute meter pressure, in. Hg
Tm	529.8	= absolute meter temperature, °R
Vmstd	46.254	= dscf

Standard Wet Volume (Vwstd), scf

$$Vwstd = 0.04716 \times Vlc$$

where,

Vlc	228.9	= weight of H_2O collected, g
Vwstd	10.795	= scf

Moisture Fraction (BWSsat), dimensionless (theoretical at saturated conditions)

$$BWSsat = \frac{10^{6.37} - \left(\frac{2,827}{Ts + 365}\right)}{Ps}$$

where,

Ts	420.8	= stack temperature, °F
Ps	29.35	= absolute stack gas pressure, in. Hg
BWSsat	20.048	= dimensionless

ALLIANCE TECHNICAL GROUP

Location: Billerud Escanaba, Inc. - Escanaba, MI
Source: Boiler 11 (EU11B68)
Project No.: AST-2024-3909
Run No.: 1
Parameter: PM, HCl Methods 5-26A

Moisture Fraction (BWS), dimensionless (measured)

$$BWS = \frac{Vwstd}{(Vwstd + Vmstd)}$$

where,

Vwstd	10.795	= standard wet volume, scf
Vmstd	46.254	= standard meter volume, dscf
BWS	0.189	= dimensionless

Moisture Fraction (BWS), dimensionless

BWS = BWSmsd unless BWSsat < BWSmsd

where,

BWSsat	20.048	= moisture fraction (theoretical at saturated conditions)
BWSmsd	0.189	= moisture fraction (measured)
BWS	0.189	

Excess Air (EA), %

$$EA = \frac{(\%\,O_2 - [0.5 \times \%CO]) \times 100}{(0.264 \times \%N_2) - \%O_2 - (0.5 \times \%CO)}$$

where,

CO_2	12.39	= carbon dioxide concentration, %
O_2	4.42	= oxygen concentration, %
CO	0.0	= carbon monoxide concentration, % (assumed zero)
N_2	83.19	= nitrogen concentration, %
EA	25.19644103	= %

Molecular Weight (DRY) (Md), lb/lb-mole

$$Md = (0.44 \times \%CO_2) + (0.32 \times \%O_2) + (0.28 \times [100 - \%CO_2 - \%O_2])$$

where,

CO_2	12.4	= carbon dioxide concentration, %
O_2	4.4	= oxygen concentration, %
Md	30.16	= lb/lb mol

Molecular Weight (WET) (Ms), lb/lb-mole

$$Ms = (Md \times [1 - BWS]) + (18.015 \times BWS)$$

where,

Md	30.16	= molecular weight (DRY), lb/lb mol
BWS	0.189	= moisture fraction, dimensionless
Ms	27.86	= lb/lb mol

Alliance
TECHNICAL GROUP

Location: Billerud Escanaba, Inc. - Escanaba, MI
Source: Boiler 11 (EU11B68)
Project No.: AST-2024-3909
Run No.: 1
Parameter: PM, HCl Methods 5-26A

Average Velocity (Vs), ft/sec

$$Vs = 85.49 \times Cp \times (\Delta P^{1/2})\ avg \times \sqrt{\frac{Ts}{Ps \times Ms}}$$

where,

Cp	0.840	= pitot tube coefficient
$\Delta P^{1/2}$	0.492	= velocity head of stack gas, (in. H_2O)$^{1/2}$
Ts	880.4	= absolute stack temperature, °R
Ps	29.35	= absolute stack gas pressure, in. Hg
Ms	27.86	= molecular weight of stack gas, lb/lb mol
Vs	36.6	= ft/sec

Average Stack Gas Flow at Stack Conditions (Qa), acfm

$$Qa = 60 \times Vs \times As$$

where,

Vs	36.6	= stack gas velocity, ft/sec
As	143.14	= cross-sectional area of stack, ft^2
Qa	314,525	= acfm

Average Stack Gas Flow at Standard Conditions (Qs), dscfm

$$Qs = \frac{17.636 \times Qa \times (1 - BWS) \times Ps}{Ts}$$

where,

Qa	314,525	= average stack gas flow at stack conditions, acfm
BWS	0.189	= moisture fraction, dimensionless
Ps	29.35	= absolute stack gas pressure, in. Hg
Ts	880.4	= absolute stack temperature, °R
Qs	149,944	= dscfm

Dry Gas Meter Calibration Check (Yqa), dimensionless

$$Yqa = \frac{Y - \left(\frac{\Theta}{Vm}\sqrt{\frac{0.0319 \times Tm \times 29}{\Delta H@ \times \left(Pb + \frac{\Delta Havg.}{13.6}\right) \times Md}}\sqrt{\Delta H}\ avg.\right)}{Y} \times 100$$

where,

Y	0.987	= meter correction factor, dimensionless
Θ	60	= run time, min.
Vm	47.665	= total meter volume, dcf
Tm	529.8	= absolute meter temperature, °R
ΔH@	1.768	= orifice meter calibration coefficient, in. H_2O
Pb	29.40	= barometric pressure, in. Hg
ΔH avg	1.875	= average pressure differential of orifice, in H_2O
Md	30.16	= molecular weight (DRY), lb/lb mol
$(\Delta H)^{1/2}$	1.364	= average squareroot pressure differential of orifice, (in. H2O)$^{1/2}$
Yqa	2.9	= percent

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TECHNICAL GROUP

Location: Billerud Escanaba, Inc. - Escanaba, MI
Source: Boiler 11 (EU11B68)
Project No.: AST-2024-3909
Run No.: 1
Parameter: PM, HCl Methods 5-26A

Volume of Nozzle (Vn), ft^3

$$Vn = \frac{Ts \times \left(0.002669 \times Vlc + \frac{Vm \times Pm \times Y}{Tm}\right)}{Ps}$$

where,

Ts	880.4	= absolute stack temperature, °R
Ps	29.35	= absolute stack gas pressure, in. Hg
Vlc	228.9	= volume of H_2O collected, ml
Vm	47.665	= meter volume, cf
Pm	29.54	= absolute meter pressure, in. Hg
Y	0.987	= meter correction factor, unitless
Tm	529.8	= absolute meter temperature, °R
Vn	96.989	= volume of nozzle, ft^3

Isokinetic Sampling Rate (I), %

$$I = \left(\frac{Vn}{\theta \times 60 \times An \times Vs}\right) \times 100$$

where,

Vn	96.989	= nozzle volume, ft3
θ	60.0	= run time, minutes
An	0.00071	= area of nozzle, ft^2
Vs	36.6	= average velocity, ft/sec
I	104.1	= %

Filterable PM Concentration (C_s), grain/dscf

$$C_s = \frac{M_n \times 15.43}{Vmstd}$$

where,

Mn	0.0068	= filterable PM mass, g
Vmstd	46.254	= standard meter volume, dscf
C_s	0.0023	= grain/dscf

Filterable PM Emission Rate (PMR), lb/hr

$$PMR = \frac{C_s \times Qs \times 60}{7000}$$

where,

C_s	0.0023	= filterable PM concentration, grain/dscf
Qs	149,944	= average stack gas flow at standard conditions, dscfm
PMR	2.92	= lb/hr

Alliance TECHNICAL GROUP

Location: Billerud Escanaba, Inc. - Escanaba, MI
Source: Boiler 11 (EU11B68)
Project No.: AST-2024-3909
Run No.: 1
Parameter: PM, HCl Methods 5-26A

Filterable PM Emission Factor (EF_{PM}), lb/MMBtu

$$EF_{PM} = \frac{PMR}{HI}$$

where,

PMR	2.92	= filterable PM emission rate, lb/hr
HI	693	= heat input, MMBtu/hr
EF_{PM}	0.0042	= lb/MMBtu

Filterable PM Emission Factor ($EF_{PM\ O2d}$), lb/MMBtu

$$EF_{PMO2d} = \frac{C_s}{7000} \times Fd \times \frac{20.9}{20.9 - O_2}$$

where,

C_s	0.0023	= grain/dscf
Fd	9,126	= oxygen based fuel factor, dscf/MMBtu
O_2	4.4	= oxygen concentration, %
$EF_{PM\ O2d}$	0.0038	= lb/MMBtu

Hydrogen Chloride Concentration (C_{HCl}), mg/dscm

$$C_{HCl} = \frac{M_{HCl}}{Vmstd \times 0.02832 \frac{m^3}{ft^3}}$$

where,

M_{HCl}	0.0614	= hydrogen chloride mass, mg
Vmstd	46.254	= standard meter volume, dscf
C_{HCl}	0.047	= mg/dscm

Hydrogen Chloride Concentration (C_{HClp}), ppmvd

$$C_{HClp} = \frac{M_{HCl} \times 24.04 \frac{L}{mol}}{MW \times Vmstd \times 28.32}$$

where,

M_{HCl}	61	= hydrogen chloride mass, ug
MW	36.5	= molecular weight, g/g mol
Vmstd	46.254	= standard meter volume, dscf
C_{HClp}	0.031	= ppmvd

Hydrogen Chloride Mass (M_{HCl}), lb

$$M_{HCl-lb} = \frac{M_{HCl} \times 10^{-6}}{453.6 \frac{grams}{lb}}$$

where,

M_{HCl}	61	= hydrogen chloride mass, ug
M_{HCl-lb}	1.4E-07	= hydrogen chloride mass, lb

TECHNICAL GROUP

Location: Billerud Escanaba, Inc. - Escanaba, MI
Source: Boiler 11 (EU11B68)
Project No.: AST-2024-3909
Run No.: 1
Parameter: PM, HCl Methods 5-26A

Hydrogen Chloride Emission Rate (ER_{HCl}), lb/hr

$$ER_{HCl} = \frac{M_{HCl}}{Vmstd} \times Qs \times 60\frac{min}{hr}$$

where,

$M_{HCl\text{-}lb}$	1.4E-07	= hydrogen chloride mass, lb
Qs	149,944	= average stack gas flow at standard conditions, dscfm
Vmstd	46.254	= standard meter volume, dscf
ER_{HCl}	0.026	= lb/hr

Hydrogen Chloride Emission Factor (EF_{HCl}), lb/MMBtu

$$EF_{HCl} = \frac{ER_{HCl}}{HI}$$

where,

ER_{HCl}	0.026	= hydrogen chloride emission rate, lb/hr
HI	693	= heat input, MMBtu/hr
EF_{HCl}	3.8E-05	= lb/MMBtu

Hydrogen Chloride Emission Factor ($EF_{HCl\,O2d}$), lb/MMBtu

$$EF_{HClO2d} = \frac{M_{HCl-}}{Vmstd} \times Fd \times \frac{20.9\%\,O_2}{20.9\%\,O_2 - O_2}$$

where,

$M_{HCl\text{-}lb}$	1.4E-07	= hydrogen chloride mass, lb
Fd	9,126	= oxygen based fuel factor, dscf/MMBtu
Vmstd	46.254	= standard meter volume, dscf
O_2	4.4	= oxygen concentration, %
$EF_{HCl\,O2d}$	3.4E-05	= lb/MMBtu

Appendix B

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Location Billerud Escanaba, Inc. - Escanaba, MI
Source Boiler 11 (EU11B68) CO (Method 10)
Project No. AST-2024-3909

Run Number		Run 1	Run 2	Run 3	Average
Date		9/12/24	9/12/24	9/12/24	--
Start Time		9:40	11:35	13:10	--
Stop Time		10:39	12:34	14:09	--
Source Data					
Fuel Factor (O2 dry), dscf/MMBtu	Fd	9,130	9,119	9,136	9,128
Heat Input, MMBtu/hr	HI	698	711	692	700
Input Data - Outlet					
Moisture Fraction, dimensionless	BWS	0.189	0.193	0.194	0.192
Volumetric Flow Rate (M1-4), dscfm	Qs	149,944	157,026	159,682	155,551
Calculated Data - Outlet					
O_2 Concentration, % dry	C_{O_2}	4.42	4.68	4.50	4.54
CO_2 Concentration, % dry	C_{CO_2}	12.39	12.16	12.38	12.31
CO Concentration, ppmvd	C_{CO}	30.33	20.14	26.82	25.76
CO Concentration, ppmvd @ 3 % O_2	C_{COc3}	32.9	22.2	29.3	28.2
CO Emission Rate, lb/hr	ER_{CO}	19.85	13.80	18.70	17.45
CO Emission Factor, lb/MMBtu (HI)	$EF_{CO\ HI}$	0.028	0.019	0.027	0.025
CO Emission Factor, lb/MMBtu (O2d)	$EF_{CO\ O2d}$	0.026	0.017	0.023	0.022

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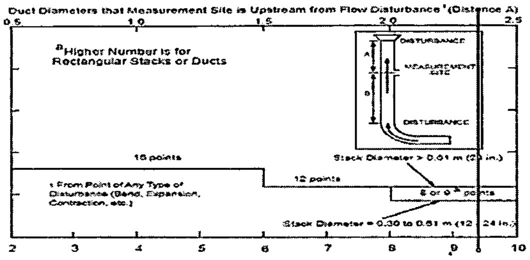
Method 1 Data

Location: Billerud Escanaba, Inc. - Escanaba, MI
Source: Boiler 11 (EU11B68) CO (Method 10)
Project No.: AST-2024-3909
Date: 09/09/24

Stack Parameters

Duct Orientation:	Vertical	
Duct Design:	Circular	
Distance from Far Wall to Outside of Port:	237.00	in
Nipple Length:	75.00	in
Diameter:	162.00	in
Cross Sectional Area of Duct:	143.14	ft^2
No. of Test Ports:	4	
Distance A:	150.0	ft
Distance A Duct Diameters:	11.1	(must be ≥ 0.5)
Distance B:	125.0	ft
Distance B Duct Diameters:	9.3	(must be ≥ 2)
Actual Number of Traverse Points:	3	
Measurer (Initial and Date):	DHH 9/9/24	
Reviewer (Initial and Date):	JJB 9/9/24	



CIRCULAR DUCT

LOCATION OF TRAVERSE POINTS

Number of traverse points on a diameter

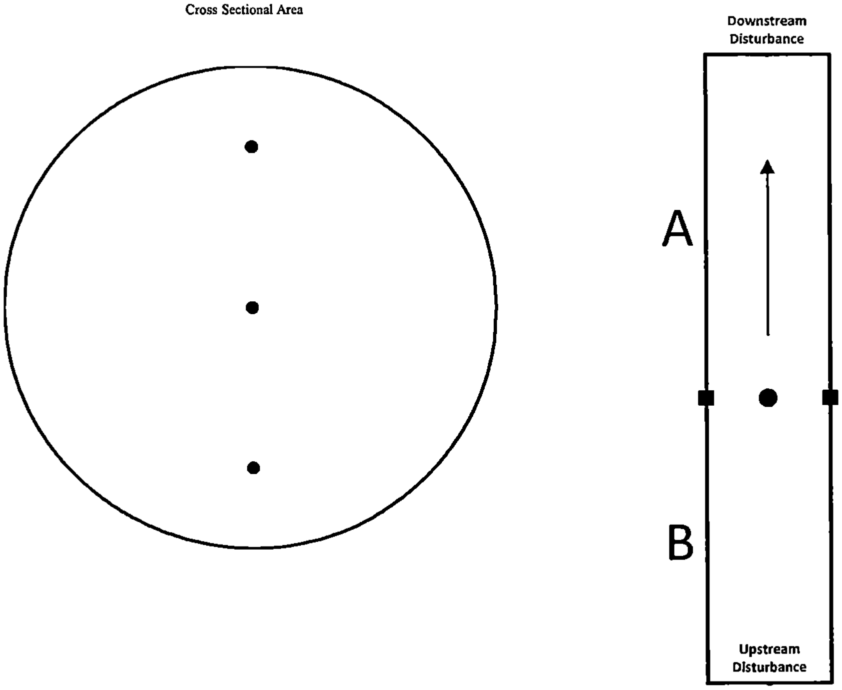
	2	3	4	5	6	7	8	9	10	11	12
1	14.6	16.7	6.7	--	4.4	--	3.2	--	2.6	--	2.1
2	85.4	50.0	25.0	--	14.6	--	10.5	--	8.2	--	6.7
3	--	83.3	75.0	--	29.6	--	19.4	--	14.6	--	11.8
4	--	--	93.3	--	70.4	--	32.3	--	22.6	--	17.7
5	--	--	--	--	85.4	--	67.7	--	34.2	--	25.0
6	--	--	--	--	95.6	--	80.6	--	65.8	--	35.6
7	--	--	--	--	--	--	89.5	--	77.4	--	64.4
8	--	--	--	--	--	--	96.8	--	85.4	--	75.0
9	--	--	--	--	--	--	--	--	91.8	--	82.3
10	--	--	--	--	--	--	--	--	97.4	--	88.2
11	--	--	--	--	--	--	--	--	--	--	93.3
12	--	--	--	--	--	--	--	--	--	--	97.9

Percent of stack diameter from inside wall to traverse point.

Traverse Point	% of Diameter	Distance from inside wall	Distance from outside of port
1	16.7	27.05	102.05
2	50.0	81.00	156.00
3	83.3	134.95	209.95
4	--	--	--
5	--	--	--
6	--	--	--
7	--	--	--
8	--	--	--
9	--	--	--
10	--	--	--
11	--	--	--
12	--	--	--

Stack Diagram
A = 150 ft.
B = 125 ft.
Diameter ==162 in.

Cross Sectional Area



Alliance TECHNICAL GROUP

Location: Billerud Escanaba, Inc. - Escanaba, MI
Source: Boiler 11 (EU11B68) CO (Method 10)
Project No.: AST-2024-3909
Date: 9/12/24

Time Unit Status	O_2 - Outlet % dry Valid	CO_2 - Outlet % dry Valid	CO - Outlet ppmvd Valid
Uncorrected Run Average (C_{obs})	4.34	12.01	29.02
Cal Gas Concentration (C_{MA})	10.98	10.90	50.00
Pretest System Zero Response	0.05	0.13	1.18
Posttest System Zero Response	0.02	0.14	0.69
Average Zero Response (Co)	0.04	0.14	0.94
Pretest System Cal Response	10.86	10.66	47.50
Posttest System Cal Response	10.60	10.50	46.98
Average Cal Response (C_M)	10.73	10.58	47.24
Corrected Run Average (Corr)	4.42	12.39	30.33
9:40	3.62	12.71	90.10
9:41	4.00	12.52	32.9
9:42	3.92	12.45	51.15
9:43	4.17	12.45	38.14
9:44	4.40	12.15	27.57
9:45	4.51	12.09	20.45
9:46	5.05	11.49	19.11
9:47	4.68	11.48	17.87
9:48	4.04	12.13	43.26
9:49	3.88	12.18	51.84
9:50	4.01	12.28	42.12
9:51	4.51	11.80	28.32
9:52	4.46	11.77	18.60
9:53	4.01	11.98	25.43
9:54	4.22	12.05	36.15
9:55	4.69	11.47	18.22
9:56	4.35	11.54	22.49
9:57	3.99	11.84	41.73
9:58	3.58	12.42	134.01
9:59	3.88	12.37	41.55
10:00	3.84	12.24	44.23
10:01	3.94	12.28	44.90
10:02	4.18	12.11	35.04
10:03	4.37	11.81	21.75
10:04	3.96	12.05	24.76
10:05	3.69	12.47	74.79
10:06	3.81	12.48	29.09
10:07	3.71	12.46	31.10
10:08	3.89	12.54	32.01
10:09	3.98	12.47	25.34
10:10	4.02	12.39	20.36
10:11	4.08	12.37	20.47
10:12	4.39	12.13	19.28
10:13	4.20	12.15	18.45
10:14	4.42	12.18	19.55
10:15	4.99	11.50	19.32
10:16	4.43	11.83	19.20
10:17	4.01	12.25	18.21
10:18	3.89	12.54	20.83
10:19	3.79	12.64	22.97
10:20	4.52	12.17	24.87
10:21	4.68	11.86	21.53
10:22	4.79	11.84	21.13
10:23	4.94	11.67	20.31
10:24	5.02	11.59	20.10
10:25	5.20	11.31	19.85
10:26	4.83	11.57	19.43
10:27	4.09	12.37	17.76
10:28	4.24	12.26	19.94
10:29	4.88	11.58	19.32
10:30	4.87	11.52	20.82
10:31	4.89	11.62	18.77
10:32	4.73	11.69	17.58
10:33	4.28	12.15	17.50
10:34	4.65	11.82	17.13
10:35	5.13	11.34	17.86
10:36	5.21	11.14	18.60
10:37	4.83	11.47	16.89
10:38	4.56	11.66	14.65
10:39	4.70	11.64	14.67

Alliance TECHNICAL GROUP

Location: Billerud Escanaba, Inc. - Escanaba, MI
Source: Boiler 11 (EU11B68) CO (Method 10)
Project No.: AST-2024-3909
Date: 9/12/24

Time Unit Status	O_2 - Outlet % dry Valid	CO_2 - Outlet % dry Valid	CO - Outlet ppmvd Valid
Uncorrected Run Average (C_{obs})	4.93	11.69	19.76
Cal Gas Concentration (C_{MA})	10.98	10.90	25.00
Pretest System Zero Response	0.84	0.10	0.46
Posttest System Zero Response	0.39	0.22	0.09
Average Zero Response (Co)	0.62	0.16	0.28
Pretest System Cal Response	10.60	10.50	24.14
Posttest System Cal Response	10.84	10.50	24.80
Average Cal Response (C_M)	10.72	10.50	24.47
Corrected Run Average (Corr)	4.68	12.16	20.14
11:35	4.88	11.98	21.53
11:36	5.30	11.56	12.92
11:37	5.66	11.14	12.67
11:38	5.19	11.54	12.76
11:39	5.04	11.68	11.27
11:40	5.25	11.40	11.34
11:41	4.98	11.62	11.77
11:42	5.04	11.63	12.34
11:43	5.54	11.05	12.92
11:44	5.42	11.04	12.00
11:45	5.30	11.11	10.53
11:46	5.20	11.15	9.09
11:47	4.91	11.29	9.02
11:48	4.41	11.89	25.62
11:49	4.53	11.66	27.39
11:50	3.84	12.47	128.26
11:51	3.95	12.49	75.49
11:52	3.96	12.42	48.08
11:53	4.25	12.34	27.31
11:54	4.45	12.15	20.43
11:55	4.14	12.41	18.33
11:56	4.24	12.46	21.64
11:57	4.49	12.28	18.51
11:58	4.38	12.26	16.09
11:59	4.55	12.19	16.28
12:00	5.17	11.54	17.60
12:01	5.22	11.39	17.58
12:02	4.87	11.66	16.31
12:03	4.76	11.87	14.96
12:04	4.96	11.71	15.83
12:05	4.97	11.65	16.54
12:06	4.87	11.64	16.93
12:07	4.70	11.78	17.12
12:08	4.68	11.91	17.11
12:09	4.84	11.89	17.04
12:10	4.93	11.81	18.06
12:11	4.90	11.78	18.15
12:12	5.11	11.67	18.26
12:13	5.36	11.33	19.06
12:14	5.12	11.59	18.39
12:15	4.84	11.78	16.66
12:16	4.52	12.22	16.46
12:17	4.82	11.81	16.15
12:18	5.04	11.69	17.29
12:19	5.22	11.51	17.64
12:20	5.09	11.55	16.88
12:21	5.18	11.56	16.75
12:22	5.04	11.57	15.96
12:23	4.63	12.15	15.60
12:24	4.66	12.10	15.75
12:25	4.79	11.98	15.54
12:26	4.97	11.85	16.90
12:27	5.33	11.39	18.05
12:28	5.66	11.08	18.95
12:29	5.67	10.97	19.87
12:30	5.41	11.17	16.89
12:31	5.33	11.25	14.43
12:32	5.64	10.85	13.41
12:33	5.48	11.00	12.75
12:34	4.91	11.61	11.33

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TECHNICAL GROUP

Location: Billerud Escanaba, Inc. - Escanaba, MI
Source: Boiler 11 (EU11B68) CO (Method 10)
Project No.: AST-2024-3909
Date: 9/12/24

Time Unit Status	O_2 - Outlet % dry Valid	CO_2 - Outlet % dry Valid	CO - Outlet ppmvd Valid
Uncorrected Run Average (C_{obs})	4.61	11.90	26.60
Cal Gas Concentration (C_{MA})	10.98	10.90	25.00
Pretest System Zero Response	0.39	0.22	0.09
Posttest System Zero Response	0.23	0.12	0.82
Average Zero Response (Co)	0.31	0.17	0.46
Pretest System Cal Response	10.84	10.50	24.80
Posttest System Cal Response	10.77	10.49	24.84
Average Cal Response (C_M)	10.81	10.50	24.82
Corrected Run Average (Corr)	4.50	12.38	26.82
13:10	4.20	12.28	17.37
13:11	4.30	12.32	18.37
13:12	5.21	11.38	16.45
13:13	5.33	11.25	19.03
13:14	4.93	11.58	17.16
13:15	4.57	11.97	14.40
13:16	4.66	11.95	15.37
13:17	4.76	11.76	15.65
13:18	4.57	12.02	15.16
13:19	4.91	11.58	15.46
13:20	4.77	11.70	15.75
13:21	4.33	12.17	16.19
13:22	4.30	12.32	19.04
13:23	4.70	11.98	19.57
13:24	4.86	11.81	19.08
13:25	4.39	12.38	19.08
13:26	4.55	12.36	19.41
13:27	4.98	11.93	21.54
13:28	5.19	11.64	22.84
13:29	4.97	11.70	20.65
13:30	5.24	11.45	18.26
13:31	5.05	11.46	20.14
13:32	4.04	12.51	39.08
13:33	4.07	12.53	44.90
13:34	4.72	11.91	22.97
13:35	4.94	11.61	21.72
13:36	4.20	12.44	37.33
13:37	4.41	12.23	40.64
13:38	4.95	11.67	21.00
13:39	4.66	11.97	20.02
13:40	4.24	12.48	19.87
13:41	4.72	12.00	23.29
13:42	5.13	11.68	20.76
13:43	5.03	11.70	21.80
13:44	4.93	11.79	20.49
13:45	4.91	11.81	19.13
13:46	4.82	11.83	20.00
13:47	4.29	12.34	19.15
13:48	4.52	12.17	22.32
13:49	4.94	11.77	17.96
13:50	5.19	11.52	17.50
13:51	5.61	10.92	16.91
13:52	5.66	10.74	16.48
13:53	4.70	11.61	13.42
13:54	4.18	11.96	16.11
13:55	4.25	12.08	14.97
13:56	4.63	11.75	14.60
13:57	5.12	11.19	14.86
13:58	4.91	11.32	15.01
13:59	4.71	11.45	13.62
14:00	4.63	11.54	14.26
14:01	4.45	11.68	13.55
14:02	3.80	12.39	62.28
14:03	3.78	12.43	73.65
14:04	3.78	12.39	72.28
14:05	3.79	12.32	72.16
14:06	3.79	12.34	71.91
14:07	3.79	12.35	71.68
14:08	3.79	12.33	71.26
14:09	3.79	12.31	70.92

Emission Calculations

Location: Billerud Escanaba, Inc. - Escanaba, MI
Source: Boiler 11 (EU11B68)
Project No.: AST-2024-3909
Parameter: Method 30B/Mercury

Run Number		Run 1	Run 2	Run 3	Average
Date		09/12/24	09/12/24	09/12/24	--
Start Time		9:40	11:35	13:10	--
Stop Time		10:53	12:50	14:22	--
Input Data					
Heat Input, MMBtu/hr	(HI)	693	707	693	698
Fuel Factor (O2 dry), dscf/MMBtu	(Fd)	9,126	9,118	9,131	9,125
Volumetric Flow Rate, dscfm	(Qs)	149,944	157,026	159,682	155,551
O2 Concentration, % dry	(O_2)	4.42	4.68	4.50	4.53
Unspiked Train (Tube A)					
Standard Meter Volume, L	(Vmstd)	35.448	35.141	34.696	35.095
Standard Meter Volume, dscf	(Vmstd)	1.252	1.241	1.225	1.239
Unspiked Trap Number	--	OL741614	OL741522	OL741632	--
Mercury Mass Section 1 (unspiked), ng		29.08	29.90	29.07	--
Mercury Mass Section 2 (unspiked), ng		0.14	0.36	0.04	--
Mercury Mass Total (unspiked), ng	(m_u)	29.22	30.26	29.11	29.53
Mercury Mass, lb	(M_{Hg-a})	6.4E-11	6.7E-11	6.4E-11	6.51E-11
Mercury Emission Rate, lb/hr	(ER_{Hg-a})	4.6E-04	5.1E-04	5.0E-04	4.90E-04
Mercury Emission Factor, lb/MMBtu (O2)	($EF_{Hg\ O2d}$)	6.0E-07	6.3E-07	6.1E-07	
Mercury Concentration (unspiked), ug/dscm	(Ca)	0.82	0.86	0.84	0.84
Spiked/Duplicate Train (Tube B)					
Standard Meter Volume, L	(Vmstd)	35.778	35.253	35.008	35.346
Standard Meter Volume, dscf	(Vmstd)	1.263	1.245	1.236	1.248
Duplicate/Spiked Trap Number	--	OL728167	OL728155	OL728153	--
Spike Mass, ng	(m_{spiked})	10	10	10	--
Mercury Mass Section 1 (with spike), ng		39.42	39.07	38.41	--
Mercury Mass Section 2 (with spike), ng		0.31	0.07	0.05	--
Mercury Mass Total (with spike), ng	(m_s)	39.73	39.14	38.46	--
Mercury Mass (without spike), ng	(m_b)	29.73	29.14	28.46	29.1
Mercury Mass, lb	(M_{Hg-b})	6.6E-11	6.4E-11	6.3E-11	6.42E-11
Mercury Emission Rate, lb/hr	(ER_{Hg-b})	4.7E-04	4.9E-04	4.9E-04	4.80E-04
Mercury Emission Factor, lb/MMBtu (O2)	($EF_{Hg\ O2d}$)	6.0E-07	6.1E-07	5.9E-07	
Mercury Concentration (duplicate/spiked), ug/dscm	(Cb)	0.83	0.83	0.81	0.82
Calculated Emissions Data					
Mercury Concentration, ug/dscm	(C_{Hg})	0.83	0.84	0.83	0.83
Mercury Mass, lb	(M_{Hg})	6.50E-11	6.55E-11	6.35E-11	6.46E-11
Mercury Emission Rate, lb/hr	(ER_{Hg})	4.65E-04	4.96E-04	4.94E-04	4.85E-04
Mercury Emission Factor, lb/MMBtu (HI)	($EF_{Hg\ HI}$)	6.71E-07	7.02E-07	7.13E-07	6.95E-07
Mercury Emission Factor, lb/MMBtu (O2)	($EF_{Hg\ O2d}$)	5.98E-07	6.19E-07	6.00E-07	6.06E-07
QC Data					
Paired Trap Agreement, %	(RD)	0.40	2.04	1.58	1.34
Paired Trap Agreement, abs. diff., ug/dscm	(RD)	0.01	0.03	0.03	0.02
Field Recovery, %	(R)	102.38	87.84	90.88	93.70
Breakthrough (unspiked), %	(B)	0.48	1.20	0.14	--
Pass Breakthrough Criteria (unspiked)		Yes	Yes	Yes	--
Breakthrough (spiked), %	(B)	0.79	0.18	0.13	--
Pass Breakthrough Criteria (spiked)		Yes	Yes	Yes	--

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Field Data

Location: Billerud Escanaba, Inc. - Escanaba, MI
Source: Boiler 11 (EU11B68)
Project No.: AST-2024-3909

Run No.		1 Unspiked			1 Spiked		
Date		9/12/24			9/12/24		
Status		Valid			Valid		
Start Time		9:40			9:40		
End Time		10:53			10:53		
Run Time (θ), min		60			60		
Meter ID		HG-220-2071-A			HG-220-2071-B		
Meter Correction Factor	(Y)	0.9923			0.9994		
Trap No.		OL741614			OL728167		
		Pre	Post		Pre	Post	
Vacuum, in. Hg (pre/post)		15.0	15.0		15.0	15.0	
Leak Check, L (pre/post)		0.000	0.000		0.000	0.000	
Flow Rate Setting, lpm		0.6			0.6		
Meter Volume, L							
Time							
0		0.000			0.000		
5		3.064			3.105		
10		6.115			6.059		
15		9.095			9.115		
20		12.026			12.112		
25		15.000			15.079		
30		18.221			18.301		
35		21.127			21.235		
40		24.002			24.094		
45		27.226			27.362		
50		30.052			30.106		
55		33.119			33.201		
60		36.057			36.134		
Total Meter Volume, L	(Vm)	36.057			36.134		
Temperatures, °F							
Time		Meter	Stack	Trap	Meter	Stack	Trap
0		61	421	285	61	421	285
5		61	421	285	61	421	285
10		61	421	285	61	421	285
15		61	421	285	61	421	285
20		61	421	285	61	421	285
25		61	421	285	61	421	285
30		61	421	285	61	421	285
35		61	421	285	61	421	285
40		61	421	285	61	421	285
45		61	421	285	61	421	285
50		61	421	285	61	421	285
55		61	421	285	61	421	285
60		61	421	285	61	421	285
Average Meter Temperature, °F	(Tm)	61.0			61.0		
Average Meter Temperature, °R	(Tm)	520.7			520.7		
Average Stack Temperature, °F	(Ts)	421.0			421.0		
Average Trap Temperature, °F	(T_T)	285.0			285.0		
Barometric Pressure, in. Hg	(Pb)	29.25			29.25		
Meter Pressure, in. Hg	(Pm)	29.25			29.25		
Standard Meter Volume, L	(Vmstd)	35.448			35.778		

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Field Data

Location: Billerud Escanaba, Inc. - Escanaba, MI
Source: Boiler 11 (EU11B68)
Project No.: AST-2024-3909

		2 Unspiked			2 Spiked		
Run No.		2 Unspiked			2 Spiked		
Date		9/12/24			9/12/24		
Status		Valid			Valid		
Start Time		11:35			11:35		
End Time		12:50			12:50		
Run Time (θ), min		60			60		
Meter ID		HG-220-2071-A			HG-220-2071-B		
Meter Correction Factor	(Y)	0.9923			0.9994		
Trap No.		OL741522			OL728155		
		Pre	Post		Pre	Post	
Vacuum, in. Hg (pre/post)		15.0	15.0		15.0	15.0	
Leak Check, L (pre/post)		0.000	0.000		0.000	0.000	
Flow Rate Setting, lpm		0.6			0.6		
Meter Volume, L							
Time							
0		0.000			0.000		
5		3.124			3.067		
10		6.035			6.156		
15		9.003			9.102		
20		12.135			12.259		
25		15.203			15.101		
30		18.534			18.379		
35		21.066			21.105		
40		24.151			24.237		
45		27.105			27.096		
50		30.195			30.164		
55		33.067			33.306		
60		36.431			36.287		
Total Meter Volume, L	(Vm)	36.431			36.287		
Temperatures, °F							
Time		Meter	Stack	Trap	Meter	Stack	Trap
0		71	421	285	71	421	285
5		71	421	285	71	421	285
10		71	421	285	71	421	285
15		71	421	285	71	421	285
20		71	421	285	71	421	285
25		71	421	285	71	421	285
30		71	421	285	71	421	285
35		71	421	285	71	421	285
40		71	421	285	71	421	285
45		71	421	285	71	421	285
50		71	421	285	71	421	285
55		71	421	285	71	421	285
60		71	421	285	71	421	285
Average Meter Temperature, °F	(Tm)	71.0			71.0		
Average Meter Temperature, °R	(Tm)	530.7			530.7		
Average Stack Temperature, °F	(Ts)	421.0			421.0		
Average Trap Temperature, °F	(T_T)	285.0			285.0		
Barometric Pressure, in. Hg	(Pb)	29.25			29.25		
Meter Pressure, in. Hg	(Pm)	29.25			29.25		
Standard Meter Volume, L	(Vmstd)	35.141			35.253		

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Field Data

Location: Billerud Escanaba, Inc. - Escanaba, MI
Source: Boiler 11 (EU11B68)
Project No.: AST-2024-3909

		3 Unspiked			3 Spiked		
Run No.		3 Unspiked			3 Spiked		
Date		9/12/24			9/12/24		
Status		Valid			Valid		
Start Time		13:10			13:10		
End Time		14:22			14:22		
Run Time (θ), min		60			60		
Meter ID		HG-220-2071-A			HG-220-2071-B		
Meter Correction Factor	(Y)	0.9923			0.9994		
Trap No.		OL741632			OL728153		
		Pre	Post		Pre	Post	
Vacuum, in. Hg (pre/post)		15.0	15.0		15.0	15.0	
Leak Check, L (pre/post)		0.000	0.000		0.000	0.000	
Flow Rate Setting, lpm		0.6			0.6		
Meter Volume, L							
Time							
0		0.000			0.000		
5		3.015			3.095		
10		6.097			6.154		
15		9.115			9.062		
20		12.187			12.239		
25		15.139			15.099		
30		18.288			18.301		
35		21.086			21.294		
40		24.195			24.263		
45		27.121			27.193		
50		30.066			30.154		
55		33.248			32.198		
60		36.241			36.307		
Total Meter Volume, L	(Vm)	36.241			36.307		
Temperatures, °F							
Time		Meter	Stack	Trap	Meter	Stack	Trap
0		75	412	285	75	412	285
5		75	412	285	75	412	285
10		75	412	285	75	412	285
15		75	412	285	75	412	285
20		75	412	285	75	412	285
25		75	412	285	75	412	285
30		75	412	285	75	412	285
35		75	412	285	75	412	285
40		75	412	285	75	412	285
45		75	412	285	75	412	285
50		75	412	285	75	412	285
55		75	412	285	75	412	285
60		75	412	285	75	412	285
Average Meter Temperature, °F	(Tm)	75.0			75.0		
Average Meter Temperature, °R	(Tm)	534.7			534.7		
Average Stack Temperature, °F	(Ts)	412.0			412.0		
Average Trap Temperature, °F	(T_T)	285.0			285.0		
Barometric Pressure, in. Hg	(Pb)	29.25			29.25		
Meter Pressure, in. Hg	(Pm)	29.25			29.25		
Standard Meter Volume, L	(Vmstd)	34.696			35.008		

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Emission Calculations

Location Billerud Escanaba, Inc. - Escanaba, MI
Source Boiler 11 (EU11B68)
Project No. AST-2024-3909
Parameter PM, HCl Methods 5-26A

Run Number		Run 1	Run 2	Run 3	Average
Date		9/12/24	9/12/24	9/12/24	--
Start Time		9:40	11:35	13:10	--
Stop Time		10:53	12:50	14:22	--
Run Time, min	(θ)	60.0	60.0	60.0	60.0
INPUT DATA					
Heat Input, MMBtu/hr	(HI)	693	707	693	698
Fuel Factor (O2 dry), dscf/MMBtu	(Fd)	9,126	9,118	9,131	9,125
Barometric Pressure, in. Hg	(Pb)	29.40	29.40	29.40	29.40
Meter Correction Factor	(Y)	0.987	0.987	0.987	--
Orifice Calibration Value	(ΔH @)	1.768	1.768	1.768	--
Meter Volume, ft^3	(Vm)	47.665	49.912	50.890	49.489
Meter Temperature, °F	(Tm)	70.2	70.8	72.3	71.1
Meter Temperature, °R	(Tm)	529.8	530.5	532.0	530.8
Meter Orifice Pressure, in. WC	(ΔH)	1.875	2.100	2.158	2.044
Volume H_2O Collected, mL	(Vlc)	228.9	245.3	251.0	241.7
Nozzle Diameter, in	(Dn)	0.360	0.360	0.360	0.360
Area of Nozzle, ft^2	(An)	0.0007	0.0007	0.0007	0.0007
Filterable PM Mass, mg	(Mn)	6.8	9.8	6.1	7.6
Filterable PM Mass, g	(Mn)	0.0068	0.0098	0.0061	0.0076
Hydrogen Chloride Mass, ug	(M_{HCl})	*61.4*	53.0	58.6	57.7
Hydrogen Chloride Mass, mg	(M_{HCl})	*0.0614*	0.0530	0.0586	0.0577
ISOKINETIC DATA					
Standard Meter Volume, ft^3	(Vmstd)	46.254	48.401	49.218	47.958
Standard Water Volume, ft^3	(Vwstd)	10.795	11.568	11.837	11.400
Moisture Fraction Measured	(BWSmsd)	0.189	0.193	0.194	0.192
Moisture Fraction @ Saturation	(BWSsat)	20.048	15.022	21.256	18.776
Moisture Fraction	(BWS)	0.189	0.193	0.194	0.192
Meter Pressure, in Hg	(Pm)	29.54	29.55	29.56	29.55
Volume at Nozzle, ft^3	(Vn)	96.989	98.894	104.456	100.11
Isokinetic Sampling Rate, (%)	(I)	104.1	104.0	104.0	104.0
DGM Calibration Check Value, (+/- 5%)	(Y_{qa})	2.9	2.4	2.0	2.5
EMISSION CALCULATIONS					
Filterable PM Concentration, grain/dscf	(C_s)	0.0023	0.0031	0.0019	0.0024
Filterable PM Emission Rate, lb/hr	(PMR)	2.92	4.20	2.62	3.25
Filterable PM Emission Factor, lb/MMBtu (HI)	(EF_{PM})	0.0042	0.0059	0.0038	0.0046
Filterable PM Emission Factor, lb/MMBtu (O2)	($EF_{PM\ O2d}$)	0.0038	0.0052	0.0032	0.0041
Hydrogen Chloride Concentration, mg/dscm	(C_{HCl})	0.047	0.039	0.042	0.043
Hydrogen Chloride Concentration, ppmvd	(C_{HClp})	0.031	0.025	0.028	0.028
Hydrogen Chloride Mass, lb	(ER_{HCl})	1.4E-07	1.2E-07	1.3E-07	1.27E-07
Hydrogen Chloride Emission Rate, lb/hr	(ER_{HCl})	0.026	0.023	0.025	0.025
Hydrogen Chloride Emission Factor, lb/MMBtu (HI)	(EF_{HCl})	3.80E-05	3.22E-05	3.63E-05	3.55E-05
Hydrogen Chloride Emission Factor, lb/MMBtu (O2)	($EF_{HCl\ O2d}$)	3.39E-05	2.84E-05	3.05E-05	3.09E-05

*The italicized value indicates that results were above the method detection limit (MDL) and below the limit of quantification (LOQ) and "J-Flagged". The analyte was positively identified, but the value is considered an estimate. The estimated value was used for calculations purposes.
*The underlined values indicate that laboratory data was reported as below detection limit; therefore, the reportable detection limit was used in emission calculations.

Location Billerud Escanaba, Inc. - Escanaba, MI
Source Boiler 11 (EU11B68)
Project No. AST-2024-3909
Parameter PM, HCl Methods 5-26A

Run Number		Run 1	Run 2	Run 3	Average
Date		9/12/24	9/12/24	9/12/24	--
Start Time		9:40	11:35	13:10	--
Stop Time		10:53	12:50	14:22	--
Run Time, min		60.0	60.0	60.0	60.0
VELOCITY HEAD, in. WC					
Point 1		0.18	0.14	0.25	0.19
Point 2		0.29	0.21	0.31	0.27
Point 3		0.27	0.18	0.31	0.25
Point 4		0.26	0.27	0.25	0.26
Point 5		0.27	0.35	0.32	0.31
Point 6		0.31	0.32	0.33	0.32
Point 7		0.24	0.25	0.24	0.24
Point 8		0.25	0.33	0.26	0.28
Point 9		0.25	0.34	0.27	0.29
Point 10		0.17	0.19	0.29	0.22
Point 11		0.22	0.28	0.25	0.25
Point 12		0.21	0.30	0.27	0.26
CALCULATED DATA					
Square Root of ΔP, (in. WC)$^{1/2}$	(ΔP)	0.492	0.509	0.528	0.509
Pitot Tube Coefficient	(Cp)	0.840	0.840	0.840	0.840
Barometric Pressure, in. Hg	(Pb)	29.40	29.40	29.40	29.40
Static Pressure, in. WC	(Pg)	-0.63	-0.63	-0.63	-0.63
Stack Pressure, in. Hg	(Ps)	29.35	29.35	29.35	29.35
Stack Cross-sectional Area, ft^2	(As)	143.14	143.14	143.14	143.14
Stack Temperature, °F	(Ts)	420.8	394.3	426.3	413.8
Stack Temperature, °R	(Ts)	880.4	854.0	886.0	873.5
Moisture Fraction Measured	(BWSmsd)	0.189	0.193	0.194	0.192
Moisture Fraction @ Saturation	(BWSsat)	20.048	15.022	21.256	18.776
Moisture Fraction	(BWS)	0.189	0.193	0.194	0.192
O_2 Concentration, %	(O_2)	4.42	4.68	4.5	4.53
CO_2 Concentration, %	(CO_2)	12.39	12.16	12.38	12.31
N_2 Concentration, %	(N_2)	83.19	83.16	83.12	83.16
Excess Air, %	(EA)	25.20	27.09	25.80	26.03
Molecular Weight, lb/lb-mole (dry)	(Md)	30.16	30.13	30.16	30.15
Molecular Weight, lb/lb-mole (wet)	(Ms)	27.86	27.80	27.81	27.82
Velocity, ft/sec	(Vs)	36.6	37.4	39.5	37.8
VOLUMETRIC FLOW RATE					
At Stack Conditions, acfm	(Qa)	314,525	320,955	339,022	324,834
At Standard Conditions, scfm	(Qsw)	184,938	194,557	198,087	192,527
At Standard Conditions, dscfm	(Qs)	149,944	157,026	159,682	155,551

Method 1 Data

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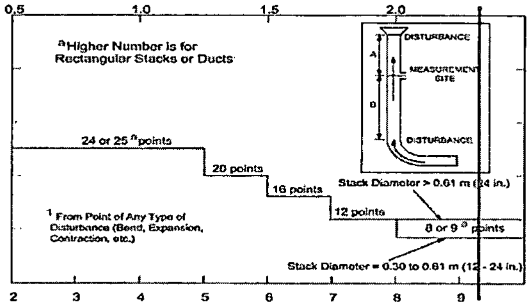
Location: Billerud Escanaba, Inc. - Escanaba, MI
Source: Boiler 11 (EU11B68)
Project No.: AST-2024-3909
Date: 09/09/24

Stack Parameters

Duct Orientation:	Vertical	
Duct Design:	Circular	
Distance from Far Wall to Outside of Port:	237.00	in
Nipple Length:	75.00	in
Diameter:	162.00	in
Cross Sectional Area of Duct:	143.14	ft^2
No. of Test Ports:	4	
Distance A:	150.0	ft
Distance A Duct Diameters:	11.1	(must be ≥ 0.5)
Distance B:	125.0	ft
Distance B Duct Diameters:	9.3	(must be ≥ 2)
Minimum Number of Traverse Points:	12	
Actual Number of Traverse Points:	12	
Number of Readings per Point:	1	
Measurer (Initial and Date):	DHH 9/9/24	
Reviewer (Initial and Date):	JJB 9/9/24	



CIRCULAR DUCT

LOCATION OF TRAVERSE POINTS

Number of traverse points on a diameter

	2	3	4	5	6	7	8	9	10	11	12
1	14.6	--	6.7	--	4.4	--	3.2	--	2.6	--	2.1
2	85.4	--	25.0	--	14.6	--	10.5	--	8.2	--	6.7
3	--	--	75.0	--	29.6	--	19.4	--	14.6	--	11.8
4	--	--	93.3	--	70.4	--	32.3	--	22.6	--	17.7
5	--	--	--	--	85.4	--	67.7	--	34.2	--	25.0
6	--	--	--	--	95.6	--	80.6	--	65.8	--	35.6
7	--	--	--	--	--	--	89.5	--	77.4	--	64.4
8	--	--	--	--	--	--	96.8	--	85.4	--	75.0
9	--	--	--	--	--	--	--	--	91.8	--	82.3
10	--	--	--	--	--	--	--	--	97.4	--	88.2
11	--	--	--	--	--	--	--	--	--	--	93.3
12	--	--	--	--	--	--	--	--	--	--	97.9

*Percent of stack diameter from inside wall to traverse point.

Traverse Point	% of Diameter	Distance from inside wall	Distance from outside of port
1	4.4	7.13	82 1/8
2	14.6	23.65	98 5/8
3	29.6	47.95	122 15/16
4	--	--	--
5	--	--	--
6	--	--	--
7	--	--	--
8	--	--	--
9	--	--	--
10	--	--	--
11	--	--	--
12	--	--	--

Stack Diagram
A = 150 ft.
B = 125 ft.
Diameter ==162 in.

Cross Sectional Area