AIR SAMPLING COMPLIANCE EVALUATION
VACUUM DEGASSER FLARE STACK
AK STEEL DEARBORN WORKS
DEARBORN, MICHIGAN

Prepared for:

AK Steel Dearborn Works
14661 Rotunda Drive
Dearborn, MI 48120-1699

Prepared by:

Environmental Quality Management, Inc.
1800 Carillon Boulevard
Cincinnati, Ohio 45240
(513) 825-7500
Fax: (513) 825-7495

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1. INTRODUCTION

Environmental Quality Management, Inc. (EQM) was retained by AK Steel Dearborn (AK Steel) to plan and conduct an air compliance sampling program on the Vacuum Degasser Flare Stack located at the AK Steel facility in Dearborn, Michigan. EPA-approved sampling methods and analysis procedures were used to meet the objectives of the sampling program.

The testing program was used to evaluate carbon monoxide emissions from the Vacuum Degasser Flare Stack and calculate a mass emission rate at the outlet based on a 99.5% destruction efficiency. The testing was required under AK Steel's Renewable Operating Permit MI-ROP-A8640-2016a, Section EUVACUUMDEGASSER V.1. The testing was conducted on August 24, 2017.

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	Vacuum Degasser Flare Stack	Flow	EPA Method 1 for Velocity, Method 2 for Temperature
		CO_2, O_2	EPA Method 3B
		% H_2O	EPA Method 4
		CO	EPA Method 10

Table 1-2. Project Participants Dearborn, Michigan

Name/Company	Responsibility
David Pate/AK Steel	Coordination of process operation and sampling activities Site/Process preparation Process information
Chris Janzen/EQM	Project Manager
Nick Pharo/EQM	Field sampling crew
Gary Drexler/EQM	Field sampling crew

2. SUMMARY OF TEST RESULTS

The Vacuum Degasser was sampled upstream of the flare stack outlet for carbon monoxide. The Vacuum Degasser is a batch process lasting approximately 25 to 35 minutes per cycle. Emissions were sampled during the entire cycle for a total of eight heats. Run 1 consisted of 2 integral heats. Runs 2 and 3 consisted of 3 integral batches. For Runs 2 and 3, a sample bag corresponding to one of the batches deflated prior to analysis. Results for each of those runs are reported using the 2 integral batches where the analysis could be performed. The vacuum degasser flare stack had an average emission rate of 376.4 pounds per hour of CO (prior to flare destruction) for the three test runs.

Based on a flare destruction efficiency of 99.5%, the average emission rate was calculated as 1.88 pounds per hour of CO for the three test runs. The CO emission rate for the process is therefore in compliance with the 2.42-pounds-per-hour limit (MI-ROP-A8640-2016a, EUVACUUMDEGASSER I.1).

Emissions are calculated and reported as follows:

Vacuum Degasser:

- CO before flare, lb/hr
- CO after flare, lb/hr

Table 2-1 presents stack gas conditions and emissions measured at the Vacuum Degasser.

Table 2-1. Summary of Stack Gas Conditions

August 24, 2017 **AK Steel – Dearborn, Michigan**

Run No.	Time	Stack Gas Velocity, fps[a]	Volumetric Flow Rate		Stack Temperature, °F	Moisture, %	CO_2, %	O_2, %	CO, %	CO Before Flare Mass Rate, lb/hr[d]	CO After Flare Mass Rate, lb/hr[e]
			acfm[b]	dscfm[c]							
D-1A	0825-0859	12.4	686	591	107	8.2	3.5	6.7	13	334.8	1.67
D-1B	0912-0939	16.0	884	771	104	8.2	3.9	6.9	15	504.1	2.52
Run 1	Average	14.2	785	681	106	8.2	3.7	6.8	14	419.5	2.10
D-2A	1003-1030	16.1	888	781	102	10.1	4.1	7.1	11	374.2	1.87
D-2B	1043-1109	16.8	928	810	104	10.1	3.5	6.7	11	388.2	1.94
D-2C[f]	1123-1148	17.5	970	842	105	10.1	0.3	6.8	1.1	40.4	0.20
Run 2	Average	16.4	908	795	103	10.1	3.8	6.9	11	381.2	1.91
D-3A	1206-1231	14.9	821	716	104	10.9	4.4	6.9	12	374.7	1.87
D-3B[g]	1258-1323	14.3	791	690	104	10.9	--	--	--	--	--
D-3C	1338-1403	18.9	1044	899	107	10.9	4.4	6.9	7.2	282.2	1.41
Run 3	Average	16.0	885	769	105	10.9	4.4	6.9	9.6	328.5	1.64
Average	-	**15.5**	**859**	**748**	**105**	**9.5**	**3.4**	**6.9**	**11.5**	**376.4**	**1.88**
										Emission Limit	**2.42**

[a]Feet per second.
[b]Actual cubic feet per minute.
[c]Dry standard cubic feet per minute.
[d]Uncontrolled emission rate at inlet to flare, pounds per hour.
[e]Emission rate based on 99.5% destruction efficiency for CO, pounds per hour.
[f]Run D2-C bag was partially deflated; results are not included in the average for Run 2.
[g]Run D3-B bag was completely flat and was not analyzed; results are not included in the average for Run 3.

3. SAMPLING AND ANALYTIC PROCEDURES

The sampling and analytical procedures used in this test program conform to EPA Reference Methods 1-4 and 10, as published in the Federal Register, with the exception of comments presented in Section 3.6, Test Comments.

3.1 Location of Measurement Sites

EPA Method 1, "Sample Velocity Traverses for Stationary Sources," was used to select a representative measurement site. The sampling location for the vacuum degasser met the requirements of EPA Method 1. A sampling point diagram is presented in Figure 4-1.

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. One flow traverse was conducted during each degasser batch.

3.3 Stack Gas Dry Molecular Weight

EPA Reference Method 3B, "Gas Analysis for the Determination of Emission Rate Correction Factor or Excess Air," was used to determine the CO_2 and O_2 concentrations. Samples were collected in Tedlar bags over the span of one batch. The bags were then sent to an off-site lab where they were analyzed using gas chromatography.

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 measurement run. The initial and final contents of all impingers were determined gravimetrically. One moisture measurement was conducted per CO test run.

3.5 Carbon Monoxide

EPA Reference Method 10B, "Determination of Carbon Monoxide Emissions from Stationary Sources, was used to determine carbon monoxide concentrations. Samples were collected in a Tedlar bag using a stainless steel probe, flexible tubing, conditioning apparatus, and a pump. The bags were then sent to an off-site lab where they were analyzed using gas chromatography. Each bag corresponded to one complete batch.

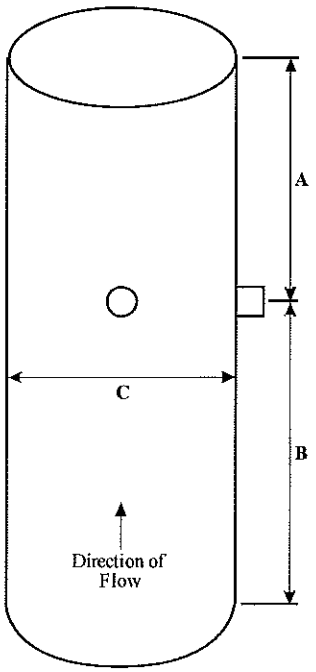
3.6 Test Comments

1. Two bags, 2C and 3B, lost sample prior to analysis. Bag 2C showed signs of having leaked out. The sample was analyzed but results for that sample are not included in the Run 2 average. Bag 3B was completely deflated and could not be analyzed. Results for Run 3 consist of the analysis for Bags 3A and 3C. This limited Runs 2 and 3 to 2 batches each for a sample time of 56 and 52 minutes, respectively. Note that the results for each run consist of 2 integral batches.

2. Method 10B was modified by replacing the acid permanganate impingers with moisture knockout impingers. This change was approved in the test protocol approval letter.

4. PROCESS DESCRIPTION/SAMPLING LOCATION

AK Steel operates a steel manufacturing facility in Dearborn, Michigan. The vacuum degasser process removes gasses that are normally dissolved in steel. A vacuum vessel is lowered into a ladle of liquid steel. The air in the vessel is evacuated, causing columns of liquid steel to rise up into two nozzles in the vacuum degasser. Argon gas is then pumped through one of the two nozzles on the vacuum degasser, thereby causing the steel to flow through the vacuum vessel and back into the ladle. Dissolved gasses are removed, and alloying agents are introduced to the steel. The gasses leaving the vessel are then exhausted through a flare stack where 99.5% are destroyed before exiting to the atmosphere. Sampling for this test program was performed upstream of the flare stack exhaust. Figure 4-1 presents a diagram of the exhaust stack sampling locations.



Upstream A	Downstream B	Inside Diameter C
82 inches	144 inches	13 inches
2 Sampling Ports	4 Traverse Points per Port	8 Total Sampling Points

Traverse Point Number	Location (not including port length)
1	0.8
2	3.3
3	10.4
4	12.1

Figure 4-1. Vacuum Degasser Sampling Location

5. QUALITY ASSURANCE AND QUALITY CONTROL

5.1 Field Sampling

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 included use of validated analytical procedures, calibration of analytical instruments, and analysis of control samples and blanks. The calibration and quality control procedures used for this test program are described in the following subsection, and included in Appendix E of this report.

5.2 Calibration Procedures and Frequency

All manual stack gas sampling equipment was calibrated before 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 were performed in preparation for this project. The meter boxes were re-calibrated after the test.

Listed in Table 5-2 are the additional calibration checks that were performed on the sampling equipment on site, just prior to the testing, to ensure that equipment was not damaged during transport. Calibration checks were conducted before and after each test run. Additional calibration information is included in Appendix E of this report.

Table 5-1. Field Equipment Calibrations

Equipment	Calibrated Against	Allowable Error
Method 5 meter box	Reference test meter	Y ±0.02 Y ΔH@ ±0.20Δ 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	High-low ±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	High-low ±0.004 in.