SOURCE TEST REPORT
2019 PARTICULATE MATTER TESTING
UNITED STATES STEEL CORPORATION
GREAT LAKES WORKS
LMF / ARGON 2 (EGLMF-OPERATIONS)
ECORSE, MI

Prepared For:

United States Steel Corporation
No. 1 Quality Drive
Ecorse, Michigan 48229

For Submittal To:

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Prepared By:

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EXECUTIVE SUMMARY

Montrose Air Quality Services, LLC (MAQS) was retained by United States Steel Corporation, Great Lakes Works (U. S. Steel) to evaluate Particulate Matter (PM) from the No. 2 Argon Stir Station / Ladle Metallurgical Furnace (No. 2 Argon/LMF) common Baghouse at the U. S. Steel facility located at No. 1 Quality Drive in Ecorse, Michigan. The testing is being performed as a compliance demonstration for permit No. 199600132d. The particulate testing program was conducted on November 18-19, 2019.

The No. 2 Argon/LMF Baghouse controls emissions from both the No. 2 Argon Stir Station and the LMF station. The testing consisted of one 75-minute run and two 67.5-minute test runs. The results of the emission test program are summarized by Table I.

Table I
Executive Summary Table PM Emission Rate Summary

Source	Emission Rate	Permit Limit
No. 2 Argon/LMF	0.17 lb/hr	*
	0.0005 gr/dscf	0.005 gr/dscf
	0.057 lb/heat	0.180 lb/heat

gr/dscf: Grains (particulate) per dry standard cubic foot
*: See section 1.b.

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1. Introduction

Montrose Air Quality Services, LLC (MAQS) was retained by United States Steel Corporation (U. S. Steel) to evaluate Particulate Matter (PM) emission rates from the EGLMF-OPERATIONS baghouse serving the No. 2 Argon Stir Station operations located at the U. S. Steel Great Lakes Works facility in Ecorse, Michigan. The testing is being performed as a compliance demonstration for permit No. 199600132d. The compliance test program was conducted on November 18-19, 2019. The purpose of this report is to document the results of the test program.

AQD has published a guidance document entitled "Format for Submittal of Source Emission Test Plans and Reports" (March 2018). The following is a summary of the emissions test report in the format suggested by the AQD test plan format guide.

1.a Identification, Location, and Dates of Test

Sampling and analysis for the emission test program was conducted on November 18-19, 2019 at the U.S. Steel facility in Ecorse, Michigan. The test program included evaluation of PM emissions from the No. 2 Argon/LMF Baghouse.

1.b Purpose of Testing

Permit No. ROP 199600132d, issued by State of Michigan Department of Environment, Great Lakes, and Energy, governs this process.

The allowable particulate emission rate by permit is:

EGLMF-OPERATIONS - No. 2 Argon Stir Station / LMF Baghouse
- 0.005 gr/dscf (LMF and No. 2 Argon Stir Station)
- 1.077 lbs/heat (LMF Operation)
- 0.180 lbs/heat (No. 2 Argon Stir Station)
- 0.856 lbs/hr (LMF Material Handling Operation)

1.c Source Description

The No. 2 Argon/LMF Baghouse is a nine compartment, shaker type, positive pressure baghouse. Each of the compartments exhaust through a short 36"x 36" curved vent. A diagram of the baghouse exhaust is presented as Figure 2.

1.d Test Program Contact

The contact for the source and test plan is:

Mr. Todd Wessel
Client Project Manager
Montrose Air Quality Services, LLC
4949 Fernlee Avenue
Royal Oak, Michigan 48073

Phone (616) 885-4013

Mr. Nathan Ganhs
Environmental Engineer
United States Steel Corporation
Great Lakes Works
No. 1 Quality Drive
Ecorse, Michigan 48229
(313) 749-3857

1.e Testing Personnel

Names and affiliations for personnel who were present during the testing program are summarized by Table 2.

Table 1
Test Personnel

Name and Title	Affiliation	Telephone
Mr. Nathan Ganhs Environmental Engineer	U.S. Steel No. 1 Quality Drive Ecorse, Michigan 48229	(313) 749-3857
Mr. Todd Wessel Field Project Manager	MAQS 4949 Fernlee Avenue Royal Oak, MI 48073	(248) 548-8072
Mr. Michael Nummer Environmental Technician	MAQS 4949 Fernlee Avenue Royal Oak, MI 48073	(248) 548-8072
Mr. Shane Rabideau Environmental Technician	MAQS 4949 Fernlee Avenue Royal Oak, MI 48073	(248) 548-8072

2. Summary of Results

Sections 2.a through 2.d summarize the results of the emissions compliance test program.

2.a Operating Data

Operating data monitored includes flow of argon gas to the ladle, approximate start and stop times, reference and sequence number and baghouse pressure drop.

2.b Applicable Permit

Michigan Renewable Operating Permit Number 199600132d.

2.c Results

The overall results of the emission test program are summarized by Table 2 (see Section 5.a). Detailed results for each run can be found in Table 3.

2.d Emission Regulation Comparison

The results are summarized by Table 3 (section 5.a). Emission limits are summarized by Table 1 (section 1.b) and also in Table 3 (section 5.a).

3. Source Description

Sections 3.a through 3.e provide a detailed description of the process.

3.a Process Description

U.S. Steel is a fully integrated steel maker. The No. 2 Basic Oxygen Processing (BOP) is a facility that converts liquid iron to liquid steel. The No. 2 BOP has two top-blown conversion vessels along with other ancillary equipment. The liquid iron and steel scrap is charged in the vessels and oxygen is blown into the mixture for mixing, removal of carbon and other impurities. The now liquid steel is sometimes further processed in the No. 2 BOP which may include the Ladle Metallurgy Facility (LMF) and the #2 Argon Stir Station.

Ladle Metallurgy occurs after the conversion process, when it is necessary to re-heat the liquid steel or alloy addition to the liquid steel prior to casting. The LMF produces a higher quality liquid steel product. LMF is also necessary to adjust the steel temperature when the caster is not ready to process.

The LMF consists of a Ladle Metallurgy Furnace, Bulk Material Storage Bins, and associated emission control system and equipment. The LMF station can perform argon stirring, ladle re-heating and/or alloy additions. The ladle will be placed on a ladle transfer car and will move to the LMF. If required, the proper amounts of fluxes will be fed into a hopper located above the ladle furnace. A metal sample will be taken for temperature and chemistry. The flux material will be charged into the ladle and stirred with Argon for a period of time to insure good mixing. Results from the sample will be recorded and processed to deliver the proper amount of alloys to meet the steel chemistry composition requirements.

Additional stirring and or heating will be required to insure proper alloy mixing and/or cast temperature. This cycle will vary with individual ladle metallurgy requirements. The approximate time of an entire cycle at the LMF and the No. 2 Argon Stir Station is 30 minutes.

After the process is completed, steel is conveyed to the Casters where the liquid steel is cast into a continuous solid steel slab.

3.b Process Instrumentation

The only process operating parameters relevant to the emissions test program is the baghouse pressure drop. Also note that one of the nine baghouse compartments was isolated for the testing event. This was done to represent the baghouse operating while maintenance or inspection was conducted on the isolated chamber.

4. Sampling and Analytical Procedures

Sections 4.a through 4.d provide a summary of the sampling and analytical procedures used.

4.a Sampling Train and Field Procedures

Measurement of exhaust gas velocity, molecular weight, and moisture content was conducted using the following reference test methods codified at Title 40, Part 60, Appendix A of the Code of Federal Regulations (40 CFR 60, Appendix A):

- Method 1 - *"Location of the Sampling Site and Sampling Points"*
- Method 2 - *"Determination of Stack Gas Velocity and Volumetric Flowrate"*
- Method 3 - *"Determination of Molecular Weight of Dry Stack Gas"*
- Method 4 - *"Determination of Moisture Content in Stack Gases"*
- Method 5D/17 - *"Determination of Particulate Emissions from Stationary Sources (In Stack Filtration)"*

Due to the majority of positive pressure Baghouses having low velocity pressure readings in each of the compartments it is necessary to perform a complete velocity traverse on the inlet duct leading to the Baghouse prior to each of the three tests. This was done to calculate the flow rate into and subsequently out of each compartment of the Baghouse. Subsequent to the velocity traverse MAQS calculated the average gas velocity at the measurement site (Baghouse compartment) utilizing equation 5D-1 of the 40 CFR part 60, Appendix A, Method 5D.

The inlet duct to the baghouse measures fifty one and a half (51.5) inches in diameter. Sixteen traverse points were determined as locations to measure the inlet volumetric flow in accordance with the provisions of the Method. Two (2) sample ports were utilized for the study, which resulted in the use of eight (8) traverse points for each port. A schematic of the traverse points and number of diameters up-stream and down-stream is presented as Figure 1.

Molecular weight determinations were conducted according to Method 3. The equipment used for this evaluation consisted of a one-way squeeze bulb with connecting tubing and a set of Fyrite® combustion gas analyzers. Moisture content was determined from the condensate collected in the Method 5D/17 sampling train according to Method 4.

The sampling train for the baghouse exhaust followed the guidelines detailed in Method 5D/17. Once the gas velocity of each compartment was calculated, MAQS sampled each of the nine compartments (in sets of three) at nine (9) points per compartment. Each compartment was sampled for approximately twenty two and a half (22.5) minutes while either process (Argon Stirring or LMF) was active. A complete test consisted of sampling three of the nine compartments. During each test a compartment was isolated to simulate maintenance. Test run number one consisted on sampling compartments 9, 7 and 5. Test number two consisted of sampling compartments 8, 6 and 4. Test number three consisted of sampling compartments 1, 2 and 3.

Method 5D/17 was used to measure particulate concentrations and calculate particulate emission rates from the exhaust stack (see Figure 3 for sampling train schematic diagram) MAQS's Nutech® Model 2010 modular isokinetic stack sampling system consisted of (1) a stainless-steel button-hook nozzle, (2) a stainless steel in stack filter holder with a pre weighed glass fiber filter, (3) a steel sample probe with a tygon tubing transfer line, (4) a set of four Greenburg-Smith (GS) impingers with the first and third modified and second standard GS impingers each containing 100 ml of deionized water, and a fourth modified GS impinger containing approximately 300 g of silica gel desiccant, (5) a length of sample line, and (6) a Nutech® control case equipped with a pump, dry gas meter, and calibrated orifice.

MAQS's Nutech® Model 2010 modular isokinetic stack sampling system consisted of (1) a stainless-steel nozzle, (2) an in stack stainless-steel filter housing, (3) a steel probe, (4) a set of four Greenburg-Smith (GS) impingers with the first modified and second standard GS impingers each containing 100 ml of deionized water, and with a third dry modified GS impinger and a fourth modified GS impinger containing approximately 300 g of silica gel desiccant, (5) a length of sample line, and (6) a Nutech® control case equipped with a pump, dry gas meter, and calibrated orifice.

A sampling train leak test was conducted before and after each test run. After completion of the final leak test for each test run, the filter was recovered, and the nozzle and the front half of the filter holder assembly were brushed and triple rinsed with acetone. The acetone rinses were collected in a pre-cleaned sample container.

MAQS labeled each container with the test number, test location, and test date, and marked the level of liquid on the outside of the container. In addition blank samples of the acetone and filter were collected. MAQS personnel carried all samples to MAQS's laboratory (for filter and acetone gravimetric analysis) in Royal Oak, Michigan.

4.b Recovery and Analytical Procedures

Recovery and analytical procedures were described in Section 4.a.

4.c Sampling Ports

Sampling port and traverse point locations for the No. 2 Argon/LMF Baghouse inlet and exhaust stack are illustrated by Figures 1 and 2.

4.d Traverse Points

Sampling port and traverse point locations for the No. 2 Argon/LMF Baghouse inlet and exhaust stack are illustrated by Figures 1 and 2.

5. Test Results and Discussion

Sections 5.a through 5.k provide a summary of the test results.

5.a Results Tabulation

The results of the emissions test program are summarized by Table 2.

Table 2
Test Program PM Emission Rate Summary

Source	Emission Rate	Permit Limit
No. 2 Argon/LMF	0.17 lb/hr	*
	0.0005 gr/dscf	0.005 gr/dscf
	0.057 lb/heat	0.180 lb/heat

gr/dscf: Grains (particulate) per dry standard cubic foot
*: See section 1.b.

Detailed data for each test run can be found in Table 3.

5.b Discussion of Results

Emission limitations for Permit No. 199600132d are summarized by section 1b. The results of the emissions test program are summarized by Table 2 (see section 5.a). Detailed results for each run are summarized by Table 3,

5.c Sampling Procedure Variations

There was not any sampling procedure variations used during the emission compliance test program.

5.d Process or Control Device Upsets

No upset conditions occurred during testing.

5.e Control Device Maintenance

No maintenance was performed during the test program.

5.f Audit Sample Analyses

No audit samples were collected as part of the test program.

5.g Calibration Sheets

Relevant equipment calibration documents are provided as Appendix B.

5.h Sample Calculations

Sample calculations are provided in Appendix C.

5.i Field Data Sheets

Field documents relevant to the emissions test program are presented in Appendix A.

5.j Laboratory Data

Laboratory results for this test program are provided in Appendix D.

MEASUREMENT UNCERTAINTY STATEMENT

Both qualitative and quantitative factors contribute to field measurement uncertainty and should be taken into consideration when interpreting the results contained within this report. Whenever possible, MAQS personnel reduce the impact of these uncertainty factors through the use of approved and validated test methods. In addition, MAQS personnel perform routine instrument and equipment calibrations and ensure that the calibration standards, instruments, and equipment used during test events meet, at a minimum, test method specifications as well as the specifications of our Quality Manual and ASTM D 7036-04. The limitations of the various methods, instruments, equipment, and materials utilized during this test have been reasonably considered, but the ultimate impact of the cumulative uncertainty of this project is not fully identified within the results of this report.

Limitations

The information and opinions rendered in this report are exclusively for use by US Steel. MAQS will not distribute or publish this report without US Steel's consent except as required by law or court order. MAQS accepts responsibility for the competent performance of its duties in executing the assignment and preparing reports in accordance with the normal standards of the profession, but disclaims any responsibility for consequential damages.

This report was prepared by:____________________________

Jacob Young
Staff Engineer

This report was reviewed by:____________________________

Todd Wessel
Client Project Manager

Tables

Table 3
Particulate Matter Emission Rates

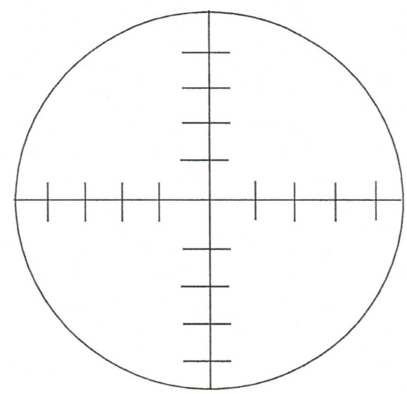
Company	**US Steel**			
Source Designation	**Argon #2**			
Test Date	**11/18/2019**	**11/18/2019**	**11/19/2019**	
Meter/Nozzle Information	P-1	P-2	P-3	Average
Meter Temperature Tm (F)	70.2	80.0	55.3	68.5
Meter Pressure - Pm (in. Hg)	29.3	29.3	29.3	29.3
Measured Sample Volume (Vm)	54.9	49.1	48.9	51.0
Sample Volume (Vm-Std ft3)	53.6	47.0	49.1	49.9
Sample Volume (Vm-Std m3)	1.52	1.33	1.39	1.41
Condensate Volume (Vw-std)	0.420	-0.104	0.938	0.418
Gas Density (Ps(std) lbs/ft3) (wet)	0.0743	0.0746	0.0740	0.0743
Gas Density (Ps(std) lbs/ft3) (dry)	0.0745	0.0745	0.0745	0.0745
Total weight of sampled gas (m g lbs) (wet)	4.01	3.50	3.70	3.74
Total weight of sampled gas (m g lbs) (dry)	3.99	3.50	3.66	3.72
Nozzle Size - An (sq. ft.)	0.001272	0.001310	0.001272	0.001285
Isokinetic Variation - I	100.9	99.1	101.4	100.5
Stack Data				
Average Stack Temperature - Ts (F)	100.0	91.1	75.5	88.9
Molecular Weight Stack Gas- dry (Md)	28.8	28.8	28.8	28.8
Molecular Weight Stack Gas-wet (Ms)	28.8	28.9	28.6	28.7
Stack Gas Specific Gravity (Gs)	0.993	0.997	0.989	0.993
Percent Moisture (Bws)	0.78	-0.22	1.87	0.81
Water Vapor Volume (fraction)	0.0078	-0.0022	0.0187	0.0081
Pressure - Ps ("Hg)	29.2	29.1	29.2	29.2
Average Stack Velocity -Vs (ft/sec)	10.2	9.6	10.0	9.9
Area of Stack (ft2)	9.0	9.0	9.0	9.0
Exhaust Gas Flowrate				
Flowrate ft^3(Actual)	46,493	42,596	41,372	43,487
Flowrate ft^3 (Standard Wet)	42,796	39,759	39,796	40,784
Flowrate ft^3 (Standard Dry)	42,462	39,759	39,052	40,425
Flowrate m^3 (standard dry)	1,202	1,126	1,106	1,145
Total Particulate Weights (mg)				
Nozzle/Probe/Filter	0.7	1.6	2.5	1.6
Total Particulate Concentration				
lb/1000 lb (wet)	0.000	0.001	0.001	0.001
lb/1000 lb (dry)	0.000	0.001	0.002	0.001
mg/dscm (dry)	0.5	1.2	1.8	1.2
gr/dscf	0.0002	0.0005	0.0008	0.0005
Total Particulate Emission Rate				
lb/ hr	0.073	0.179	0.263	0.172
lb/heat	0.031	0.067	0.074	0.057

Rev. 14.0
3-20-15 BC

Figures

diameter = 51.5 inches

Points	Distance "
1	1.6
2	5.4
3	9.9
4	16.5
5	34.5
6	41.1
7	45.7
8	49.4



Not to Scale

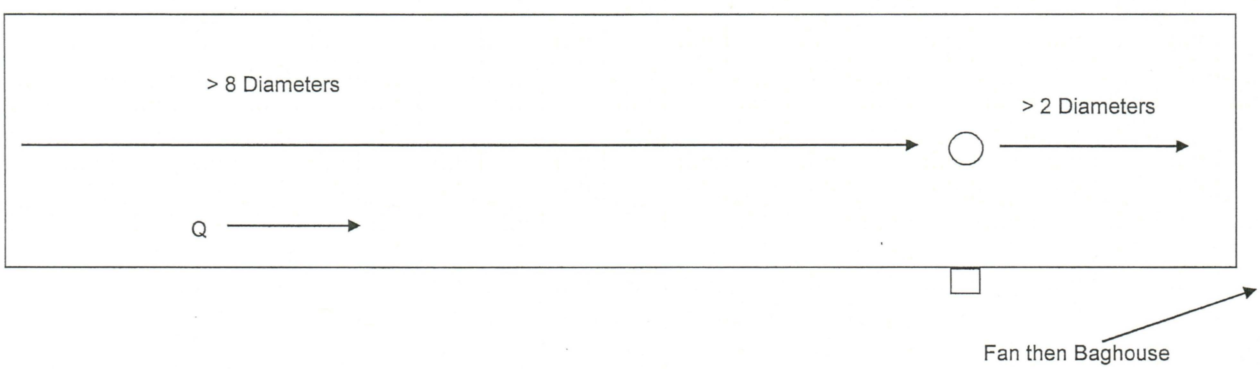
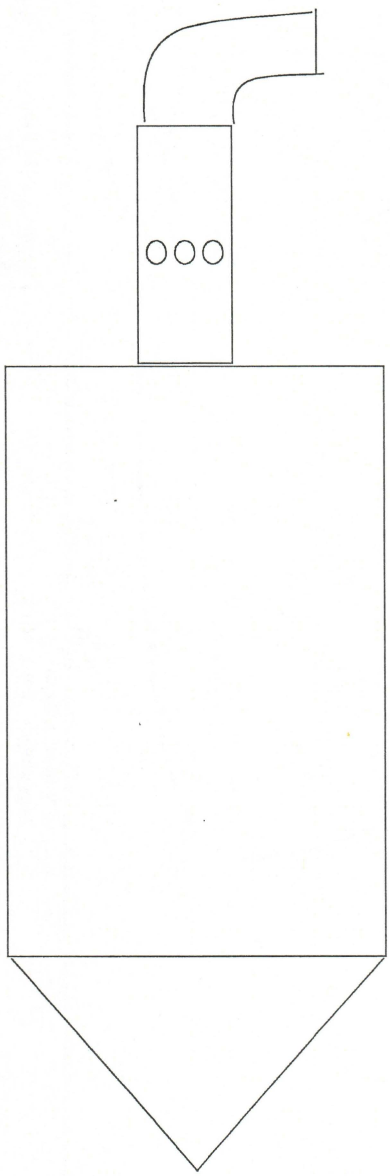


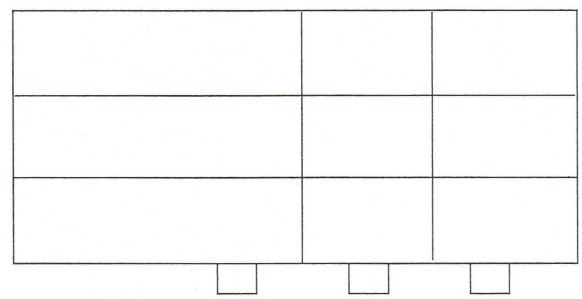
Figure No. 1

Site:	Sampling Date:	
Inlet to the No. 2 Argon Strir / LMF BH US Steel Ecorse, Michigan	November 18-19, 2019	Montrose Air Quality Services, LLC 4949 Fernlee Avenue Royal Oak, Michigan 48073

MONTROSE
AIR QUALITY SERVICES

Stack Dimensions: 36" X 36"





Not to Scale

Points	Distance "
1	6
2	18
3	30

Figure No. 2

Site: **No. 2 Argon Strir / LMF BH / Exhaust** **US Steel** **Ecorse, Michigan**	**Sampling Date:** **November 18-19, 2019**	**Montrose Air Quality Services, LLC.** **4949 Fernlee Avenue** **Royal Oak, Michigan 48073**

MONTROSE
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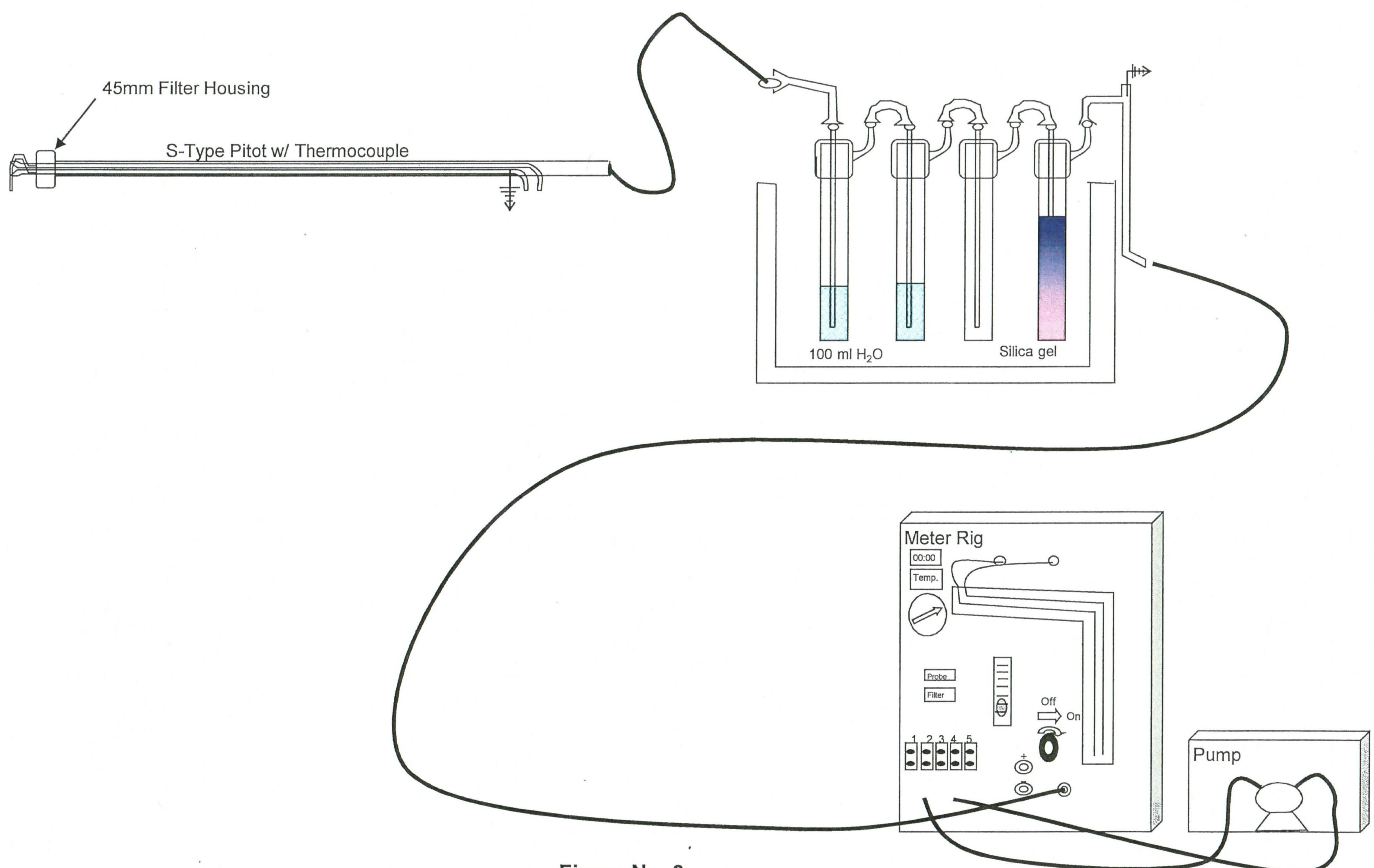

Figure No. 3

Site: **USEPA Method 17** **United States Steel Corp.** **No. 2 Argon Stir Station / LMF Baghouse** **Ecorse, Michigan**	**Sampling Date:** **November 18-19, 2019**	**Montrose Air Quality Services, LLC** **4949 Fernlee Avenue** **Royal Oak, Michigan 48073**