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**EMISSION MEASUREMENT COMPLIANCE REPORT  
BOF ESP OUTLET STACK  
AK STEEL – DEARBORN WORKS  
DEARBORN, MICHIGAN**

**RECEIVED**  
DEC 29 2014  
AIR QUALITY DIVISION

*Prepared for:*



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**1. INTRODUCTION**

Environmental Quality Management, Inc. (EQ) was retained by AK Steel – Dearborn Works (AK) to plan and conduct an air sampling program on the Basic Oxygen Furnace (BOF) Electrostatic Precipitator (ESP) exhaust stack at the AK facility in Dearborn, Michigan. Sampling was conducted from October 28-29, 2014. Measurements were made to determine the concentration and mass emission rate of nitric oxides (NO<sub>x</sub>) and carbon monoxide (CO). EQ used EPA Reference Methods 1 through 4, 7E, and 10 for the test program. Three total test runs were performed.

Table 1-1 presents the sampling locations and test methods performed at the sampling site. Project participants and responsibilities are presented in Table 1-2.

**Table 1-1. Sampling Locations and Test Methods for AK Steel, Dearborn, Michigan**

<b>Test Point No.</b>	<b>Test Point Name</b>	<b>Parameter Tested</b>	<b>Test Method</b>
1	BOF ESP	Flow CO <sub>2</sub> , O <sub>2</sub> Moisture NO <sub>x</sub> CO	EPA Method 1 for Velocity, Method 2 for Temp EPA Method 3A EPA Method 4 EPA Method 7E EPA Method 10

**Table 1-2. Project Participants**

<b>Name/Company</b>	<b>Responsibility</b>
Jim Earl/AK Steel Ted Bishop/BEC	Coordinate process operation and sampling activities Site/Process preparation, Process information
Tom Maza/DEQ	Agency Review of Process and Sampling Procedures
Doug Allen/EQ Gary Drexler/EQ Chris Janzen/EQ	Project Manager/Field sampling crew Field sampling crew Field sampling crew

## 2. SUMMARY OF TEST RESULTS

The emission measurement program was performed from October 28-29, 2014. Sampling was performed at the BOF ESP outlet sampling location. Table 2-1 presents the average results and comparison to the permit limits in PTI 182-05C. Table 2-2 presents the summary of stack gas conditions for the ESP sampling location. Table 2-3 presents the NO<sub>x</sub> and CO concentrations and mass emission rates. Appendix A summarizes emission and example calculations, Appendix B presents field data, Appendix C presents CEM data, Appendix D presents calibration data, and Appendix E presents process data.

**Table 2-1. Average Results and Limit Comparison**

<b>Pollutant</b>	<b>BOF ESP</b>	<b>Limits</b>
NO <sub>x</sub> (lb/hr)	25.4	52.9
CO (lb/hr)	2,286	7,048

Table 2-2. Stack Gas Conditions, BOF ESP Exhaust Stack

October 28-29, 2014

AK Steel - Dearborn

Run No.	Date/Time	Stack Gas Velocity, fps <sup>a</sup>	Volumetric Flow Rate		Stack Temperature, °F	Moisture Content, % H <sub>2</sub> O	CO <sub>2</sub> , %	O <sub>2</sub> , %
			acfm <sup>b</sup>	dscfm <sup>c</sup>				
<b>BOF ESP</b>								
ESP-1A	10/28/14 1109-1119	58.6	797,543	519,796	203	17.5	2.5	19.5
ESP-1B	10/28/14 1149-1157	43.9	598,506	402,327	183	17.5	2.5	19.5
ESP-2A	10/29/14 0827-0837	59.3	807,805	473,514	249	21.2	4.1	18.5
ESP-2B	10/29/14 0922-0930	58.5	796,691	473,925	239	21.2	4.1	18.5
ESP-3A	10/29/14 1047-1056	57.4	782,134	477,867	255	17.1	4.1	18.5
ESP-3B	10/29/14 1111-1122	52.5	715,344	460,968	218	17.1	4.1	18.5
<b>Average</b>		<b>55.0</b>	<b>749,670</b>	<b>468,066</b>	<b>225</b>	<b>18.6</b>	<b>3.6</b>	<b>18.8</b>

<sup>a</sup>Feet per second.

<sup>b</sup>Actual cubic feet per minute.

<sup>c</sup>Dry standard cubic feet per minute.

Table 2-3. NO<sub>x</sub> and CO Emissions BOF ESP Exhaust Stack

October 28-29, 2014

AK Steel - Dearborn

Run No.	Date/Time	NO <sub>x</sub>		CO	
		Concentration, ppm <sup>a</sup>	Mass Rate, lb/hr <sup>b</sup>	Concentration, ppm <sup>a</sup>	Mass Rate, lb/hr <sup>b</sup>
ESP-1	10/28/14 1100-1201	5.6	18.45	979.2	1969.3
ESP-2	10/29/14 0823-1016	7.7	26.17	1290.2	2665.9
ESP-3	10/29/14 1038-1151	9.4	31.52	1085.3	2222.2
<b>Average</b>		<b>7.6</b>	<b>25.38</b>	<b>1118.2</b>	<b>2285.8</b>

<sup>a</sup>Parts per million, dry basis.

<sup>b</sup>Pounds per hour.

### **3. SAMPLING AND ANALYTICAL PROCEDURES**

The sampling and analytical procedures used in this test program conform to EPA Reference Methods 1 through 4, 7E, and 10 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 BOF ESP. 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 the 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. A total of six traverses were performed, 2 per run. One traverse was completed during the blow of a heat and another was conducted not during the blow, and the average was used to calculate the mass emission rate.

#### **3.3 Stack Gas Molecular Weight**

The gaseous pollutant measurements were conducted according to EPA Reference Method 3A, "Gas Analyses for the Determination of Dry Molecular Weight." The ESP exhaust was sampled continuously for CO<sub>2</sub> and O<sub>2</sub> by using non-dispersive infrared analyzers (CO<sub>2</sub>) or paramagnetic analyzers (O<sub>2</sub>) while measuring the other gaseous pollutants.

### **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. The initial and final contents of all impingers were determined gravimetrically.

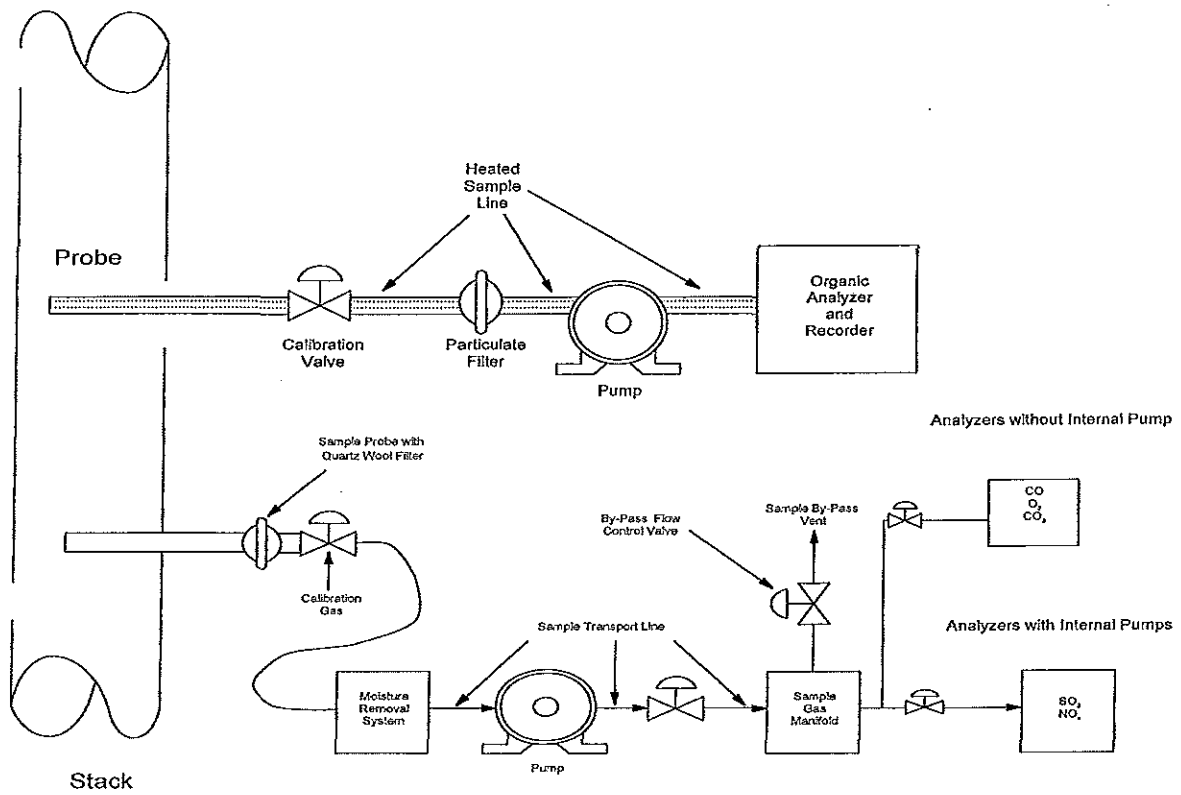
### **3.5 Nitrogen Oxides (NO<sub>x</sub>)**

Nitrogen oxide concentrations were measured and analyzed for following the procedures of EPA Reference Method 7E, "Determination of Nitrogen Oxide Emissions from Stationary Sources by Instrumental Analyzer Technique." Three sampling runs were conducted. The sampling system consisted of an Inconel probe with a sintered filter for particulate matter removal, a heated Teflon sampling line, and a sample gas conditioner to remove moisture prior to entering the chemiluminescent analyzer. A zero gas and two Protocol One calibration gases were used to calibrate the instrument. Data was collected on a data-logging system for 1-minute averages of pollutant data. Figure 3-1 is a schematic of the continuous emission analyzer system.

### **3.6 Carbon Monoxide (CO)**

Carbon monoxide concentrations was sampled and analyzed for 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 was 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.



**Figure 3-1. CEM Sampling System – O<sub>2</sub>, CO<sub>2</sub>, CO, and NO<sub>x</sub>**  
 (Note: SO<sub>2</sub> and TGO were not sampled.)



#### **4. PROCESS DESCRIPTION/SAMPLING LOCATIONS**

AK Steel operates a steel manufacturing facility in Dearborn, Michigan. The sampling program included the BOF ESP outlet stack. The following is a description of the process.

Scrap steel is charged into the 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 (which results in emissions of CO). 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 amount of particulate generated during the oxygen injection process (oxygen blow), the flue gas is controlled by a 32-field ESP. The CO that is generated during the "oxygen blow" for each production cycle is captured and mostly converted to CO<sub>2</sub> before being routed to the ESP stack.

In addition to the ESP, a Secondary Emission Control Baghouse is in operation at the facility to collect and control particulate emissions resulting from reladling, hot metal charging, and tapping operations during steel making heats.

##### **4.1 Raw and Finished Materials Used**

Once the molten iron has completed the desulfurization process, it is poured into the BOF vessel which has already been charged with scrap steel. Once the charge is complete, the oxygen blow begins. Following the oxygen blow, the BOF vessel is tapped to remove the molten steel. Approximately 250 tons of molten steel is produced at the BOF during each heat.

##### **4.2 Operations That Could Produce Variable Emissions**

The BOF operation is a batch process that takes approximately 40 minutes to complete, including a 20-minute oxygen blow. Therefore, emissions would only be expected to occur during scrap and hot metal charging, oxygen blowing, turndown (vessel sampling), additional oxygen blowing (if required), tapping, and deslagging operations. In addition, the BOF Baghouse

also controls particulate emissions generated during the reladling of molten iron at the Hot Metal Transfer (HMT) operation within the BOF building, which often occurs simultaneously with the vessel operations.

#### **4.3 Basic Operating Parameters Used to Regulate the Process**

During the various BOF operations, fan suction pressure is controlled to draw the fumes through the hoods and ductwork for both the ESP and Secondary Emission Baghouse based on which operations are occurring within the BOF vessel(s).

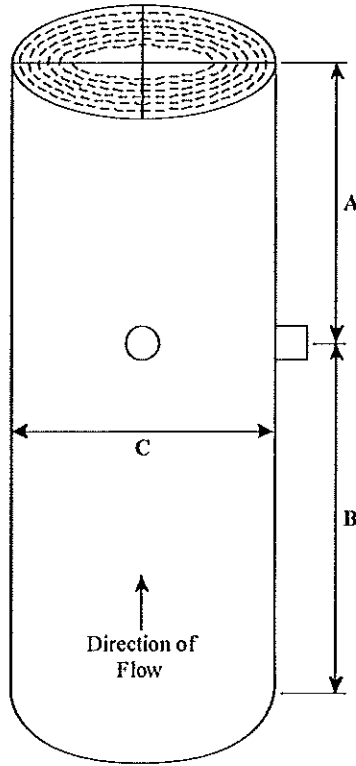
#### **4.4 Rated Capacity of Process**

The rated capacity is approximately 250 to 500 tons per hour, depending on demand and whether both BOF vessels are operating.

#### **4.5 BOF ESP Sampling Location**

A total of 16 points (4 per port) were used to sample the BOF ESP exhaust stack for the velocity measurement. The CO/NO<sub>x</sub> traverse was 6 points (3 per port). The stack has 4 ports.

Figure 4-1 is an example schematic detailing sampling location parameters for the ESP exhaust.



Location	Upstream A	Downstream B	Inside Diameter C	Number of Sampling Points
ESP Stack	>240"	>480"	204"	24

Figure 4-1. BOF ESP Exhaust Sampling Location

## 5. QUALITY ASSURANCE AND QUALITY CONTROL

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. Analytical quality assurance includes use of validated analytical procedures, calibration of equipment, and analysis of control samples and blanks. 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 prior to 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. Summarized in Table 5-1 are the stack gas sampling equipment calibrations that are performed in preparation for this project. The meter boxes were 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 5-1. Field Equipment Calibration Summary<sup>a</sup>**

Equipment	Calibrated Against	Allowable Error
Method 5 meter box	Reference test meter	Y ±0.02 Y ΔH@ ±0.20 ΔH@ 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

<sup>a</sup> 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<sub>2</sub>, CO<sub>2</sub>, CO, and NO<sub>x</sub> Analyzers**

Calibration	Instrument Check	Acceptable Limit
Initial Calibration	O <sub>2</sub> , CO <sub>2</sub> , CO, & NO <sub>x</sub> Calibration Error, % Span	±2%
	Sampling System Bias	±5% of Span
Daily Calibration	O <sub>2</sub> , CO <sub>2</sub> , CO, & NO <sub>x</sub> Calibration Error, % Span	±2%
	O <sub>2</sub> , CO <sub>2</sub> , CO, & NO <sub>x</sub> Drift, % Span	±3% of Span