FINAL REPORT

CLEVELAND CLIFFS

DEARBORN, MICHIGAN

QUARTER 4 (Q4) NOVEMEBER 21 & 22, 2023 SOURCE TESTING REPORT: BASIC OXYGEN FURNACE (EUBOF) AND BASIC OXYGEN FURNACE SHOP OPERATIONS (FGBOFSHOP)

RWDI #2303982.04

December 28, 2023

SUBMITTED TO

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EXECUTIVE SUMMARY

RWDI USA LLC (RWDI) was retained by Cleveland-Cliffs Dearborn Works (CCDW) to complete the Quarter 4 (Q4) 2023 emission sampling program at their facility located at 4001 Miller Road, Dearborn, Michigan. The purpose of the emissions test program was to verify emissions required by Michigan Department of Environment, Great Lakes, and Energy (EGLE) Renewable Operating Permit MI-ROP-A8640-2016a, and to comply with the testing requirements specified within the current lodged but not effective First Material Modification to the consent decree, Civil Action No. 15-cv-11804, DJ # 90-5-2-1-10702. The test program consisted of testing for particulate matter, particulate matter less than 10 microns (PM_{10}), particulate matter less than 2.5 microns ($PM_{2.5}$), lead (Pb), manganese (Mn), and visible emissions (VE) from the Electrostatic Precipitator (ESP) (SVBOFESP) and Pb and Mn from the Secondary Emission Control (SEC) Baghouse (SVBOFBH). In addition, visible emission observations were conducted on the BOF Roof Monitor at the request of EGLE. Pb and Mn testing was performed simultaneously on the ESP and the SEC Baghouse. Condensable Particulate Emissions (CPM) was measured from the ESP along with the FPM testing and $PM_{2.5}$ and PM_{10} emissions are reported as the sum of FPM and CPM.

Executive Table i: Test Results

		Concentration	
Source	**Parameter**	**Average Emission Rate**	**Emission Limit**
BOF ESP	PM (Filterable only)	0.0019 gr/dscf	0.0152 gr/dscf
		7.2 lb/hr	62.6 lb/hr
	PM_{10} (Filterable + Condensable)	9.7 lb/hr	47.5 lb/hr
	$PM_{2.5}$ (Filterable + Condensable)	9.70 lb/hr	46.85 lb/hr
	Lead	0.0077 lb/hr	--
	Manganese	0.045 lb/hr	--
	Visible Emissions	1%, 6-minute average (1)(2)	20%, 6-minute average (1)
BOF SEC Baghouse	Lead	0.0021 lb/hr	--
	Manganese	0.0056 lb/hr	0.07 lb/hr
BOF ESP & SEC Baghouse Combined	Lead	0.010 lb/hr	0.067 lb/hr
	Manganese	0.051 lb/hr	0.10 lb/hr
BOF Roof Monitor	Visible Emissions	1%, 3-minute Average(2)	15% 3-minute Average (FGBOFSHOP) 20% 3-minute Average (EUBOF)

Notes: (1) One 6-minute average opacity of up to 27% is exempt per hour
(2) Reported as maximum 3-minute average observed for BOF Roof Monitor and 6-minute average for ESP during all observations

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CLEVELAND CLIFFS - DEARBORN WORKS
RWDI#2303982.04
December 28, 2023

3.4 Normal Rated Capacity of Process

Approximately 250 tons steel per batch.

3.5 Process Instrumentation Monitored During the Test

The process data recorded during the testing can be found in **Appendix A**. The following parameters were recorded:

- Steel Production Rate, TPH
- Start and stop time of each steel production cycle and oxygen blow
- Average oxygen blow rate per heat
- Start and stop time of charging, tapping, and reladling per heat
- Number and identification of the ESP casings, compartments, and fields in operation per heat
- Average ESP inlet draft during oxygen blowing measured per heat
- Average primary louver position of the blowing vessel per heat
- ESP COMS 1-hour and 6-minute block average data per run
- Baghouse pressure drop and bag leak detection readings per heat
- Identification of baghouse compartments in operation per heat
- Manganese and lead concentration in hot metal per heat
- Analysis of a dust sample for Pb and Mn from the ESP hopper per test run

4 SAMPLING AND ANALYTICAL PROCEDURES

4.1 Description of Sampling Train and Field Procedures

4.1.1 Stack Velocity, Temperature, and Volumetric Flow Rate Determination USEPA Method 1-4

The exhaust velocities and flow rates were determined following the US EPA Method 2, "Determination of Stack Gas Velocity and Flow Rate (Type S Pitot Tube)". Velocity measurements were taken with a pre-calibrated S-Type pitot tube. Volumetric flow rates were determined following the equal area method as outlined in US EPA Method 1. Temperature measurements were made simultaneously with the velocity measurements and were conducted using a chromel-alumel type "k" thermocouple in conjunction with a digital temperature indicator.

The dry molecular weight of the stack gas was determined following calculations outlined in U.S. EPA Method 3/3A, "Gas Analysis for the Determination of Dry Molecular Weight (Instrumental) for the ESP and SEC. RWDI collected integrated sample bags for each of the ESP and SEC using the orsat pump from the sampling consoles. The integrated bag samples were collected over the duration of each test period. The bag samples were delivered to our continuous monitoring system for CO_2 and O_2 measurements. The CO_2 and O_2 analyzers were operated according to USEPA Method 3A. Prior to testing, a 3-point analyzer calibration error check was conducted using USEPA protocol gases. The calibration error check was performed by introducing zero, mid and high-level calibration gases directly into the analyzer. The calibration error check was performed to confirm that the analyzer response is within ±2% of the certified calibration gas introduced. Prior to each test run, a system-bias test was performed where known concentrations of calibration gases were introduced at the probe tip to measure if the analyzers response was within ±5% of the introduced calibration gas concentrations. At the conclusion of each set of bag samples a system-bias check was performed to evaluate the percent drift from pre and post-test system bias checks. The system bias checks were used to confirm that the analyzer did not drift greater than ±3% throughout a test run.

Zero and upscale calibration checks were conducted both before and after each set of bag samples in order to quantify measurement system calibration drift and sampling system bias. Upscale is either the mid- or high-range gas, whichever most closely approximates the flue gas level. During these checks, the calibration gases were introduced into the sampling system at a conjunction where the sample bag would be introduced to ensure that system was working properly. The analyzers were calibrated on-site using EPA Protocol No. 1 certified calibration mixtures.

Stack moisture content was determined through direct condensation from the PM or metals sampling trains according to U.S. EPA Method 4, "Determination of Moisture Content of Stack Gases".

4.1.2 Particulate Matter and Condensable Particulate Matter USEPA Method 5/202

Filterable particulate matter was collected isokinetically by USEPA Method 5, and the condensable particulate matter was sampled by USEPA Method 202. The sampling train consisted of a stainless-steel nozzle, glass-lined probe, filter, pot belly impinger, empty impinger, CPM filter, water knockout impinger, and silica gel impinger. Samples were sent to the laboratory for analysis. A schematic of the sampling train is included in **Figure Section** (**Figure 3**).

For the Total Particulate, only the filterable results were used for comparison to the Permit Limits. For PM_{10} and $PM_{2.5}$, filterable + condensable results were used for comparison to applicable Permit Limits.

4.1.3 Metals (Lead and Manganese) USEPA Method 29

A sample of stack gas was drawn from the stack isokinetically to measure metals. The sampling train consisted of a Teflon coated nozzle, a glass-lined probe, quartz filter, and five impingers in series. Particulate metals were collected in the nozzle, probe, and filter. The gaseous emissions were collected in the impinger train with the first impinger being empty, the next two impingers containing acidified hydrogen peroxide, an empty fourth impinger, and a final impinger containing silica gel. The recovery process followed USEPA Method 29, and all samples were sent to the laboratory for analysis. A schematic of the sampling train is included in **Figure Section** (**Figure 4**).

4.1.4 Visible Emissions USEPA Method 9

Visible emissions were determined in accordance with U.S. EPA Reference Method 9, "Visual Determination of the Opacity of Emissions from Stationary Sources". For the visible emission observations, readings were observed every 15 seconds over a continuous period of time. A certified observer stood at a distance that provided a clear view of the emissions with the sun oriented in the 140 degree sector at their back. Observations were taken every 15 seconds. A minimum of one 60-minute, 1 heat observation was conducted during each particulate matter test run on the ESP.

Visible emissions readings for the ESP were taken by RWDI staff. Additional VE measurements were taken by a 3rd party vendor for the BOF Roof Monitor. These readings covered 8 heats and were conducted while sampling was taking place on the ESP. All results are provided in this report (See **Appendices B-3 and H**).

4.1.5 Method Deviations and Comments

The following modifications were provided and accepted in the Source Testing Plan. All modifications were applied during the testing.

1. CCDW operates two BOF Vessels that exhaust to the common ESP. While oxygen blowing can only take place on one vessel at a time, oxygen blowing could be occurring on a vessel while performing charging, tapping, and deslagging on the other vessel. Some overlapping into a heat on the other vessel at the end of a production cycle could occur. All tests ended at the end of the production cycle regardless of what is taking place on the other vessel. Production will be prorated to account for these occurrences where there is overlap.
2. No port changes took place during oxygen blowing on the ESP. When it was time for a port change, the probe was left at the same port and the points were re-traversed until the oxygen blow was completed. The probe was then moved to the next port and testing was resumed at the first point.
3. In cases where the end of the sampling run did not correspond with the end of a heat, the points were traversed in reverse order until the heat was completed.

The following modification was provided and accepted in the Source Testing Plan. It did not apply during this testing event.

4. Each batch consists of 5 steps: 1) scrap charge; 2) hot metal charge; 3) oxygen blowing; 4) tapping; and 5) deslagging. It is a common occurrence for the scrap charge to take place at a time that is far in advance of charging hot metal. For this reason, there could be occasions where starting the test on a hot metal charge is desirable as it is a better indicator of when the batch is actually starting. In these cases, Cleveland-Cliffs is proposing that the integral heat requirement be satisfied by testing during the scrap charge of the following heat.
5. The dry molecular weight of the stack gas was determined following calculations outlined in U.S. EPA Method 3/3A, "Gas Analysis for the Determination of Dry Molecular Weight (Instrumental) for the ESP and SEC. RWDI collected integrated sample bags for each of the ESP and SEC using the orsat pump from the sampling consoles. The integrated bag samples were collected over the duration of each test period. The bag samples were delivered to acontinuous monitoring system for CO_2 and O_2 measurements. The CO_2 and O_2 analyzers were operated according to USEPA Method 3A.

4.2 Description of Recovery and Analytical Procedures

The recovery followed USEPA Method 5, 202, and 29.

4.3 Sampling Port Description

EUBOF ESP (SVBOFESP) is a circular stack with an inner diameter of 204". 4 ports are used for testing.

FGBOFSHOP (SVBOFBH) is a circular stack with an inner diameter of 222". 4 ports are used for testing.

5 TEST RESULTS AND DISCUSSION

5.1 Detailed Results

Table 5.1: Test Results

		Concentration	
Source	**Parameter**	**Average Emission Rate**	**Emission Limit**
BOF ESP	PM Filterable only	0.0019 gr/dscf	0.0152 gr/dscf
		7.2 lb/hr	62.6 lb/hr
	PM_{10} (Filterable + Condensable)	9.7 lb/hr	47.5 lb/hr
	$PM_{2.5}$ (Filterable + Condensable)	9.70 lb/hr	46.85 lb/hr
	Lead	0.0077 lb/hr	--
	Manganese	0.045 lb/hr	--
	Visible Emissions	1%, 6-minute average (1)(2)	20%, 6-minute average (1)
BOF SEC Baghouse	Lead	0.0021 lb/hr	--
	Manganese	0.0056 lb/hr	0.07 lb/hr
BOF ESP & SEC Baghouse Combined	Lead	0.010 lb/hr	0.067 lb/hr
	Manganese	0.051 lb/hr	0.10 lb/hr
BOF Roof Monitor	Visible Emissions	1%, 3-minute average(2)	15%, 3-minute average (FGBOFSHOP) 20%, 3-minute average (EUBOF)

Notes: (1) One 6-minute average opacity of up to 27% is exempt per hour
(2) Reported as maximum 3-minute average observed for BOF Roof Monitor and 6-minute average for ESP during all observations

5.1.1 Discussion of Results

Detailed results for the program are provided in the following Appendices:

- SVBOFESP (ESP) – **Appendix B**
- SVBOFBH (Secondary Baghouse) – **Appendix B**
- 3rd Party Visible Emissions – **Appendix H**

5.2 Process Upset Conditions During Testing

There were no process upsets during testing.

5.3 Maintenance Performed in Last Three Months

Only routine maintenance has been performed within the last three months.

5.4 Audit Samples

This test did not require any audit samples.

5.5 Calibration Sheets

Calibration sheets can be found in **Appendix D**.

5.6 Field Data Sheets

Field data sheets can be found in **Appendix E**.

5.7 Laboratory Data

Laboratory data can be found in **Appendix F**.

5.8 Sample Calculations

Sample calculations can be found in **Appendix G**.

TABLES

Table 1: Summary of Sampling Parameters and Methodology

Source Location	No. of Tests per Stack	Sampling Parameter	Sampling Method
ESP (SVBOFESP)	3	Velocity, Temperature and Flow Rate	U.S. EPA [1] Methods 1, 2, and 4
	3	PM / PM_{10} / $PM_{2.5}$	U.S. EPA [1] Method 5/202
	3	Lead / Manganese	U.S. EPA [1] Method 29
	3	Oxygen / Carbon Dioxide	U.S. EPA [1] Method 3A
	3	Visible Emission	U.S. EPA [1] Method 9
Secondary Baghouse (SVBOFBH)	3	Velocity, Temperature and Flow Rate	U.S. EPA [1] Methods 1, 2 and 4
	3	Lead / Manganese	U.S. EPA [1] Method 29
	3	Oxygen / Carbon Dioxide	U.S. EPA [1] Method 3A

Notes:

[1] U.S. EPA - United States Environmental Protection Agency

Table 2A: Sampling Summary and Sample Log (SVBOFESP)

Source and Test #	Sampling Date	Start Time	End Time	Filter ID / Trap ID
SVBOFESP - Velocity / Total Particulate				
Blank	21-Nov-23	-	-	QZ123
Test #1	21-Nov-23	8:31 AM	10:49 AM	QZ126
Test #2	21-Nov-23	11:51 AM	2:14 PM	QZ128
Test #3	22-Nov-23	7:57 AM	10:29 AM	QZ122
SVBOFESP - Velocity / Lead / Manganese				
Blank	21-Nov-23	-	-	M29-Blank
Test #1	21-Nov-23	8:31 AM	10:49 AM	QZ116
Test #2	21-Nov-23	11:51 AM	2:14 PM	QZ131
Test #3	22-Nov-23	7:57 AM	10:29 AM	QZ1
SVBOFESP - Visble Emissions				
Test #1	21-Nov-23	8:31 AM	9:31 AM	--
Test #2	21-Nov-23	11:51 AM	1:40 PM	--
Test #3	22-Nov-23	7:57 AM	8:57 AM	--

Table 2B: Sampling Summary and Sample Log (SVBOFBH)

Source and Test #	Sampling Date	Start Time	End Time	Filter ID / Trap ID
SVBOFBH - Velocity / Lead / Manganese				
Blank	21-Nov-23	-	-	M29-Blank
Test #1	21-Nov-23	8:31 AM	10:49 AM	QZ10
Test #2	21-Nov-23	11:51 AM	2:10 PM	QZ11
Test #3	22-Nov-23	7:57 AM	10:29 AM	QZ18

Table 3A: Sampling Summary - Flow Characteristics - SVBOFESP

Stack Gas Parameter		Test No. 1		Test No. 2		Test No. 3		Average
		Particulate	Lead/Manganese	Particulate	Lead/Manganese	Particulate	Lead/Manganese	
Testing Date		21-Nov-22		21-Nov-23		22-Nov-23		
Stack Temperature	°F	239	241	214	219	233	237	231
Moisture	%	14.9%	16.4%	14.0%	15.9%	14.7%	16.5%	15.4%
Velocity	ft/s	50.6	50.8	47.9	48.6	51.5	51.8	50.2
Referenced Flow Rate	CFM	430,866	423,806	427,961	421,637	444,949	434,918	430,690
Oxygen	%	18.9	18.9	18.7	18.7	18.8	18.8	18.8
Carbon Dioxide	%	3.2	3.2	3.4	3.4	3.3	3.3	3.3
Sampling Isokinetic Rate	%	105.2	102.5	104.4	101.6	104.5	102.8	103.5

Notes:

[1] Referenced flow rate expressed as dry at 101.3 kPa, 68 °F, and Actual Oxygen

Table 3B: Sampling Summary - Flow Characteristics - SVBOFBH

Stack Gas Parameter		Test No. 1 Lead/Manganese	Test No. 1 Lead/Manganese	Test No. 3 Lead/Manganese	Average
Testing Date		21-Nov-23	21-Nov-23	22-Nov-23	
Stack Temperature	°F	81	80	78	79
Moisture	%	1.8%	1.8%	0.7%	1.4%
Velocity	ft/s	32.8	33.5	28.5	31.6
Referenced Flow Rate	CFM	491,846	503,897	434,115	476,619
Oxygen	%	20.8	20.8	20.9	20.8
Carbon Dioxide	%	0.1	0.1	0.1	0.1
Sampling Isokinetic Rate	%	99.0	101.0	99.2	99.7

Notes:

[1] Referenced flow rate expressed as dry at 101.3 kPa, 68 °F, and Actual Oxygen

Table 4A: Total Particulate Matter and Metals – Averaged Results - SVBOFESP

SVBOFESP	Test 1		Test 2		Test 3		Average		Emission Limit			
	Concentration	Emission Rate	Concentration	Emission Rate	Concentration	Emission Rate						
Particulate	**(gr/dscf)**	**(lb/hr)**	**(gr/dscf)**	**(lb/hr)**	**(gr/dscf)**	**(lb/hr)**	**(gr/dscf)**	**(lbs/hr)**	**(gr/dscf)**	**PM lb/hr**	**PM_{10} lb/hr**	**$PM_{2.5}$ lb/hr**
PM (Filterable only)	0.0015	5.7	0.0024	8.8	0.0019	7.1	0.0019	7.2	0.0152	62.6	--	--
PM (Filterable + Condensable)	0.0022	8.0	0.0030	11.1	0.0026	9.9	0.0026	9.7	--	--	47.5	46.85
Metals	**(gr/dscf)**	**(lb/hr)**	**(gr/dscf)**	**(lb/hr)**	**(gr/dscf)**	**(lb/hr)**	**(gr/dscf)**	**(lb/hr)**	**lb/hr**			
Total Lead (Pb)	1.60E-06	0.0058	1.65E-06	0.0060	2.99E-06	0.011	2.08E-06	0.0077	--			
Total Manganese (Mn)	1.26E-05	0.046	1.06E-05	0.039	1.38E-05	0.052	1.23E-05	0.045	--			

Table 4B: Metals – Averaged Results (SVBOFBH)

SVBOFBH	Test 1		Test 2		Test 3		Average		Emission Limit
	Concentration	Emission Rate	Concentration	Emission Rate	Concentration	Emission Rate			
Metals	**(gr/dscf)**	**(lb/hr)**	**(gr/dscf)**	**(lb/hr)**	**(gr/dscf)**	**(lb/hr)**	**(gr/dscf)**	**(lb/hr)**	**lb/hr**
Total Lead (Pb)	4.59E-07	0.0019	6.82E-07	0.0030	3.78E-07	0.0014	5.06E-07	0.0021	--
Total Manganese (Mn)	1.30E-06	0.0055	1.28E-06	0.0055	1.54E-06	0.0057	1.37E-06	0.0056	0.07

Table 4C: Metals – Averaged Results (SVBOFESP + SVBOFBH)

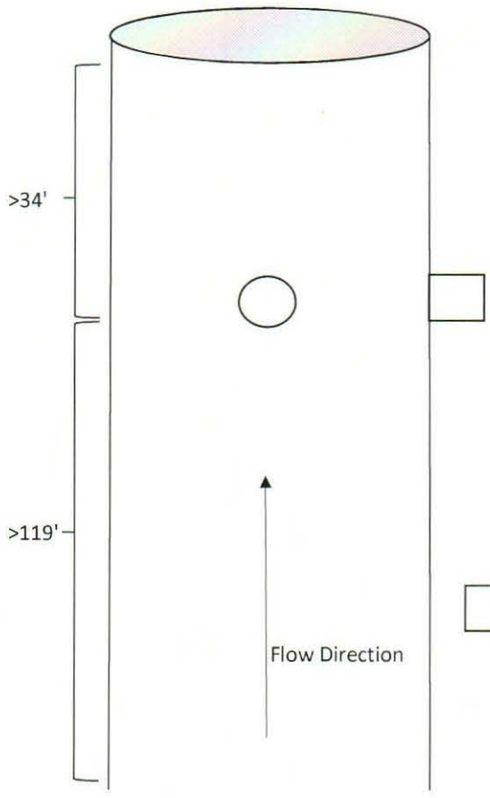
SVBOFESP + SVBOFBH	Test 1		Test 2		Test 3		Average		Emission Limit
	Concentration	Emission Rate	Concentration	Emission Rate	Concentration	Emission Rate			
Metals	**(gr/dscf)**	**(lb/hr)**	**(gr/dscf)**	**(lb/hr)**	**(gr/dscf)**	**(lb/hr)**	**(gr/dscf)**	**(lb/hr)**	**lb/hr**
Total Lead (Pb)	2.06E-06	0.0078	2.33E-06	0.0089	3.36E-06	0.013	2.59E-06	0.010	0.067
Total Manganese (Mn)	1.39E-05	0.051	1.19E-05	0.044	1.53E-05	0.057	1.37E-05	0.051	0.10

Table 5: Opacity- Averaged Results - SVBOFESP

SVBOFESP	Opacity						Average Opacity	Maximum 6-Min Opacity	Average 6-Min Opacity Limit
	Average	Max 6-Min Reading	Average	Max 6-Min Reading	Average	Max 6-Min Reading			
	Test 1		Test 2		Test 3				
Parameter	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)
Opacity	0	1	0	1	0	1	0	1	20

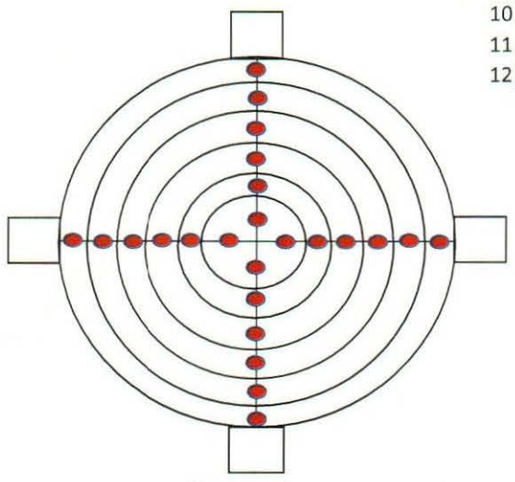
FIGURES

Figure 1: Sampling Points and Configuration - **SVBOFESP**



Diameter: 204

Sampling Points (in.)	
1	4.28
2	13.67
3	24.07
4	36.11
5	51.00
6	72.62
7	131.38
8	153.00
9	167.89
10	179.93
11	190.33
12	199.72

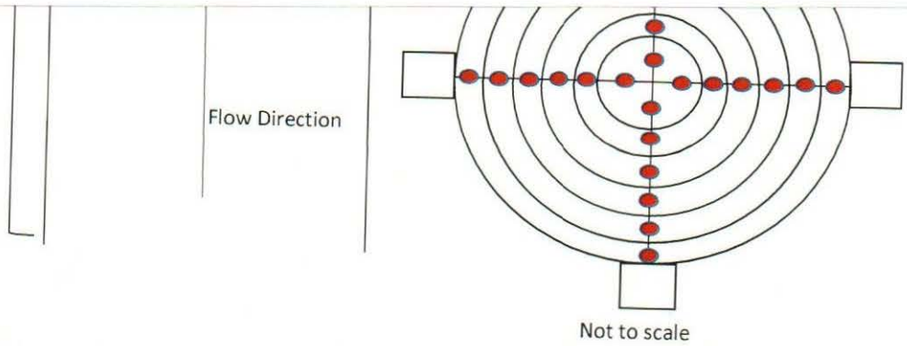


Not to scale

ESP (SVBOFESP)
Cleveland-Cliffs
Dearborn Works
Dearborn, Michigan

Date:
Nov. 21-22, 2023

RWDI USA LLC
2239 Star Court
Rochester Hills, MI 48309



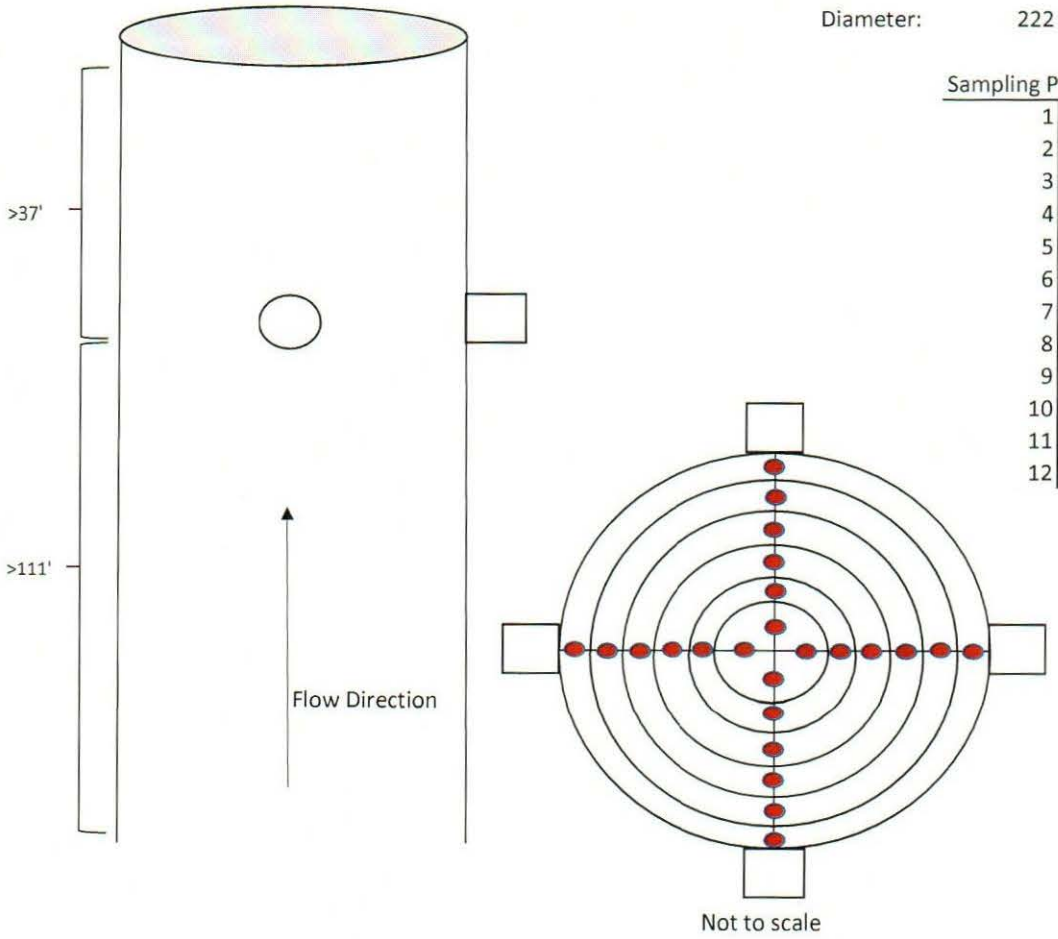
Not to scale

SEC Baghosue (SVBOFBH)
Cleveland-Cliffs
Dearborn Works
Dearborn, Michigan

Date:
Nov. 21-22, 2023

RWDI USA LLC
2239 Star Court
Rochester Hills, MI 48309

Figure 2: Sampling Points and Configuration (SVBOFBH)



Diameter: 222

Sampling Points (in.)	
1	4.66
2	14.87
3	26.20
4	39.29
5	55.50
6	79.03
7	142.97
8	166.50
9	182.71
10	195.80
11	207.13
12	217.34

SEC Baghosue (SVBOFBH)
Cleveland-Cliffs
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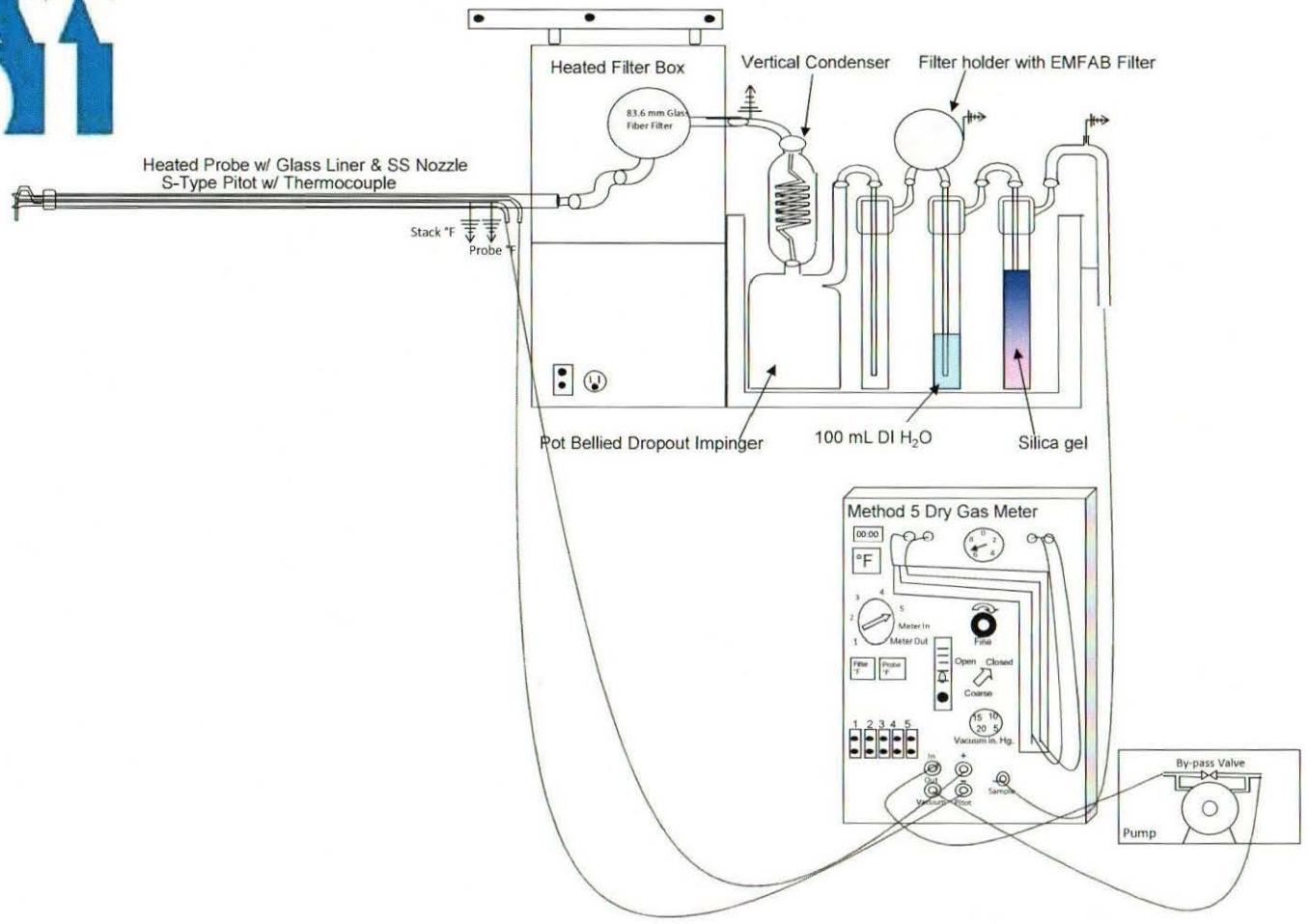
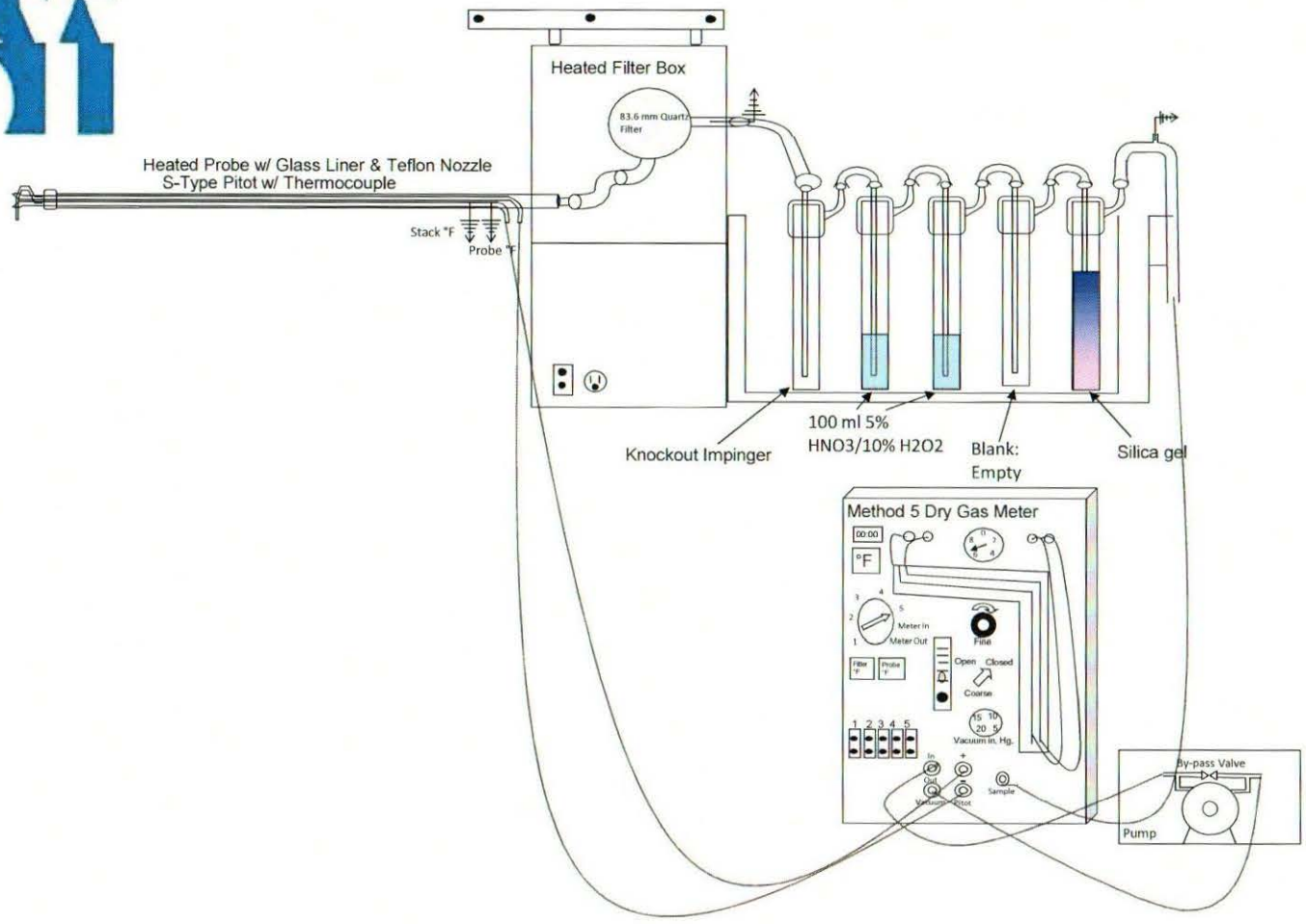


USEPA Method 5/202

Cleveland-Cliffs
Dearborn Works
Dearborn, Michigan

Figure 3:
Schematic of USEPA Method 5/202

Nov. 21-22, 2023



USEPA Method 29

Cleveland-Cliffs
Dearborn Works
Dearborn, Michigan

Figure 4:
Schematic of USEPA Method 29

Nov. 21-22, 2023