1.0 INTRODUCTION

1.1 SUMMARY OF TEST PROGRAM

Cleveland-Cliffs Dearborn Works (CCDW) (State Registration Number: A8640) contracted Montrose Air Quality Services, LLC (Montrose) to perform a compliance test program on the Basic Oxygen Furnace (EUBOF) Electrostatic Precipitator (ESP) at the Cleveland-Cliffs Dearborn Works (CCDW) facility located in Dearborn, Michigan. Testing was performed on August 3-4, 2021, for the purpose of evaluating compliance with PM, PM_{10}, and $PM_{2.5}$ emission limits after the completion of Phase I of the ESP rebuild project.

The specific objectives were to:

- Verify the emissions of filterable particulate matter (FPM), particulate matter less than 10-µm (PM_{10}), and particulate matter less than 2.5-µm ($PM_{2.5}$) from the ESP exhaust stack serving the EUBOF
- Conduct the test program with a focus on safety

Montrose performed the tests to measure the emission parameters listed in Table 1-1.

TABLE 1-1
SUMMARY OF TEST PROGRAM

Test Dates	Unit ID/ Source Name	Activity/ Parameters	Test Methods	No. of Runs	Duration (Minutes)
8/3/2021 - 8/4/2021	EUBOF	Velocity/Volumetric Flow Rate	EPA 1 & 2	3	136-154.75
8/3/2021 - 8/4/2021	EUBOF	O_2, CO_2	EPA 3A	3	134-154.8
8/3/2021 - 8/4/2021	EUBOF	Moisture	EPA 4	3	136-154.75
8/3/2021 - 8/4/2021	EUBOF	$PM_{10}/PM_{2.5}$	EPA 201A/202	3	136-154.75
8/3/2021 - 8/4/2021	EUBOF	Velocity/Volumetric Flow Rate	EPA 1 & 2	3	130-135
8/3/2021 - 8/4/2021	EUBOF	O_2, CO_2	EPA 3A	3	134-154.8
8/3/2021 - 8/4/2021	EUBOF	Moisture	EPA 4	3	130-135

TABLE 1-1
SUMMARY OF TEST PROGRAM - CONTINUED

Test Dates	Unit ID/ Source Name	Activity/ Parameters	Test Methods	No. of Runs	Duration (Minutes)
8/3/2021 - 8/4/202/	EUBOF	FPM	EPA 5	3	130-135

To simplify this report, a list of Units and Abbreviations is included in Appendix D.1. Throughout this report, chemical nomenclature, acronyms, and reporting units are not defined. Please refer to the list for specific details.

This report presents the test results and supporting data, descriptions of the testing procedures, descriptions of the facility and sampling locations, and a summary of the quality assurance procedures used by Montrose. The average emission test results are summarized and compared to their respective permit limits in Table 1-2. Detailed results for individual test runs can be found in Section 4.0. All supporting data can be found in the appendices.

The testing was conducted by the Montrose personnel listed in Table 1-3. The tests were conducted according to the Intent-to-Test notification dated June 30, 2021 that was submitted to EGLE.

TABLE 1-2
SUMMARY OF AVERAGE COMPLIANCE RESULTS -
EUBOF
AUGUST 3-4, 2021

Parameter/Units	Average Results	Emission Limits
Filterable Particulate Matter (FPM)		
gr/dscf	0.0069	0.0152
lb/hr	34.7	62.6
Particulate Matter < 10-µm (PM_{10})		
lb/hr	39.7	47.5
Particulate Matter < 2.5-µm ($PM_{2.5}$)		
lb/hr	39.67	46.85

1.2 KEY PERSONNEL

A list of project participants is included below:

Facility Information

Source Location:	Cleveland-Cliffs Dearborn Works (CCDW) 4001 Dearborn Road Dearborn, MI 48120
Project Contact:	David Pate
Role:	Senior Environmental Engineer
Company:	Cleveland-Cliffs Dearborn Works (CCDW)
Telephone:	313-323-1261
Email:	david.pate@clevelandcliffs.com

Agency Information

Regulatory Agency:	EGLE
Agency Contact:	Karen Kajiya-Mills
Telephone:	517-256-0880
Email:	Kajiya-millsk@michigan.gov

Testing Company Information

Testing Firm:	Montrose Air Quality Services, LLC	
Contact:	Matthew Young	David Trahan
Title:	District Manager	Field Project Manager
Telephone:	248-548-8070	248-548-8070
Email:	myoung@montrose-env.com	dtrahan@montrose-env.com

Laboratory Information

Laboratory:	Montrose
City, State:	Royal Oak, MI
Method:	EPA 5 and 201A
Laboratory:	Enthalpy Analytical, LLC
City, State:	Durham, NC
Method:	EPA 202

Test personnel and observers are summarized in Table 1-3.

TABLE 1-3
TEST PERSONNEL AND OBSERVERS

Name	Affiliation	Role/Responsibility
David Trahan	Montrose	Field Project Manager, QI
Steve Smith	Montrose	Client Project Manager, QI
David Koponen	Montrose	Field Technician
Scott Dater	Montrose	Field Technician
Mike Nummer	Montrose	Field Technician
David Pate	Cleveland-Cliffs Dearborn Works (CCDW)	Observer/Client Liaison/Test Coordinator
Katherine Koster	EGLE	Observer
Regina Angellotti	EGLE	Observer

2.0 PLANT AND SAMPLING LOCATION DESCRIPTIONS

2.1 PROCESS DESCRIPTION, OPERATION, AND CONTROL EQUIPMENT

Cleveland-Cliffs Steel Corporation owns and operates an electrostatic precipitator (ESP) located in Dearborn, Michigan. Scrap steel is charged into the basic oxygen furnace (BOF) vessel and then molten iron is charged into the vessel on top of the scrap. Fluxing agents are also added during the steelmaking process, Oxygen is blown into the molten iron/scrap mixture causing the scrap to melt and refining the iron into steel by reducing the carbon content. The heat for the steelmaking process comes from the reaction of oxygen with the dissolved carbon in the molten iron.

Particulate emissions consisting of iron oxides and various other metal oxides are also produced. In order to remove the large amounts of particulate, flue gas is controlled by an ESP. The ESP is considered to be the "Primary" control device in the steel making process at Cleveland Cliffs – Dearborn's BOF shop. The dust-laden gases enter the ESP and the dust particulates are electrically energized (negative charge) prior to entering the ESP. The charged particles then migrate over to the positively charged collector plates, where the particulate matter is collected. Rappers are used to impart a vibration to both the discharge electrodes and the collection plates to dislodge the accumulated dust. The clean gases pass through the ID fans and are discharged out the stack passing through the COM light pathway.

In addition to the ESP, a Secondary Emission Control Baghouse (BOF Baghouse) is in operation at the facility, which collects and controls particulate emissions during the hot metal charging and tapping operations that occur at the BOF vessels during the steel making heats. Additionally, the BOF Secondary Baghouse controls emissions generated by the iron reladling operation. The ESP and BOF were in operation for this testing event.

2.2 FLUE GAS SAMPLING LOCATION

Information regarding the sampling location is presented in Table 2-1.

TABLE 2-1
SAMPLING LOCATION

Sampling Location	Stack Inside Diameter (in.)	Distance from Nearest Disturbance		Number of Traverse Points
		Downstream EPA "B" (in./dia.)	Upstream EPA "A" (in./dia.)	
EUBOF ESP Exhaust Stack	204.0	1200 / 5.9	600 / 2.9	Isokinetic: 12 (3/port) - Method 201A/202; Isokinetic: 20 (5/port) - Method 5; Gaseous: 1

The sampling location was verified in the field to conform to EPA Method 1. Acceptable cyclonic flow conditions were confirmed prior to testing using EPA Method 1, Section 11.4. See Appendix A.1 for more information.

2.3 OPERATING CONDITIONS AND PROCESS DATA

Emission tests were performed while the EUBOF and air pollution control devices were operating at the conditions required by the permit. The EUBOF was tested when operating normally and at a minimum of two process heats for each sampling run.

Plant personnel were responsible for establishing the test conditions and collecting all applicable unit-operating data. The process data that was provided is presented in Appendix B. Data collected includes the following parameters:

- Start and stop time of each steel production cycle
- Production rate, tons/hr,
- COMS Data, 6 minute and 1-hour block average
- Number and identification of the ESP compartments and fields in operation.

3.0 SAMPLING AND ANALYTICAL PROCEDURES

3.1 TEST METHODS

The test methods for this test program were presented previously in Table 1-1. Additional information regarding specific applications or modifications to standard procedures is presented below.

3.1.1 EPA Method 1, Sample and Velocity Traverses for Stationary Sources

EPA Method 1 is used to assure that representative measurements of volumetric flow rate are obtained by dividing the cross-section of the stack or duct into equal areas, and then locating a traverse point within each of the equal areas. Acceptable sample locations must be located at least two stack or duct equivalent diameters downstream from a flow disturbance and one-half equivalent diameter upstream from a flow disturbance.

3.1.2 EPA Method 2, Determination of Stack gas Velocity and Volumetric Flow Rate (Type S Pitot Tube)

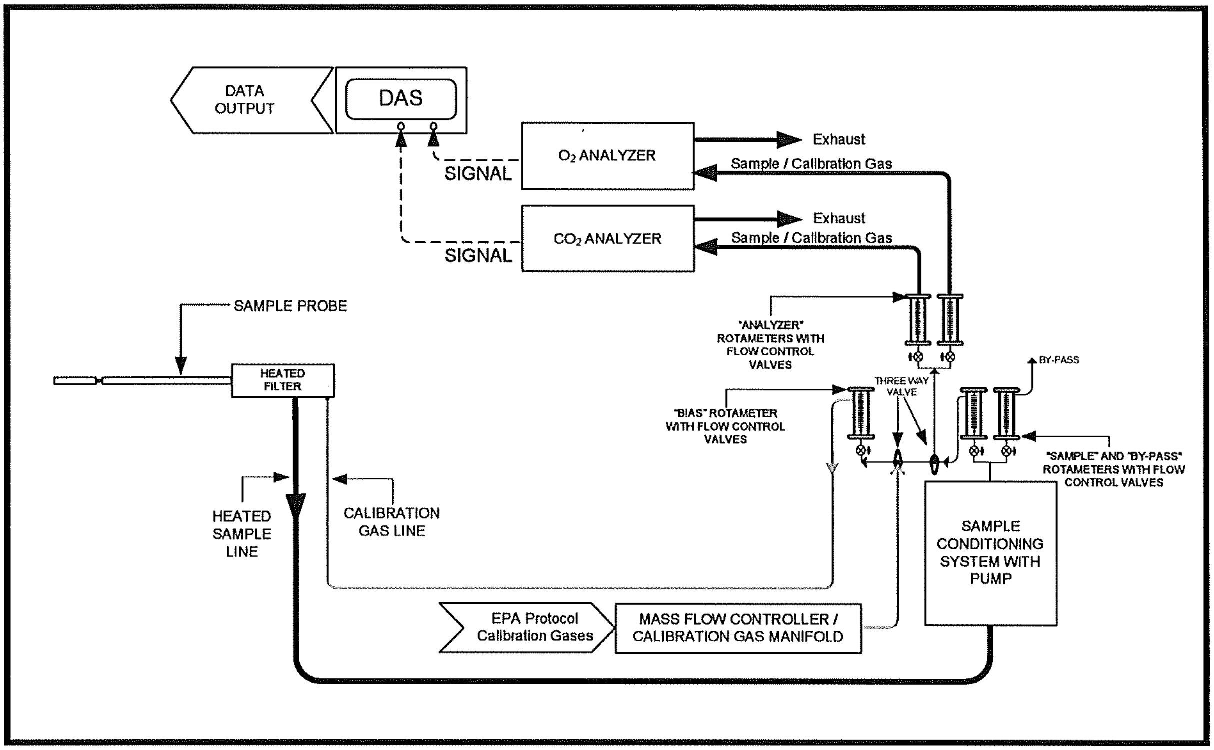
EPA Method 2 is used to measure the gas velocity using an S-type pitot tube connected to a pressure measurement device, and to measure the gas temperature using a calibrated thermocouple connected to a thermocouple indicator. Typically, Type S (Stausscheibe) pitot tubes conforming to the geometric specifications in the test method are used, along with an inclined manometer. The measurements are made at traverse points specified by EPA Method 1. The molecular weight of the gas stream is determined from independent measurements of O_2, CO_2, and moisture. The stack gas volumetric flow rate is calculated using the measured average velocity head, the area of the duct at the measurement plane, the measured average temperature, the measured duct static pressure, the molecular weight of the gas stream, and the measured moisture.

3.1.3 EPA Method 3A, Determination of Oxygen and Carbon Dioxide Concentrations in Emissions from Stationary Sources (Instrumental Analyzer Procedure)

EPA Method 3A is an instrumental test method used to measure the concentration of O_2 and CO_2 in stack gas. The effluent gas is continuously or intermittently sampled and sent to analyzers that measure the concentration of O_2 and CO_2. The performance requirements of the method must be met to validate data.

The typical sampling system is detailed in Figure 3-1.

FIGURE 3-1
EPA METHOD 3A SAMPLING TRAIN



3.1.4 EPA Method 4, Determination of Moisture Content in Stack Gas

EPA Method 4 is a manual, non-isokinetic method used to measure the moisture content of gas streams. Gas is sampled at a constant sampling rate through a probe and impinger train. Moisture is removed using a series of pre-weighed impingers containing methodology-specific liquids and silica gel immersed in an ice water bath. The impingers are weighed after each run to determine the percent moisture.

The typical sampling system is detailed in Figures 3-2 and 3-3

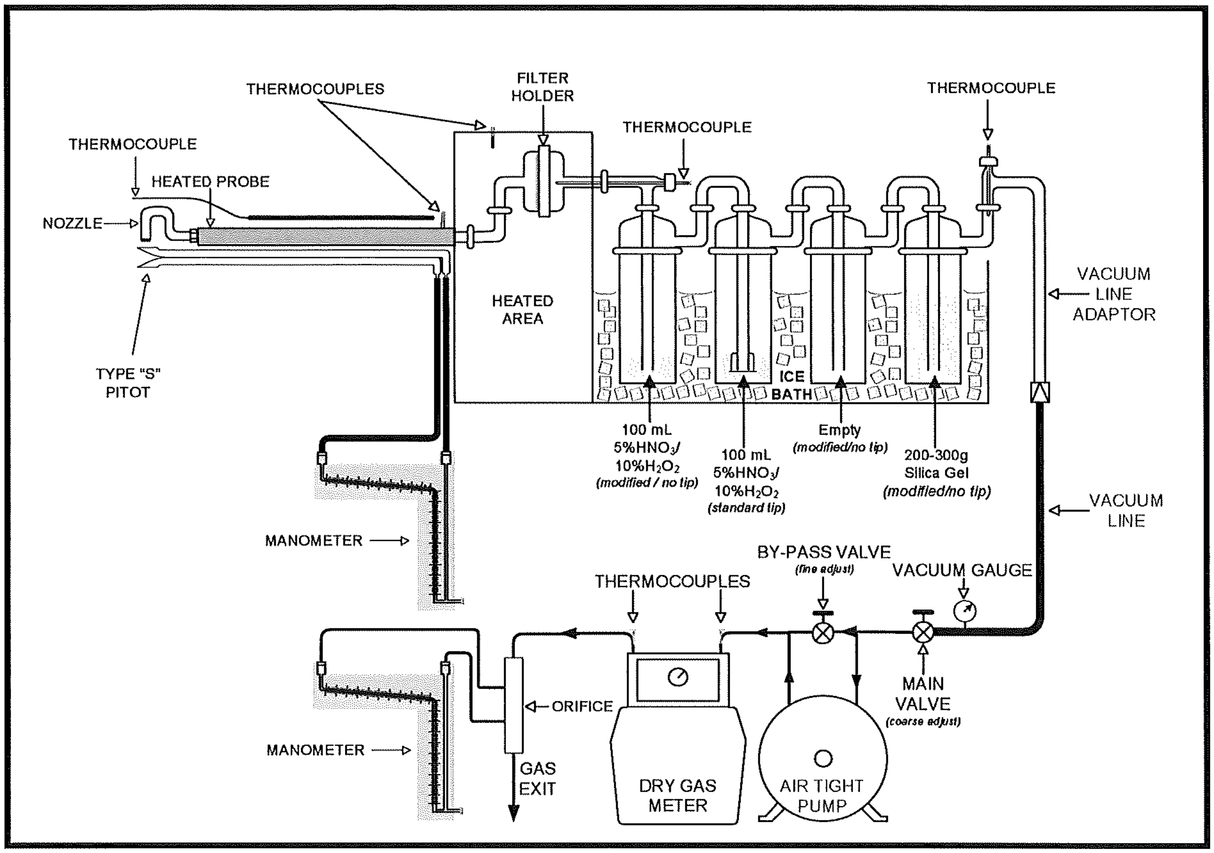
3.1.5 EPA Method 5, Determination of Particulate Matter from Stationary Sources

EPA Method 5 is a manual, isokinetic method used to measure FPM emissions. The samples are analyzed gravimetrically. This method is performed in conjunction with EPA Methods 1 through 4. The stack gas is sampled through a nozzle, probe, filter, and impinger train. FPM results are reported in emission concentration and emission rate units.

This EPA Method 5 sampling train utilized a EPA Method 29 impinger set up.

The typical sampling system is detailed in Figure 3-2.

FIGURE 3-2
EPA METHOD 5 SAMPLING TRAIN



3.1.6 EPA Method 201A, Determination of PM_{10} and $PM_{2.5}$ Emissions from Stationary Sources (Constant Sampling Rate Procedure)

To measure PM_{10} and $PM_{2.5}$, a sample of gas is extracted at a predetermined constant flow rate through an in-stack sizing device. The particle-sizing device separates particles with nominal aerodynamic diameters of 10 micrometers and 2.5 micrometers. To minimize variations in the isokinetic sampling conditions, well-defined limits must be established. After a sample is obtained, uncombined water is removed from the particulate. Gravimetric analysis is then used to determine the particulate mass for each size fraction. The method allows the use of a $PM_{2.5}$ cyclone downstream of the PM_{10} cyclone. Both cyclones were developed and evaluated as part of a conventional five-stage cascade cyclone train. The addition of a $PM_{2.5}$ cyclone between the PM_{10} cyclone and the stack temperature filter in the sampling train supplements the measurement of PM_{10} with the measurement of $PM_{2.5}$.

Without the addition of the $PM_{2.5}$ cyclone, the filterable particulate portion of the sampling train may be used to measure total and PM_{10} emissions. Likewise, with the exclusion of the PM_{10} cyclone, the filterable particulate portion of the sampling train may be used to measure total and $PM_{2.5}$ emissions.

During this test event, only the PM_{10} cyclone was used. $PM_{2.5}$ was assumed to be equivalent to $PM_{10.}$

The typical sampling system is detailed in Figure 3-3.

3.1.7 EPA Method 202, Dry Impinger Method for Determining Condensable Particulate Emissions from Stationary Sources

The CPM is collected in dry impingers after filterable PM has been collected on a filter maintained as specified in either Method 5 of Appendix A-3 to 40 CFR 60, Method 17 of Appendix A-6 to 40 CFR 60, or Method 201A of Appendix M to 40 CFR 51. The organic and aqueous fractions of the impingers and an out-of-stack CPM filter are then taken to dryness and weighed. The total of the impinger fractions and the CPM filter represents the CPM. Compared to the version of Method 202 that was promulgated on December 17, 1991, this method eliminates the use of water as the collection media in impingers and includes the addition of a condenser followed by a water dropout impinger immediately after the final in-stack or heated filter. This method also includes the addition of one modified Greenburg Smith impinger (backup impinger) and a CPM filter following the water dropout impinger.

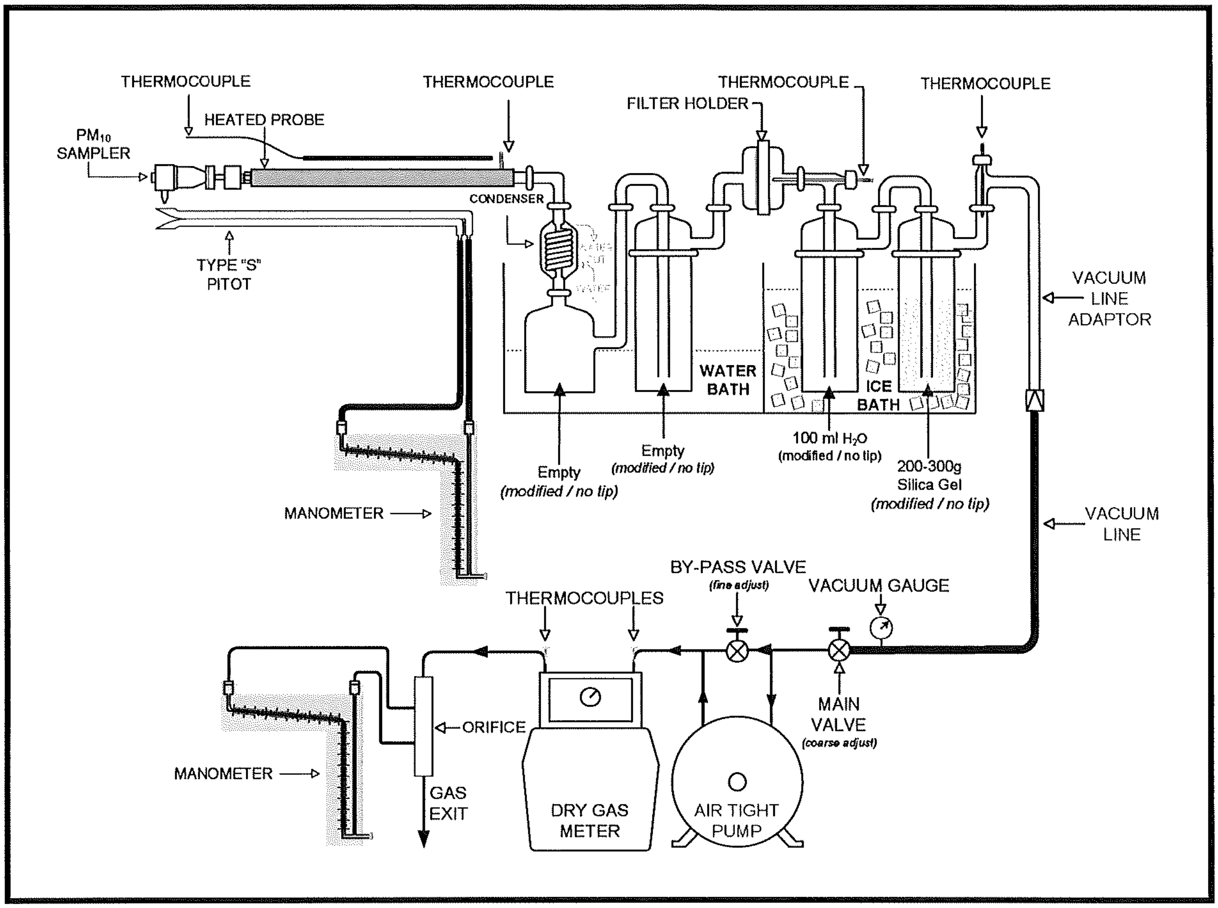
CPM is collected in the water dropout impinger, the modified Greenburg Smith impinger, and the CPM filter of the sampling train as described in this method. The impinger contents are purged with nitrogen immediately after sample collection to remove dissolved SO_2 gases from the impinger. The CPM filter is extracted with water and hexane. The impinger solution is then extracted with hexane. The organic and aqueous fractions are dried and the residues are weighed. The total of the aqueous and organic fractions represents the CPM.

The potential artifacts from SO_2 are reduced using a condenser and water dropout impinger to separate CPM from reactive gases. No water is added to the impingers prior to the start of sampling. To improve the collection efficiency of CPM, an additional filter (the "CPM filter") is placed between the second and third impingers.

CPM, for this test event, is counted as PM_{10} and $PM_{2.5}$ and the results for PM10 and PM2.5 includes the condensable fraction.

The typical sampling system is detailed in Figure 3-3.

FIGURE 3-3
EPA METHOD 201A/202 SAMPLING TRAIN



3.2 PROCESS TEST METHODS

The test plan did not require that process samples be collected during this test program; therefore, no process sample data are presented in this test report.

4.0 TEST DISCUSSION AND RESULTS

4.1 FIELD TEST DEVIATIONS AND EXCEPTIONS

An EPA Method 29 backhalf was used with the EPA Method 5 sampling train to allow for the possible analysis of Lead and Manganese. No EPA Method 29 analysis was performed.

Sampling for an integral number of heats was conducted as specified within the test plan (Section 3.3, comment 1).

Sampling was extended past the calculated end point of the traverse to meet the integral heat requirement as described in the test plan (Section 3.3, comment 2).

At EGLE's request, port changes were not conducted during an oxygen blow, instead, sampling continued until completion of the oxygen blow and at the traverse point. After the oxygen blow, sampling then resumed at the next port at the first traverse point.

See section 5.2 for the QA/QC discussion conceming deviations to Method 201A testing.

4.2 PRESENTATION OF RESULTS

The average results are compared to the permit limits in Table 1-2. The results of individual compliance test runs performed are presented in Tables 4-1 and 4-2. Emissions are reported in units consistent with those in the applicable regulations or requirements. Additional information is included in the appendices as presented in the Table of Contents.

TABLE 4-1
PM_{10} AND $PM_{2.5}$ EMISSIONS RESULTS -
EUBOF

Run Number	1	2	3	Average
Date	8/3/2021	8/3/2021	8/4/2021	--
Time	8:01-11:06	12:05-14:49	8:03-10:55	--
Process Data				
production rate, ton/hr	359.3	439.8	352.6	383.9
Flue Gas Parameters				
O_2, % volume dry	19.34	18.78	19.28	19.13
CO_2, % volume dry	2.38	3.24	2.42	2.68
flue gas temperature, °F	223.5	234.1	211.2	222.9
moisture content, % volume	12.3	16.8	14.0	14.4
volumetric flow rate, dscfm	551,535	563,526	550,833	555,298
Condensable Particulate Matter (CPM)				
gr/dscf	0.0011	0.0022	0.0011	0.0015
lb/hr	5.43	10.4	5.22	7.01
Filterable PM < 10-µm (PM_{10}) and Filterable PM < 2.5 ($PM_{2.5}$)				
gr/dscf	0.0082	0.0069	0.0056	0.0069
lb/hr	38.5	33.1	26.3	32.7
Particulate Matter < 10-µm (PM_{10}) and Particulate Matter < 2.5 ($PM_{2.5}$)				
gr/dscf	0.0093	0.0090	0.0067	0.0083
lb/hr	44.0	43.5	31.5	39.7

TABLE 4-2
FILTERABLE PM EMISSIONS RESULTS -
EUBOF

Run Number	1	2	3	Average
Date	8/3/2021	8/3/2021	8/4/2021	--
Time	8:01-11:02	12:05-14:46	8:03-10:53	--
Process Data				
production rate, ton/hr	359.3	439.8	352.6	383.9
Flue Gas Parameters				
O_2, % volume dry	19.34	18.78	19.28	19.13
CO_2, % volume dry	2.38	3.24	2.42	2.68
flue gas temperature, °F	229.0	242.0	212.7	227.9
moisture content, % volume	14.4	16.9	15.8	15.7
volumetric flow rate, dscfm	576,660	592,811	590,801	586,757
Filterable Particulate Matter (FPM)				
gr/dscf	0.0053	0.0074	0.0080	0.0069
lb/hr	26.0	37.6	40.4	34.7

5.0 INTERNAL QA/QC ACTIVITIES

5.1 QA/QC AUDITS

The meter boxes and sampling trains used during sampling performed within the requirements of their respective methods. All post-test leak checks, minimum metered volumes, minimum sample durations, and percent isokinetics met the applicable QA/QC criteria..

EPA Method 3A calibration audits were all within the measurement system performance specifications for the calibration drift checks, system calibration bias checks, and calibration error checks.

EPA Method 201A QA/QC for aerodynamic cut sizes (D_{50}) met the criteria specified in Section 8.5 of the method, other exceptions to the method are noted in Section 5.2.

EPA Method 5 analytical QA/QC results are included in the laboratory report. The method QA/QC criteria were met, except if noted in Section 5.2. An EPA Method 5 reagent blank was analyzed. The maximum allowable amount that can be subtracted is 0.001% of the weight of the acetone blank. The blank did not exceed the maximum residue allowed.

EPA Method 202 analytical QA/QC results are included in the laboratory report. The method QA/QC criteria were met. An EPA Method 202 Field Train Recovery Blank (FTRB) was performed for each source category. The maximum allowable amount that can be subtracted is 0.002 g (2.0 mg). For this project, the FTRB had a mass of 2.9 mg, and 2.0 mg was subtracted.

5.2 QA/QC DISCUSSION

As outlined in EPA Method 201A Section 8.5.5, the nozzle selected established a ΔP-min/max range for each run. As per Section 8.5.5, when sampling PM_{10}, 8% of the ΔPs are allowed to be outside the specified range (failure rate). The failure rates for this event were 27%, 38%, and 19% for Runs 1-3, respectively.

As outlined in EPA Method 201A Sections 8.1.6, 8.2.1, 8.4, 8.5.5, and 8.7, sampling should be performed at a constant rate in order to maintain the correct cut diameters. Sampling was not performed at a constant rate during this test event.

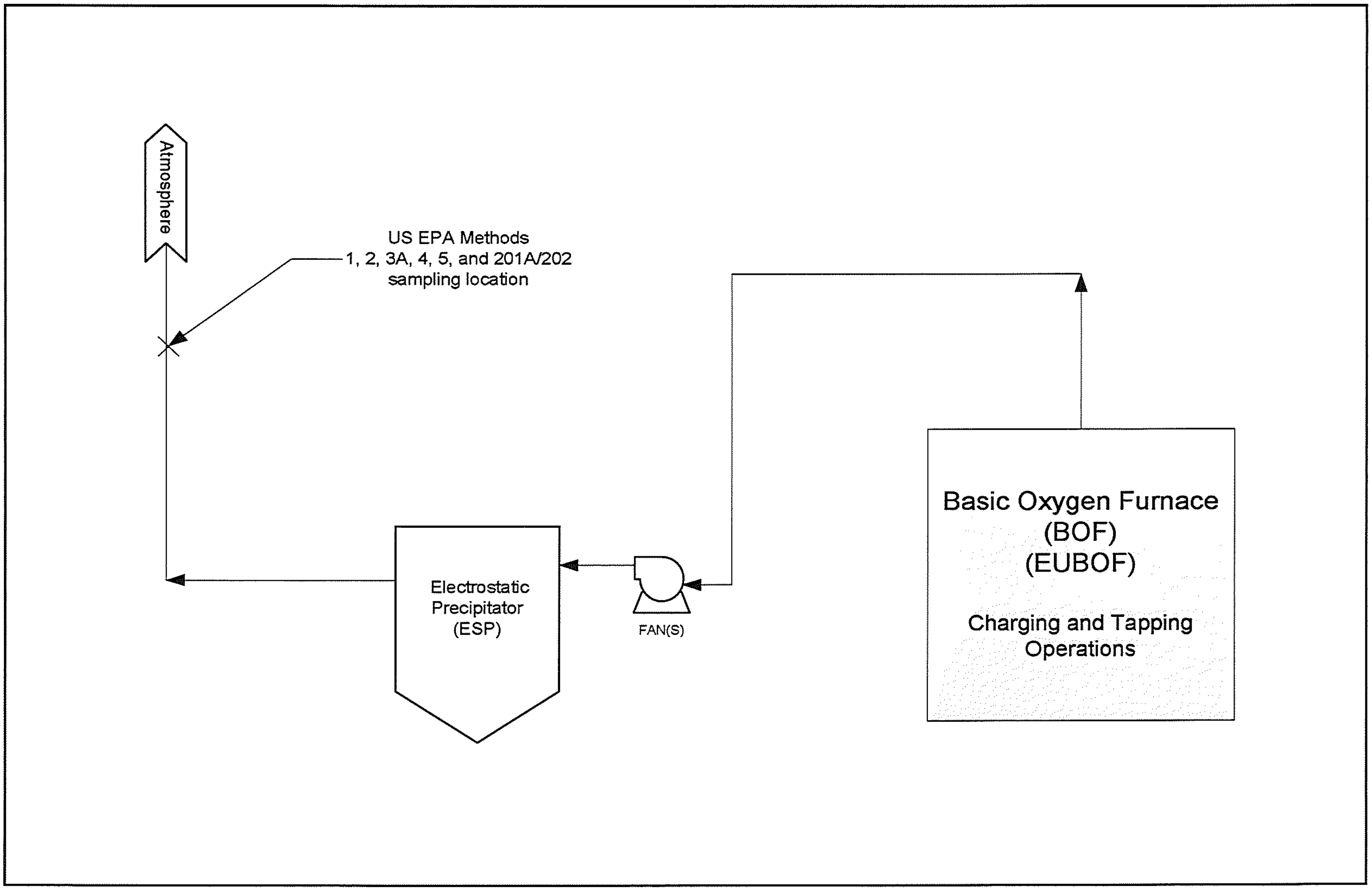
5.3 QUALITY STATEMENT

Montrose is qualified to conduct this test program and has established a quality management system that led to accreditation with ASTM Standard D7036-04 (Standard Practice for Competence of Air Emission Testing Bodies). Montrose participates in annual functional assessments for conformance with D7036-04 which are conducted by the American Association for Laboratory Accreditation (A2LA). All testing performed by Montrose is supervised on site by at least one Qualified Individual (QI) as defined in D7036-04 Section 8.3.2. Data quality objectives for estimating measurement uncertainty within the documented limits in the test methods are met by using approved test protocols for each project as defined in D7036-04 Sections 7.2.1 and 12.10. Additional quality assurance information is included in the report appendices. The content of this report is modeled after the EPA Emission Measurement Center Guideline Document (GD-043).

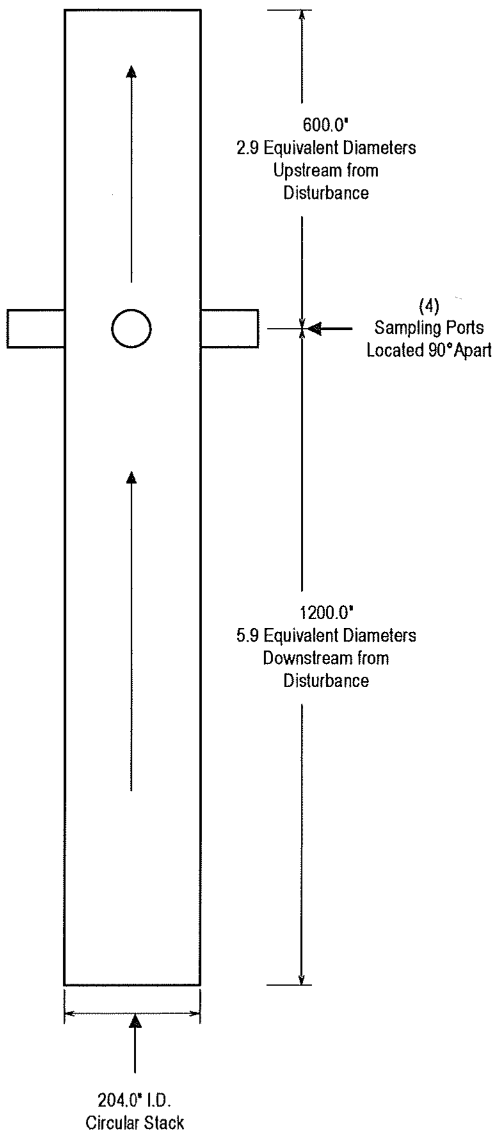
APPENDIX A
FIELD DATA AND CALCULATIONS

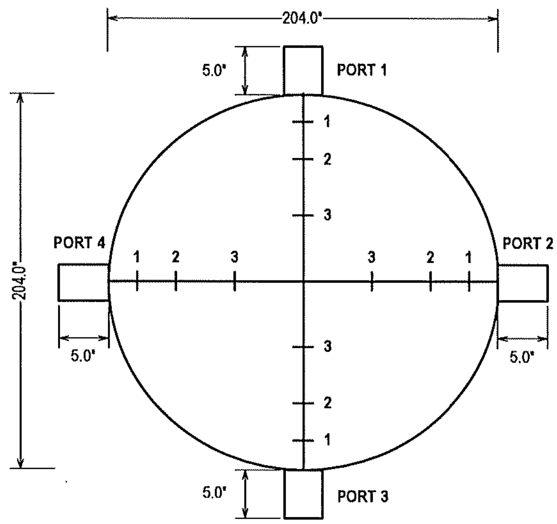
Appendix A.1
Sampling Locations

EUBOF PROCESS AND SAMPLING LOCATION SCHEMATIC



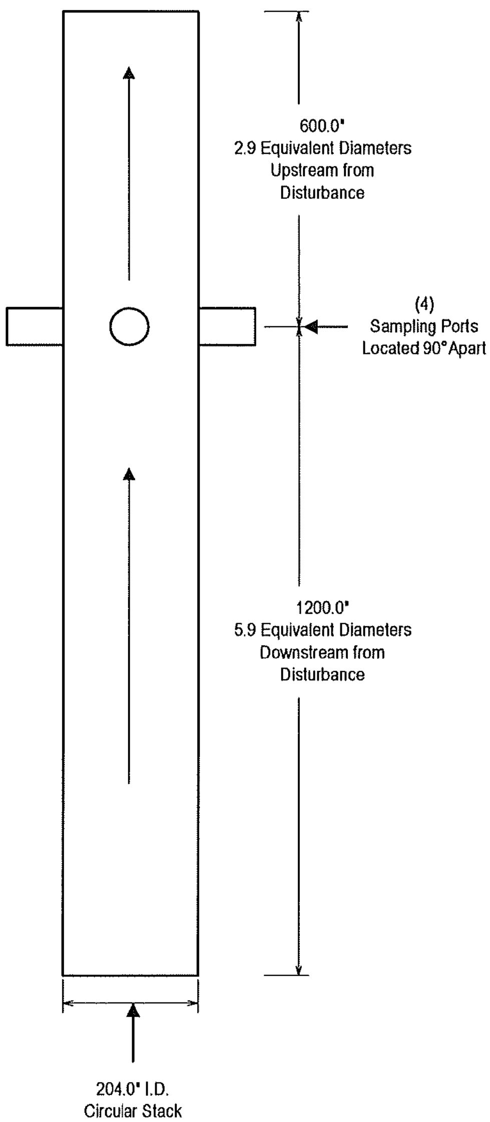
EUBOF ESP EXHAUST METHOD 201A/202 TRAVERSE POINT LOCATION DRAWING

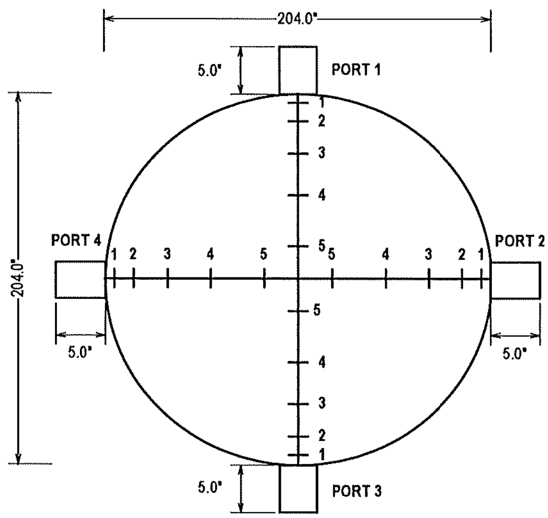




Point	% of Stack Depth	Distance from Inside Wall (in.) PORTS 1 & 3	Distance from Inside Wall (in.) PORTS 2 & 4
1	4.4	9.0	9.0
2	14.6	29.8	29.8
3	29.6	60.4	60.4

EUBOF ESP EXHAUST METHOD 5 TRAVERSE POINT LOCATION DRAWING





Point	% of Stack Depth	Distance from Inside Wall (in.) PORT 1	Distance from Inside Wall (in.) PORT 2
1	2.6	5.3	5.3
2	8.2	16.7	16.7
3	14.6	29.8	29.8
4	22.6	46.1	46.1
5	34.2	69.8	69.8

MONTROSE AIR QUALITY SERVICES