BTEC Inc.

No. 2 BOP Skimming Operations Flow Verification Test Report

Prepared for:

United States Steel Corporation

Ecorse, Michigan

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

Project No. 049AS-223380
January 9, 2018

BT Environmental Consulting, Inc.
4949 Fernlee Avenue
Royal Oak, MI 48073
(248) 548-8070

EXECUTIVE SUMMARY

BT Environmental Consulting, Inc. (BTEC) was retained by United States Steel Corporation, Great Lakes Works (U. S. Steel) to evaluate volumetric flow rate from the East and West desulfurization stations serving the No. 2 Basic Oxygen Process (BOP) at the U. S. Steel facility located at No. 1 Quality Drive in Ecorse, Michigan. The testing was performed to demonstrate compliance with 40 CFR Part 60 Subpart Na. The compliance test program was conducted on November 13, 2017.

The results of the flow Verification test program are summarized by Table E-1.

Table E-1

Executive Summary Flow Verification Result Summary

Source	Flow Relative Accuracy Result
West Hood	1.5%
East Hood Top Duct	5.3%
East Hood Bottom Duct	7.7%

1. Introduction

BT Environmental Consulting, Inc. (BTEC) was retained by United States Steel Corporation, Great Lakes Works (U. S. Steel) to evaluate volumetric flow rate from the East and West desulfurization stations serving the No. 2 Basic Oxygen Process (BOP) at the U. S. Steel facility located at No. 1 Quality Drive in Ecorse, Michigan. The testing was performed to demonstrate compliance with 40 CFR Part 60 Subpart Na. The compliance test program was conducted on November 13, 2017. 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" (December 2013). 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 13, 2017 at the U. S. Steel facility in Ecorse, Michigan. The test program included evaluation of volumetric flow rate from the East and West desulfurization stations serving the No. 2 BOP.

1.b Purpose of Testing

40 CFR Part 60 Subpart Na "Standards of Performance for Secondary Emissions from Basic Oxygen Process Steelmaking Facilities for Which Construction is Commenced after January 20, 1983" requires the installation of flow monitors. All monitoring devices are to be certified by the manufacturer to be accurate to within ±10 percent compared to Method 2"

1.c Source Description

A diagram of the exhaust stacks are presented as Figures 1-3.

1.d Test Program Contact

The contacts for the source are:

Mr. Nathan Ganhs
U. S. Steel Environmental
United States Steel Corporation
No. 1 Quality Drive
Ecorse, Michigan 48192
Phone (313) 749 3857

Mr. Todd Wessel
Senior Project Manager
BT Environmental Consulting, Inc.
4949 Fernlee Avenue
Royal Oak, Michigan 48073
Phone (616) 885-4013

1.e Testing Personnel

Names and affiliations for personnel who were present during the testing program are summarized by Table 1.

Table 1
Test Personnel

Name and Title	Affiliation	Telephone
Matt Young Senior Project Manager	BTEC 4949 Fernlee Avenue Royal Oak, MI 48073	(248) 548-8070
Mr. Jake Zott Environmental Technician	BTEC 4949 Fernlee Avenue Royal Oak, MI 48073	(248) 548-8070
Mr. Dave Trahan Environmental Technician	BTEC 4949 Fernlee Avenue Royal Oak, MI 48073	(248) 548-8070
Mr. Nathan Ganhs Environmental Department	U. S. Steel No. 1 Quality Drive Ecorse, Michigan 48229	(313) 749-3857

2. Summary of Results

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

2.a Operating Data

Relevant operating data is available in Appendix E.

2.b Applicable Permit

MI-ROP-199600132d

2.c Results

All sources passed the relative accuracy test audit (RATA). 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 Tables 3-5.

2.d Emission Regulation Comparison

The results are summarized by table 2 (section 5.a). All sources should be within ±10% required by 40 CFR Part 60 Subpart Na.

3. Source Description

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

3.a Process Description

The No. 2 BOP Shop Hot Metal Processing Facility receives and processes molten iron (hot metal) produced at the plant's blast furnaces and prepares it for the conversion to steel at the No. 2 BOP Shop Furnaces.

There are two hot metal transfer stations, two desulfurization/slag skimming stations at the subject facility. The process steps at the No. 2 BOP Shop Hot Metal Processing stations are as follows:

Hot Metal in torpedo cars is delivered from the blast furnaces. Then the hot metal is transferred (poured) from the torpedo car into a charging ladle. The charging ladle is moved into position at the desulfurization station. A lance is then lowered into position in the charging ladle.

A powdered desulfurization agent is blown through the lance using an inert carrier gas and injected by fluid momentum into the hot metal bath. Desulfurization agent is injected for time periods and in amounts calculated to meet the desired sulfur specification.
The charging ladle is tilted to the slag skimming position where the slag is skimmed from the surface of the hot metal. After skimming the charging ladle is removed from the desulfurization/slag skimming station for further processing.

The flow meters that were tested are located in the ductwork serving the East and West Desulfurization stations.

3.b Process Instrumentation

East Desulfurization Flow Meter
Veris Verabar, Model V550, Serial Number V12331-01.1
Veris Verabar, Model V550, Serial Number V12331-01.2

NOTE: East Desulfurization has two flow meters inserted into two separate ductworks.
West Desulfurization Flow Meter

Veris Verabar, Model V150, Serial Number V10845-01.1
Veris Verabar, Model V150, Serial Number V12331-01.2

NOTE: West Desulfurization has two flow meters inserted into one common square ductwork. Since there is only one square ductwork these two meter outputs are computed to obtain a common flow value.

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 and molecular weight were 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"*

Stack gas velocity traverses were conducted in accordance with the procedures outlined in Methods 1 and 2. Figures 1-3 present the test ports and traverse/sampling point locations used. A cyclonic flow evaluation was conducted at each sampling location. An S-type pitot tube and thermocouple assembly calibrated in accordance with Method 2, Section 4.1.1 was used to measure exhaust gas velocity pressures and temperatures during testing. Because the pitot tube dimensions outlined in Sections 2.6 through 2.8 were within the specified limits, the baseline pitot tube coefficient of 0.84 (dimensionless) was assigned for this testing. After an initial preflow was conducted, 2-3 sample points per location were chosen as representative of the overall flowrate. These 2-3 sample points were used to rapidly obtain twelve successive flowrate measurements.

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 assumed to be 1% at each source. A sampling pitot tube leak test was conducted before and after each test run.

4.b Recovery and Analytical Procedures

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

4.c Sampling Ports

Sampling ports are located on the stack and meet method 1 criteria.

4.d Traverse Points

Sampling port and traverse point locations are illustrated by Figures 1-3.

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

Executive Summary Flow Verification Result Summary

Source	Flow Relative Accuracy Result
West Hood	1.5 %
East Hood Top Duct	5.3%
East Hood Bottom Duct	7.7%

Detailed data for each test run can be found in Tables 3-5.

5.b Discussion of Results

All sources tested passed the ±10% requirement. The results of the emissions test program are summarized by Table 2 (see section 5.a). Detailed results for each run are summarized by Tables 3-5.

5.c Sampling Procedure Variations

After an initial preflow was conducted, 2 sample points per location were chosen as representative of the overall flowrate. These 2 sample points were used to rapidly obtain twelve successive flowrate measurements.

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 D.

5.i Field Data Sheets

West Hood, East Top Hood, and East Bottom Hood duct flow data sheets are presented in Appendix C.

5.j Laboratory Data

The test program required no laboratory data.

Tables

TABLE 3

SUMMARY OF VOLUMETRIC FLOW RATE RATA RESULTS

November 13, 2017

UNITED STATES STEEL COMPANY

Flow Rate Relative Accuracy

Relative Accuracy: 1.5

Run #	Time	RM ACFM	US Steel ACFM	Diff	%Diff
1	16:18	136625	129808	6816.70	0.05
2	16:18	132426	129808	2617.80	0.02
3	16:18	130311	129808	503.30	0.00
4	16:19	130253	129736	516.50	0.00
5	16:19	128300	129736	-1435.70	-0.01
6	16:19	133263	129736	3526.80	0.03
7	16:20	128415	130402	-1986.80	-0.02
8	16:20	130956	130402	554.00	0.00
9	16:21	126121	130331	-4209.70	-0.03
10	16:21	126234	130331	-4097.30	-0.03
11	16:22	126234	132202	-5968.30	-0.05
12	16:22	131306	132202	-895.70	-0.01
		130150.17	130240.11	-89.944	-0.001
		Sdev	2360.5573		
		CC	1814.4850		
		RA (based on Ref. Meth.)	1.5%		

Confidence Coefficient =
n=9
t = 2.306

$$CC = t_{0.975}\frac{S_d}{\sqrt{n}}$$

P.S. 2 Equation 2-5

Standard Deviation =

$$S_d = \left[\frac{\sum_{i=1}^{n} d_i^2 - \frac{(\sum_{i=1}^{n} d_i)^2}{n}}{n-1}\right]^{1/2}$$

P.S. 2 Equation 2-4

Relative Accuracy =
RM=Reference Monitor

$$RA = \frac{|\bar{d}| + |cc|}{\overline{RM}} x100$$

P.S. 2 Equation 2-6

RA calculated as specified in Performance Specification 2, Appendix B, 40 CFR 60 - Equation 2-4

As specified in P.S. 2, subsection 8.4.4, three sets of test runs may be rejected, these rejected test runs are high-lighted in the table

Part 60 Requires +/- 20% RA, Part 75 Requires +/- 12 PPM

TABLE 4

SUMMARY OF VOLUMETRIC FLOW RATE RATA RESULTS

November 13, 2017

UNITED STATES STEEL COMPANY

Flow Rate Relative Accuracy

Relative Accuracy: **5.3**

Run #	Time	RM ACFM	US Steel ACFM	Diff	%Diff
1	12:51	91669	91212	457.00	0.00
2	12:51	90203	91212	-1009.00	-0.01
3	12:51	90203	91212	-1009.00	-0.01
4	12:52	90115	96288	-6173.00	-0.07
5	**12:52**	**88561**	**96288**	**-7727.00**	**-0.09**
6	12:52	90203	96288	-6085.00	-0.07
7	12:53	91669	93477	-1808.00	-0.02
8	12:53	93172	93477	-305.00	0.00
9	12:53	91759	93477	-1718.00	-0.02
10	**12:54**	**91669**	**101389**	**-9720.00**	**-0.11**
11	**12:54**	**93172**	**101389**	**-8217.00**	**-0.09**
12	12:54	94768	101389	-6621.00	-0.07
		91529.00	94225.78	-2696.778	-0.029
		Sdev	2785.5818		
		CC	2141.1877		
		RA (based on Ref. Meth.)	**5.3%**		

Confidence Coefficient =

n=9

t = 2.306

$$CC = t_{0.975}\frac{S_d}{\sqrt{n}}$$

P.S. 2 Equation 2-5

Standard Deviation =

$$S_d = \left[\frac{\sum_{i=1}^{n} d_i^2 - \frac{\left(\sum_{i=1}^{n} d_i\right)^2}{n}}{n-1}\right]^{1/2}$$

P.S. 2 Equation 2-4

Relative Accuracy =

RM=Reference Monitor

$$RA = \frac{|\bar{d}| + |cc|}{\overline{RM}} x100$$

P.S. 2 Equation 2-6

RA calculated as specified in Performance Specification 2, Appendix B, 40 CFR 60 - Equation 2-4

As specified in P.S. 2, subsection 8.4.4, three sets of test runs may be rejected, these rejected test runs are high-lighted in the table

Part 60 Requires +/- 20% RA, Part 75 Requires +/- 12 PPM

TABLE 5

SUMMARY OF VOLUMETRIC FLOW RATE RATA RESULTS

November 13, 2017

UNITED STATES STEEL COMPANY

Flow Rate Relative Accuracy

Relative Accuracy: 7.7

Run #	Time	RM ACFM	US Steel ACFM	Diff	%Diff
1	17:03	71146	77155	-6009.00	-0.08
2	17:03	71189	77155	-5966.00	-0.08
3	17:03	72717	77155	-4438.00	-0.06
4	17:04	72650	78186	-5536.00	-0.08
5	**17:04**	**71816**	**78186**	**-6370.00**	**-0.09**
6	**17:04**	**71123**	**78186**	**-7063.00**	**-0.10**
7	17:05	72377	77696	-5319.00	-0.07
8	17:05	72754	77696	-4942.00	-0.07
9	**17:05**	**71071**	**77696**	**-6625.00**	**-0.09**
10	17:06	71423	75581	-4158.00	-0.06
11	17:06	71561	75581	-4020.00	-0.06
12	17:06	71556	75581	-4025.00	-0.06
		71930.33	76865.11	-4934.778	-0.069
		Sdev	809.4138		
		CC	622.1705		
	RA (based on Ref. Meth.)		**7.7%**		

Confidence Coefficient =
n=9
t = 2.306

$$CC = t_{0.975}\frac{S_d}{\sqrt{n}}$$

P.S. 2 Equation 2-5

Standard Deviation =

$$S_d = \left[\frac{\sum_{i=1}^{n} d_i^2 - \frac{\left(\sum_{i=1}^{n} d_i\right)^2}{n}}{n-1}\right]^{1/2}$$

P.S. 2 Equation 2-4

Relative Accuracy =
RM=Reference Monitor

$$RA = \frac{|\bar{d}| + |cc|}{\overline{RM}} x100$$

P.S. 2 Equation 2-6

RA calculated as specified in Performance Specification 2, Appendix B, 40 CFR 60 - Equation 2-4

As specified in P.S. 2, subsection 8.4.4, three sets of test runs may be rejected, these rejected test runs are high-lighted in the table

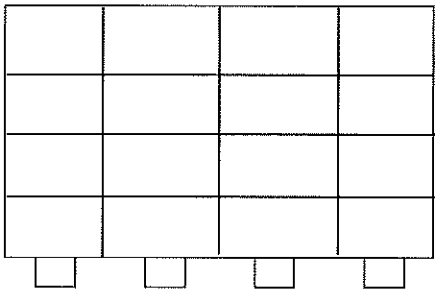
Part 60 Requires +/- 20% RA, Part 75 Requires +/- 12 PPM

Figures

BTEC Inc.

Stack Dimensions: 48" Deep X 96" Tall

Points	Distance "
1	6
2	18
3	30
4	42



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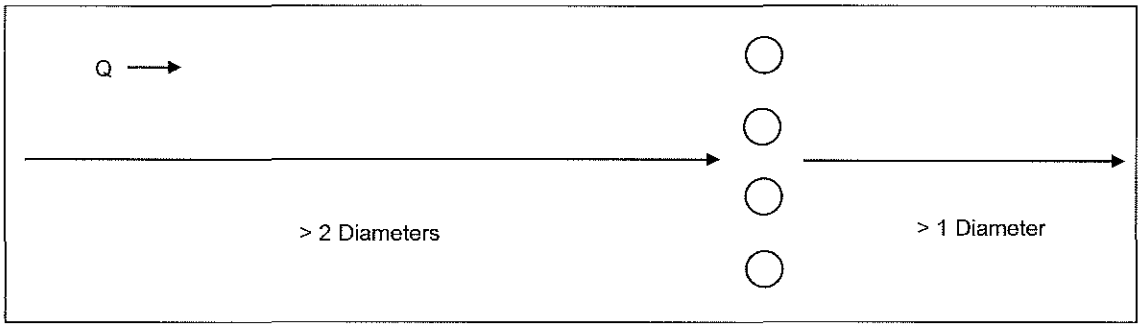


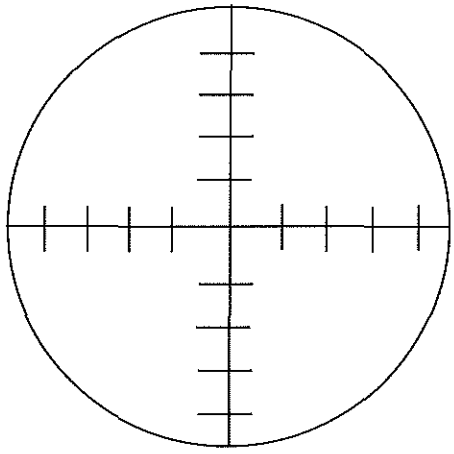
Figure No. 1

Site: **Square Duct (West Hood)** **U.S. Steel - No. 2 BOP** **Ecorse, Michigan**	**Sampling Date:** **November 13, 2017**	**BT Environmental Consulting, Inc.** **4949 Fernlee** **Royal Oak, Michigan**

BTEC Inc.

Stack Diameter: 64 inches

Points	Distance "
8	2.05
7	6.72
6	12.42
5	20.67
4	43.33
3	51.58
2	57.28
1	61.95



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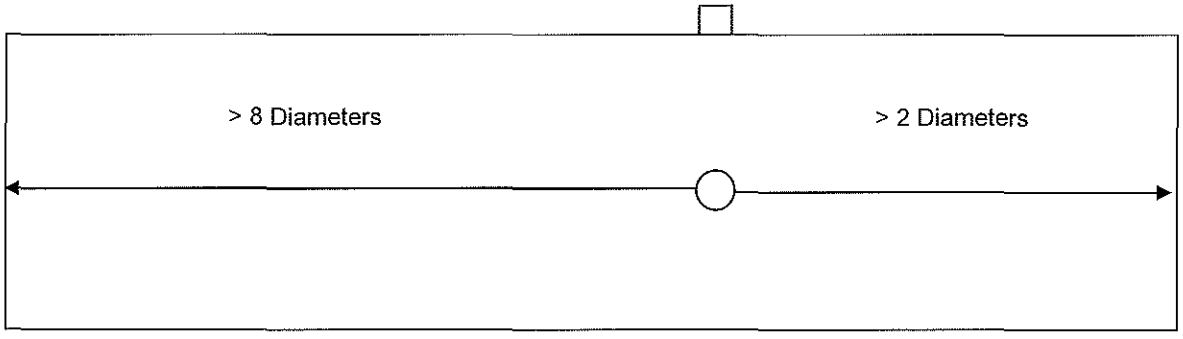


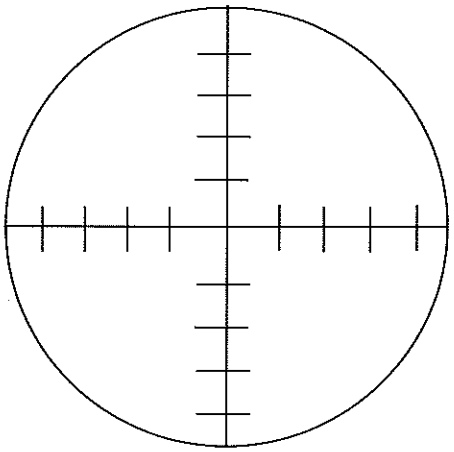
Figure No. 2

Site: **Top Duct East Hood** **U.S. Steel - No. 2 BOP** **Ecorse, Michigan**	**Sampling Date:** **November 13, 2017**	**BT Environmental Consulting, Inc.** **4949 Fernlee Avenue** **Royal Oak, Michigan 48073**

BTEC Inc.

Stack Diameter: 64 inches

Points	Distance "
8	2.05
7	6.72
6	12.42
5	20.67
4	43.33
3	51.58
2	57.28
1	61.95



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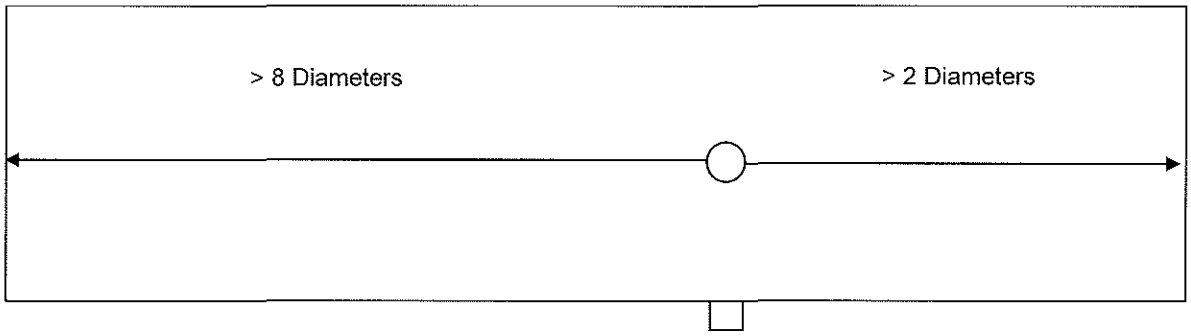

Figure No. 3

Site: **Bottom Duct East Hood** **U.S. Steel - No. 2 BOP** **Ecorse, Michigan**	**Sampling Date:** **November 13, 2017**	**BT Environmental Consulting, Inc.** **4949 Fernlee Avenue** **Royal Oak, Michigan 48073**