1. INTRODUCTION

Environmental Quality Management, Inc. (EQM) was retained by AK Steel Dearborn Works to plan and conduct a compliance air sampling program at the C-Blast Furnace Baghouse exhaust. The compliance program was conducted to evaluate emissions of filterable and condensable particulate (PM, PM_{10}, and $PM_{2.5}$); metals [lead (Pb) and manganese (Mn)]; carbon monoxide (CO); nitrogen oxide (NO_X); volatile organic compounds (VOC); and visible emissions (VEs). Three sampling runs (each run at least 1 cast in duration) were conducted for each method except for visible emissions. One 1-hour run was conducted for visible emissions concurrently with each PM/CPM sampling run. EPA-approved sampling methods and laboratory analysis procedures were used to meet the objectives of the sampling program.

An outline of the test program is presented in Table 1-1. Project participants and responsibilities are presented in Table 1-2.

Table 1-1. Sampling Requirements for AK Steel Dearborn, Michigan

Test Point No.	Test Point Name	Parameter Tested	Test Method
1	C-Blast Furnace Baghouse	Flow	EPA Method 2
		Moisture	EPA Method 4
		PM/Condensables	EPA Method 5/202
		O_2, CO_2, CO, NO_X	EPA Method 3A, 7E & 10
		Metals: Pb and Mn	EPA Method 5/29
		VOC	EPA Method 25A
		Opacity	EPA Method 9

Table 1-2. Project Participants

Name/Company	Responsibility
David Pate/AK Steel Jim Earl/AK Steel	Coordinate process operation and sampling activities Site/Process preparation Process information VE Observations
Mark Dziadosz/EGLE Katherine Koster/EGLE	Agency Review of Process and Sampling Procedures
Doug Allen/EQM	Project Manager
Chris Janzen/EQM	Field sampling crew
Ron Kolde/EQM	Field sampling crew
Jeremy Gallagher/EQM	Field sampling crew
Nick Pharo/EQM	Field sampling crew
Eric Zang/EQM	Field sampling crew

2. SUMMARY OF TEST RESULTS

The emission measurement program was performed on August 13, 2020. Table 2-1 presents the average results and limit comparison. Table 2-2 presents a summary of stack gas conditions. Table 2-3 presents total particulate concentrations and mass emission rates. Table 2-4 presents manganese concentrations and mass emission rates. Table 2-5 presents lead concentrations and mass emission rates. Table 2-6 presents nitrogen oxides (NO_x), carbon monoxide (CO), and volatile organic compound (VOC) concentrations and mass emission rates.

Appendix A summarizes emission and example calculations, Appendix B presents field data, Appendix C presents laboratory results, Appendix D presents calibration data, Appendix E presents process data, Appendix F presents visible emissions data, and Appendix G presents the test protocol, regulatory letter, and correspondence regarding the test effort.

Table 2-1. Average Results and Limit Comparison

Pollutant	**C-Blast Furnace Baghouse**	**Limits[a]**
PM (lb/hr)	2.07	13.87
PM_{10} (lb/hr)	6.39	18.24
$PM_{2.5}$ (lb/hr)	6.39	18.24
Mn (lb/hr)	0.035	0.042
Lead (lb/hr)	0.0009	0.0077
VOC (lb/hr)	2.36	9.92
NO_x (lb/hr)	2.37	5.46
CO (lb/hr)	36.14	56.25
VE	0%[b]	10%[c]

[a] Limits as provided in Permit MI-ROP-A8640-2016a.
[b] Calculated as highest observed 6-minute average.
[c] 6-minute average.

Table 2-2. Stack Gas Conditions
C-Blast Furnace Baghouse

August 13, 2020 AK Steel, Dearborn Works

Run No.	Date/Time	Stack Gas Velocity, fps[a]	Volumetric Flow Rate acfm[b]	dscfm[c]	Stack Temperature, °F	Moisture Content, % H_2O	CO_2, %	O_2, %
Method 5/202 Test Runs (Total Particulate)								
2	8/13/2020 1037-1227	80.3	607,176	514,208	148	1.3	0.2	20.7
3	8/13/2020 1513-1725	75.7	572,147	489,701	144	1.0	0.2	20.7
4	8/13/2020 1738-1939	60.7	458,727	386,589	151	1.4	0.4	21.0
Average		**72.2**	**546,017**	**463,500**	**148**	**1.2**	**0.2**	**20.8**
Method 5/29 Test Runs (Metals)								
2	8/13/2020 1037-1227	75.8	572,792	486,735	149	0.8	0.2	20.7
3	8/13/2020 1513-1725	76.6	578,890	493,348	145	1.2	0.2	20.7
4	8/13/2020 1738-1939	63.8	482,066	407,091	151	1.2	0.4	21.0
Average		**72.0**	**544,583**	**462,392**	**148**	**1.1**	**0.2**	**20.8**

[a] Feet per second.

[b] Actual cubic feet per minute.

[c] Dry standard cubic feet per minute.

Note – Averages are for runs 2-4. Run 1 Data and results are presented in Appendix A.

Table 2-3. Total Particulate Emissions
C-Blast Furnace Baghouse

August 13, 2020 AK Steel, Dearborn Works

Run No.	Date/Time	Total Particulate Matter		Filterable Particulate Matter		Condensable Particulate Matter	
		Concentration, gr/dscf[a]	Mass Rate, lb/hr[b]	Concentration, gr/dscf[a]	Mass Rate, lb/hr[b]	Concentration, gr/dscf[a]	Mass Rate, lb/hr[b]
2	8/13/2020 1037-1227	1.14E-03	5.01	4.68E-04	2.06	6.68E-04	2.95
3	8/13/2020 1513-1725	1.05E-03	4.40	4.20E-04	1.76	6.29E-04	2.64
4	8/13/2020 1738-1939	2.94E-03	9.75	7.24E-04	2.40	2.22E-03	7.35
Average		**1.71E-03**	**6.39**	**5.37E-04**	**2.07**	**1.17E-03**	**4.31**

[a] Grains per dry standard cubic foot.
[b] Pounds per hour.
Note – Averages are for runs 2-4. Run 1 Data and results are presented in Appendix A.

Table 2-4. Front-Half and Back-Half Manganese and Total Manganese Emissions
C-Blast Furnace Baghouse

August 13, 2020 AK Steel, Dearborn Works

Run No.	Date/Time	Front Half Manganese		Back Half Manganese		Total Manganese	
		Concentration, µg/dscm[a]	Mass Rate, lb/hr[b]	Concentration, µg/dscm[a]	Mass Rate, lb/hr[b]	Concentration, µg/dscm[a]	Mass Rate, lb/hr[b]
2	8/13/2020 1037-1227	19.6	3.56E-02	0.4	7.58E-04	20.0	3.64E-02
3	8/13/2020 1513-1725	27.2	5.01E-02	0.7	1.20E-03	27.8	5.13E-02
4	8/13/2020 1738-1939	10.5	1.59E-02	0.5	8.24E-04	11.0	1.67E-02
Average		**19.1**	**3.39E-02**	**0.5**	**9.28E-04**	**19.6**	**3.48E-02**

[a] Micrograms per dry standard cubic meter.
[b] Pounds per hour.
Note: Averages are for runs 2-4. Run 1 Data and results are presented in Appendix A.

Table 2-5. Front-Half and Back Half-Lead and Total Lead Emissions
C-Blast Furnace Baghouse

August 13, 2020 AK Steel, Dearborn Works

Run No.	Date/Time	Front-Half Lead		Back-Half Lead		Total Lead	
		Concentration, µg/dscm[a]	Mass Rate, lb/hr[b]	Concentration, µg/dscm[a]	Mass Rate, lb/hr[b]	Concentration, µg/dscm[a]	Mass Rate, lb/hr[b]
2	8/13/2020 1037-1227	0.4	6.92E-04	0.2	3.53E-04	0.6	1.05E-03
3	8/13/2020 1513-1725	0.3	5.54E-04	0.2	2.83E-04	0.5	8.36E-04
4	8/13/2020 1738-1939	0.4	5.96E-04	0.2	3.04E-04	0.6	9.00E-04
Average		**0.4**	**6.14E-04**	**0.2**	**3.14E-04**	**0.5**	**9.28E-04**

[a]Micrograms per dry standard cubic meter.

[b]Pounds per hour.

Note: Averages are for runs 2-4. Run 1 Data and results are presented in Appendix A. All of the results were below detection limit. Detection limit used in the results.

Table 2-6. NOx, CO, and VOC Emissions
C-Blast Furnace Baghouse

August 13, 2020 AK Steel, Dearborn Works

Run Date/Time	Nitrogen Oxides			Carbon Monoxide			Volatile Organic Compounds		
	Concentration, ppm[a]	Mass Rate lb/hr[b]	Mass Rate lb/ton[c]	Concentration, ppm[a]	Mass Rate lb/hr[b]	Mass Rate lb/ton[c]	Concentration, ppm[a]	Mass Rate lb/hr[b]	Mass Rate lb/ton[c]
8/13/2020 1037-1227	0.9	3.25	1.33E-02	19.1	41.70	0.17	1.0	1.25	5.08E-03
8/13/2020 1513-1725	0.7	2.43	8.98E-03	16.3	35.03	0.13	3.9	4.84	1.79E-02
8/13/2020 1738-1939	0.5	1.41	5.21E-03	18.3	31.68	0.12	1.0	0.99	3.65E-03
Average	**0.7**	**2.37**	**9.15E-03**	**17.9**	**36.14**	**0.14**	**2.0**	**2.36**	**8.86E-03**

[a]Parts per million, dry basis. VOC ppm is methane corrected.

[b]Pounds per hour.

[c]Pounds per ton.

Note: Averages are for runs 2-4. Run 1 Data and results are presented in Appendix A.

3. SAMPLING AND ANALYTICAL PROCEDURES

The sampling and analytical procedures used in this test program conform to EPA Reference Methods 1 through 4, 5, 7E, 9, 10, 25A, 29, and 202, as published in the Federal Register.

3.1 Location of Measurement Sites

EPA Method 1, "Sample Velocity Traverses for Stationary Sources," was used to select representative measurement sites. The sampling location was at the exhaust of the C-Blast Furnace baghouse. A schematic of the test location is shown in Figure 4-1 in Section 4.

3.2 Stack Gas Volumetric Flow Rate

EPA Method 2, "Determination of Stack Gas Velocity and Volumetric Flow Rates," was used to determine stack gas volumetric flow rates. Type "S" pitot tubes meeting EPA specifications and an inclined manometer were used to measure velocity pressures. A calibrated Type "K" thermocouple attached directly to the pitot tube was used to measure stack gas temperature. The stack gas velocity was calculated from the average square root of the stack gas velocity pressure, average stack gas temperature, stack gas molecular weight, and absolute static pressure. The volumetric flow rate is the product of velocity and stack cross-sectional area.

3.3 Stack Gas Dry Molecular Weight

The baghouse sampling location was sampled continuously for CO_2 and O_2 by using non-dispersive infrared analyzers (CO_2) or paramagnetic analyzers (O_2); gaseous pollutants were measured according to EPA Reference Method 3A, "Determination of Oxygen and Carbon Dioxide Concentrations in Emissions From Stationary Sources (Instrumental Analyzer Procedure)." Figure 3-1 is a schematic of the sampling system.

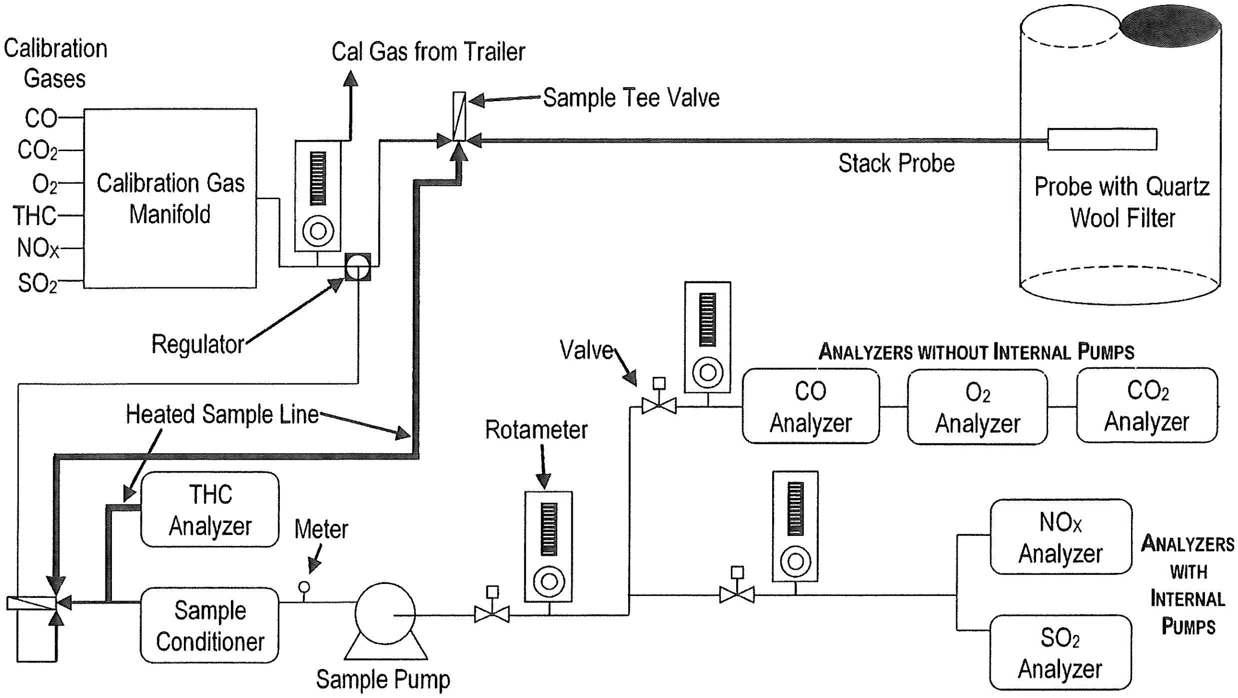


Figure 3-1. CEM Sample Flow and Calibration System
Note: This study used the CO, NO_X, THC, CO_2, and O_2 analyzers.

3.4 Stack Gas Moisture Content

EPA Reference Method 4, "Determination of Moisture Content in Stack Gases," was used to determine stack gas moisture content. This method was conducted as part of each particulate and metals measurement run. The initial and final contents of all impingers were determined gravimetrically.

3.5 Filterable andCondensable Particulate

EPA Methods 5/202 were used to measure the concentration and mass emission rate of total filterable particulate matter. Particulate matter of less than 10 microns (PM_{10}) and particulate matter of less than 2.5 microns ($PM_{2.5}$) were determined as the sum of the filterable and condensable fractions. Total suspended particulate (TSP) particulate matter was determined as only the total filterable particulate matter.Four sampling runs and a blank were collected at the baghouse stack outlet location. Figures 3-2 and 3-3 present schematics of the sampling trains for Method 5 and Method 202, respectively.

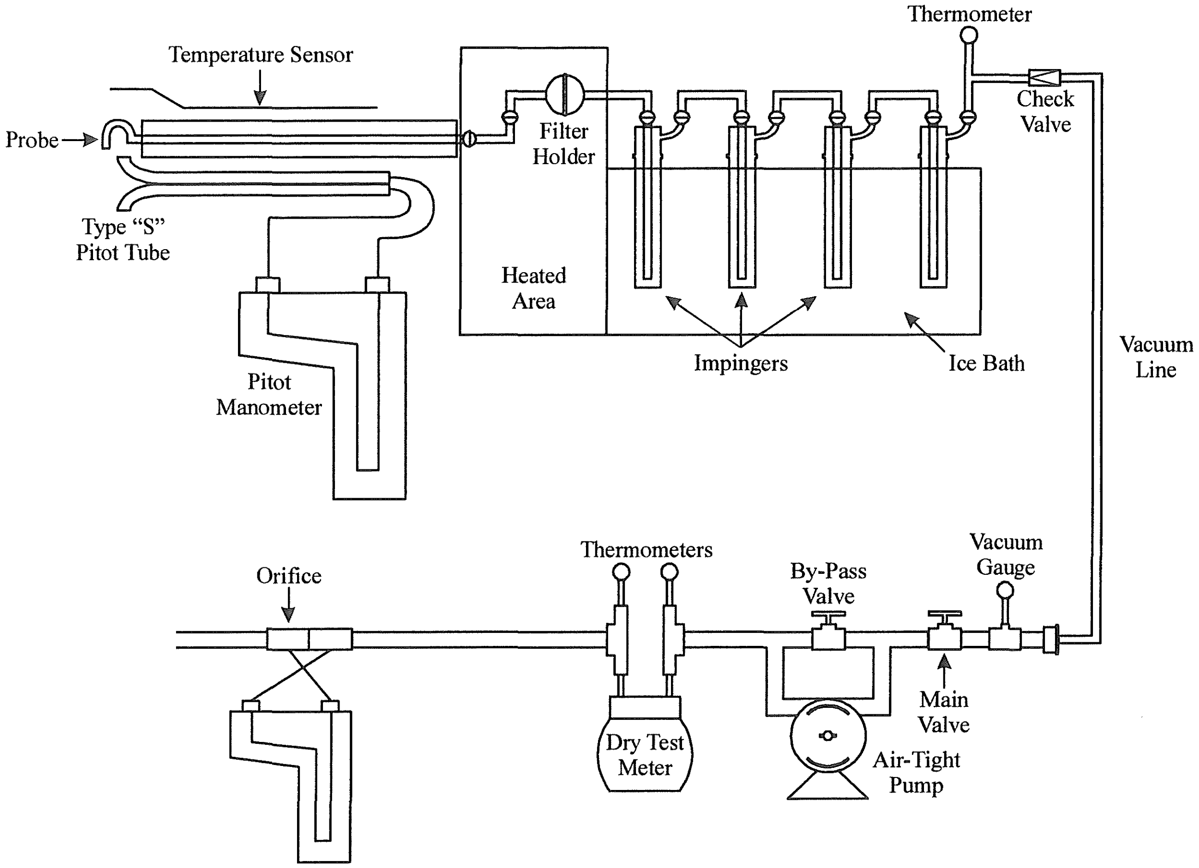


Figure 3-2. Method 5 Front-half of Sampling Train

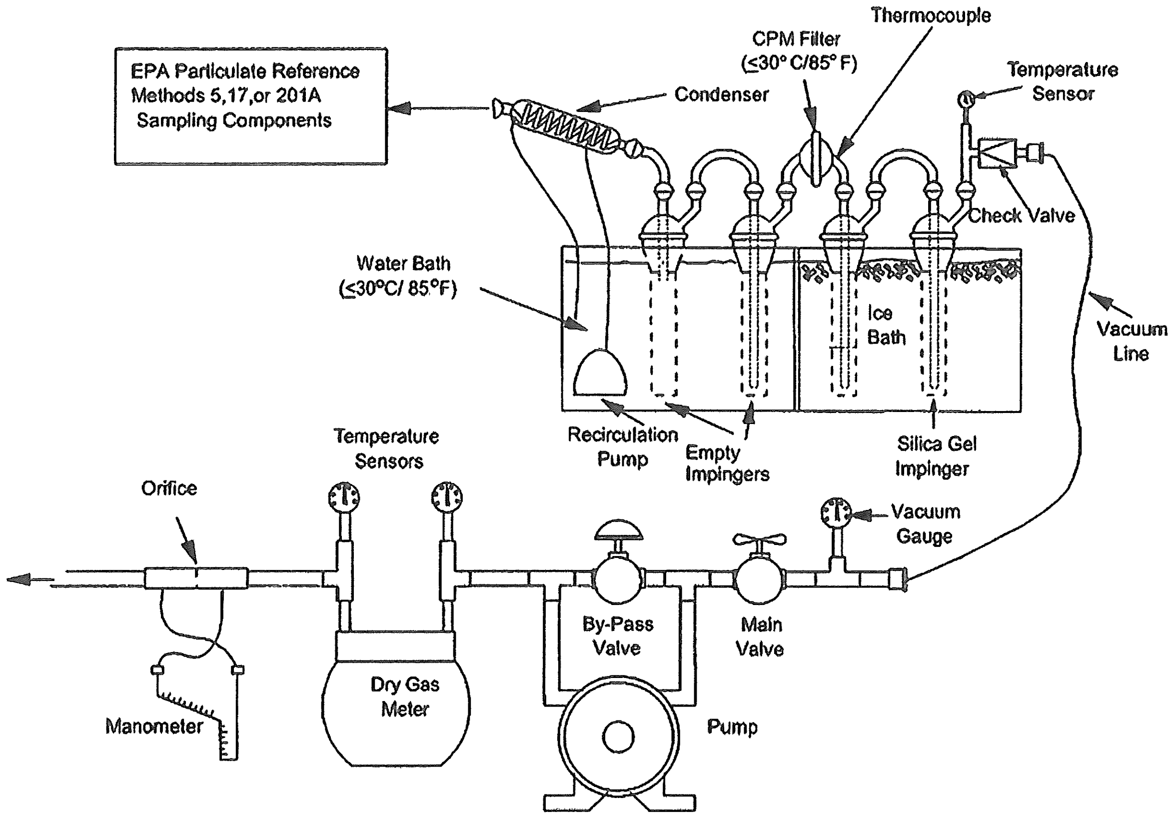


Figure 3-3. Method 202 Sampling Train

3.6 Nitrogen Oxides (NOx)

Nitrogen oxide concentrations were analyzed following the procedures of EPA Reference Method 7E, "Determination of Nitrogen Oxide Emissions from Stationary Sources by Instrumental Analyzer Technique." The sampling system consists of a stainless steel probe, a glass fiber filter for particulate matter removal, a heated Teflon sampling line, and a sample gas conditioner to remove moisture prior to the gas entering the chemiluminescent analyzer. A zero gas and two Protocol One calibration gases were used to calibrate the instrument. Data was recorded on a data-logging system recording 1-minute averages of pollutant data. Figure 3-1 is a schematic of the continuous emission analyzer system. An NO_2-NO_x converter efficiency test was conducted according to EPA Method 7E. An NO_2 calibration gas with a value of 49.2 ppm was introduced to the analyzer. The lowest response observed was 48.62 ppm, which is an efficiency of 98.8%. This result is above the 90% converter efficiency that is required. Results are provided in Appendix B.

3.7 Carbon Monoxide (CO)

Carbon monoxide concentrations were sampled and analyzed continuously following the procedures of EPA Method 10, "Determination of Carbon Monoxide Emissions from Stationary Sources by Instrumental Analyzer Technique." The same sampling system that was used for the other continuous analyzers was used for the CO analyzer. The instrument used is a non-dispersive infrared analyzer manufactured by Thermo Environmental.

A zero gas and two calibration gases were used to calibrate the instrument. Figure 3-1 is a schematic of the sampling system.

3.8 Volatile Organic Compounds (VOC)

EPA Reference Method 25A, "Determination of Total Gaseous Organic Concentration," was used. The sampling system consisted of a stainless steel probe, a heated Teflon® line, and a heated flame ionization analyzer (FIA). The FIA was calibrated with three Protocol One methane standards in air and a zero gas. Calibrations and drift checks were conducted after each sampling run. After the first run was stopped, the VOC analyzer had a high VOC value and would not calibrate accurately. A second analyzer was calibrated and used with the next three runs. Data was reduced on a dry basis using moisture values from the EPA Reference Method 5 sampling system. A schematic of the sampling system is shown in Figure 3-1. Tedlar bags were collected during each run and were analyzed by Method 18 for methane. VOCs reported in this report are non-methane hydrocarbons.

3.9 Metals

EPA Method 29 was used to determine metals (Pb and Mn) emissions. The test apparatus consisted of a glass nozzle, a heated glass-lined probe, a heated 83-mm quartz fiber filter, four chilled impingers, and a metering console. The samples were withdrawn isokinetically from the source. Particulate emissions were collected in the probe and on the heated filter, and the gaseous emissions were then collected in an aqueous acidic solution of hydrogen peroxide in order to measure lead and manganese emissions. The recovered samples were digested and analyzed at the laboratory. Three test runs were performed at the baghouse stack outlet. Figure 3-4 is a schematic of the Method 29 sampling train.

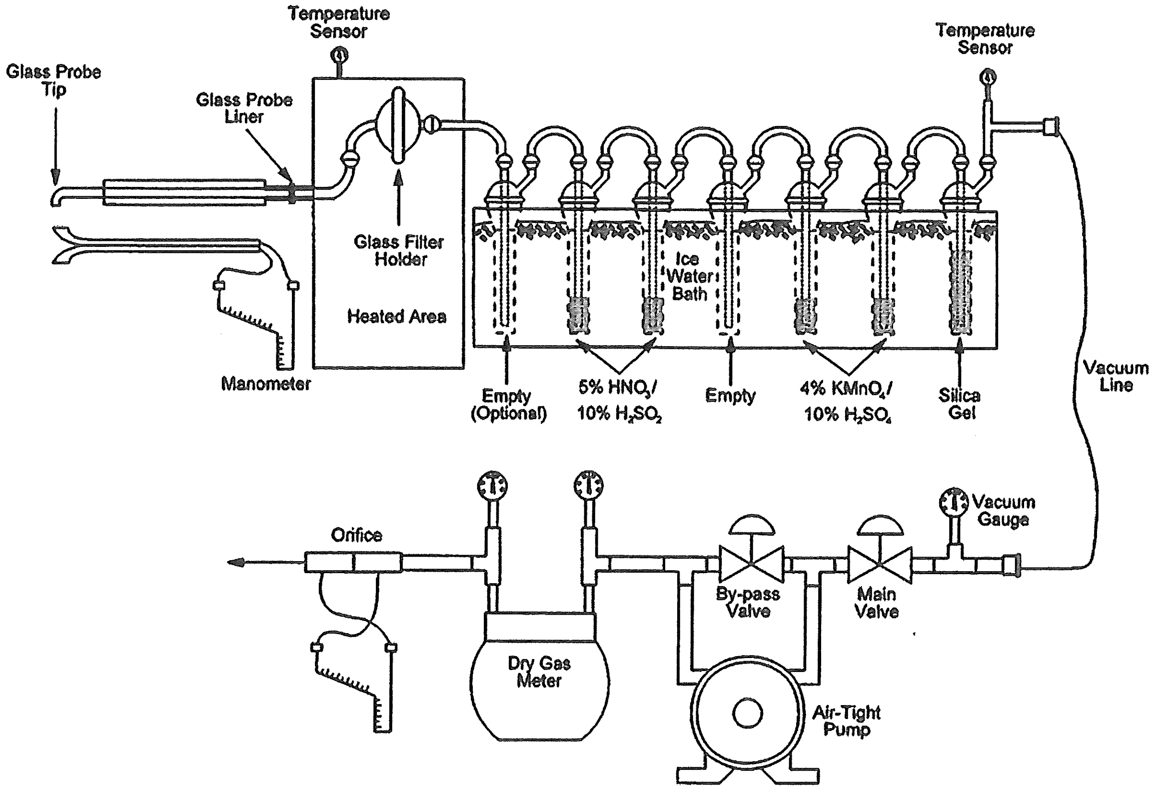


Figure 3-4. Method 5/29 Sampling Train

3.10 Opacity

EPA Method 9, "Visual Determination of the Opacity of Emissions from Stationary Sources," was used to measure visible emissions from the C-Blast Furnace baghouse exhaust for the test program. During each particulate measurement run, plume opacity was recorded by a certified method 9 observer every 15 seconds (four readings per minute) for 60 minutes. Emissions were calculated as the average of 24 consecutive readings.

3.11 Test Comments

1. A number of issues occurred during the first test run that resulted in the run 1 test results not being included in the test average. These issues were as follows:

A. A pin of one of the ID Fan louvers failed which caused the fan louver to drift shut. This resulted reduced baghouse inlet pressure that is not representative of normal operations.

B. A valve feeding a natural gas lance on the casthouse tuyere deck was inadvertently opened allowing uncombusted natural gas to vent to the casthouse collection hoods and thus to the baghouse. This was discovered due to elevated VOC readings that were observed during the first test run and is not indicative of normal operations. Once discovered, the valve was closed.

C. While the run consisted of a full cast and more than one hour of testing, it was not of sufficient length to complete a full traverse on the stack. After consultation with EGLE personnel, it was agreed that due to the non-representative nature of the run, it could be ended after 1 cast without sampling for another cast so that all test points could be sampled.

D. After the first run, the VOC analyzer would not pass calibration due to a high VOC background. A second analyzer was used on the subsequent runs without any issues. Because of the failed post-test calibration, the run 1 results for VOC are not valid results and are likely erroneously high.

Because of these reasons, the results reported are the average of runs 2 through 4. The results for run 1 are included in appendix A.

2. If EQM had completed a full traverse with the sampling prior to the cast being completed, the traverse was restarted at Point 1. Sampling was continued until the cast was completed. All traverse points sampled were used in the velocity calculations.
3. The test plan specified that a non-methane hydrocarbon cutter would be used to determine methane concentration so that non-methane hydrocarbon emissions could be reported. The methane measurement system failed during the first run. Consequently, bag samples were collected and sent to an offsite laboratory for analysis. This was discussed with and approved by EGLE representatives.
4. The mass emission calculations for NOx, CO, and NMVOC used the average flow of the Method 29 and Method 5/202 test runs.
5. The analytical report for metals in appendix C only contains the analytical results which is presented within the first 39 pages of the report. The remainder of the analytical report is available on request from AK Steel.

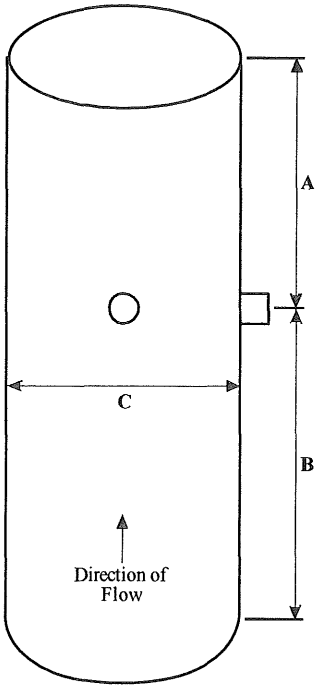
6. The audit results were within the acceptable range and are presented in Appendix C.

4. PROCESS DESCRIPTION/SAMPLING LOCATIONS

Molten iron (hot metal) is produced in the blast furnaces by heating iron ore pellets and other iron-bearing materials, coke, limestone, slag, or other fluxing material. Burden materials consisting of iron ore pellets, flux material (slag, limestone, or dolomite), and a carbon source (usually coke) are delivered to and charged into the top of the furnace. Additional carbon is supplied to the furnace by injecting natural gas and pulverized coal into the hot blast section of the furnace. Preheated combustion (hot blast) air is pushed vertically through the burden material in the furnace from tuyeres located at the bottom of the furnace. The components of the burden chemically react with the hot blast air to reduce the iron oxides into elemental iron and melt. The blast furnace produces molten iron, blast furnace gas, and slag.

Periodically, the molten iron and slag are cast from the furnace into a trough and iron runners in the floor of the casthouse. The slag is separated from the molten iron in the trough prior to entering refractory-lined bottle cars. The slag is then diverted to slag pots. The molten iron is transported in bottle cars to the BOF for use in the steelmaking process.

Emissions generated within the casthouse from the molten iron and slag that are cast from the C Blast Furnace are captured by collection hoods and routed to a baghouse that is used to control particulate emissions from the process. Figure 4-1 presents the sampling location. During the testing, production for the C-Blast Furnace averaged 271.2 tons per hour.



Location	Upstream A	Downstream B	Inside Diameter C
C Blast Furnace Baghouse	>37 ft	>148 ft	152 in.
4 Sampling Ports	Three Traverse Points per Port		12 Total Sampling Points
Traverse Pt 1: 20.69 in.	Travers Pt 2: 36.19 in.		Traverse Pt 3: 58.99 in.

Figure 4-1. Sampling Location

5. QUALITY ASSURANCE AND QUALITY CONTROL

The field sampling quality assurance for this project included the use of calibrated source sampling equipment, reference test methods, and traceability protocols for recording and calculating data. The analytical quality assurance includes use of validated analytical procedures, calibration of equipment, and analysis of control samples and blanks. The calibration and quality control procedures used for this test program are described in the following subsection.

5.1 Calibration Procedures and Frequency

All manual stack gas sampling equipment is calibrated before the start of the test program in accordance with the procedures outlined in the *Quality Assurance Handbook for Air Pollution Measurement Systems, Volume III*, EPA-600/4-72-027B. Table 5-1 is a summary of the stack gas sampling equipment calibrations that are performed in preparation for this project. The meter boxes are re-calibrated after the test.

Table 5-2 lists additional calibration checks performed on the sampling equipment on site, just prior to the testing, to ensure that equipment was not damaged during transport. Table 5-3 details the field checks conducted on the continuous emission monitoring systems before and during the test program.

Table 5-1. Field Equipment Calibration Summary[a]

Equipment	Calibrated Against	Allowable Error
Method 5 meter box	Reference test meter	Y ±0.02 Y $\Delta H@$ ±0.20 $\Delta H@$ post-test Y ±0.05 Y
Pitot tube	Geometric specifications	See EPA Method 2
Thermocouple	ASTM-3F thermometer	±1.5%
Impinger (or condenser thermometer)	ASTM-3F	±2°F
Dry gas meter thermometer	ASTM-3F	±5°F
Probe nozzles	Caliper	±0.004 in.
Barometer	NBS traceable barometer	±0.1 in. Hg

[a] As recommended in the *Quality Assurance Handbook for Air Pollution Measurement Systems: Volume III. Stationary Source-Specific Methods*. EPA-600/4-77-027b, August 1977.

Table 5-2. Field Checks of Sampling Equipment

Equipment	Checked Against	Allowable Difference
Pitot tube	Inspection	No visible damage
Thermocouples	ASTM 2F or 3F	±1.5%
Probe nozzles	Caliper	±0.004 in.

Table 5-3. Field Checks of O_2, CO_2, CO, NO_X, and VOC Analyzers

Calibration	Instrument Check	Acceptable Limit
Initial Calibration	O_2, CO_2, CO, & NO_X Calibration Error, % Span VOC Calibration Error, % Calibration Gas Value	±2% ±5%
	Sampling System Bias	±5% of Span
Daily Calibration	O_2, CO_2, CO, & NO_X Calibration Error, % Span VOC Calibration Error, % Calibration Gas Value	±2% of Span ±5% of Cylinder Value
	O_2, CO_2, CO, VOC, & NO_X Drift, % Span	±3% of Span