BTEC Inc.

No. 5 Pickle Line Hydrogen Chloride Emission Test Report

Prepared for:

United States Steel Corporation

Ecorse, Michigan

United States Steel Corporation
Great Lakes Works
No. 1 Quality Drive
Ecorse, Michigan 48829

Project No. 049AS-470744
October 18, 2018

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BTEC Inc.

Executive Summary

BT Environmental Consulting, Inc. (BTEC) was retained by United States Steel Corporation Great Lakes Works (U. S. Steel) to conduct an evaluation of the hydrogen chloride (HCl) concentrations and emissions from the No. 5 Pickle Line Scrubber inlet and exhaust stacks. The scrubber is located at the U. S. Steel facility in Ecorse, Michigan. The evaluation consisted of triplicate 60-minute test runs at each sampling location.

The results of the Hydrogen Chloride test program are summarized by the following table.

Executive Summary Table E-1
Test Program Results Summary
No. 5 Pickle Line Scrubber
September 27, 2018

Unit	Emission Rates		Permit Limit	
	HCl (lb/hr)	HCl (PPMV, dry)	HCl (lb/hr)	HCl (PPMV, dry)
Pickle Line - Inlet	87.37	1,665.9		
Pickle Line - Outlet	0.21	4.1	1.64	18

1.0 Introduction

BT Environmental Consulting, Inc. (BTEC) was retained by United States Steel Corporation Great Lakes Works (U. S. Steel) to conduct an evaluation of the hydrogen chloride (HCl) concentrations and emissions from the No. 5 Pickle Line Scrubber inlet and exhaust stacks. The scrubber is located at the U. S. Steel facility in Ecorse, Michigan. The evaluation consisted of triplicate 60-minute test runs at each sampling location. US EPA Methods 1, 2, 3, 4 and 26A were utilized to perform the study.

The No. 5 Pickle Line Scrubber was tested for a compliance demonstration required by Permit No. 199600132d. BTEC personnel Mr. Matt Young, Mr. Mason Sakshaug, Mr. David Trahan, and Mr. Ben Durham performed the testing on September 27, 2018. Mr. Nathan Ganhs of U. S. Steel assisted in the study by coordinating the testing and documenting the scrubber operating parameters.

The purpose of this document is to summarize the sampling and analytical methodologies utilized and the results of the emissions test program. Section 2.0 provides a description of the process tested. Sections 3.0 and 4.0 summarize the sampling and analytical methods utilized as well as the results of the emissions test program. Overall results for the emissions test program are summarized by Table 1. Detailed results for each source are presented in Tables 2-3.

All testing was performed in accordance with BTEC test plan 049AS-470744.

2.0 Process Description

The pickling process uses a mineral acid (hydrochloric acid) to remove metal oxides formed when steel is hot rolled and cooled in the presence of oxygen. It is necessary to remove these oxides to provide a smooth clean surface for use as hot roll steel and/or to perform subsequent cold forming operations.

The No. 5 Pickle Line at U. S. Steel consists of three pickle tubs in series. The fresh acid solution is introduced in the 3rd pickle tank. The acid solution then cascades from the 3rd tank to the 1st tank in a direction counter to the direction of the metal strip. By this countercurrent arrangement, the cleanest strip near the process exit is treated by the freshest acid, ensuring that the steel strip is as free of oxide scale as possible.

The No. 5 Pickle Line Scrubber captures and removes acid mist and vapors from the process line. All pickle line tubs are completely covered with capture hoods to evacuate the acid mist and fumes. Ductwork carries the fumes to the packed bed scrubber rated at 16,950 ACFM. The fumes are moved through the scrubber by an I.D. fan.

The water flow monitor calibration was last completed on January 18, 2018.

3.0 Sampling and Analytical Methodologies

Sampling and analytical methodologies for the emissions test program can be separated into two categories as follows:

(1) Measurement of exhaust gas velocity, molecular weight, and moisture content; and,
(2) Sampling and analysis of exhaust gases for HCl concentrations and emissions.

Sections 3.1 and 3.2 summarize the methodologies used to evaluate exhaust gas parameters for each of the aforementioned categories.

3.1 Exhaust Gas Velocity, Molecular Weight, and Moisture Content

Measurement of exhaust gas velocity, molecular weight, and moisture content 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 (Fyrite)"*
Method 4 - *"Determination of Moisture Content in Stack Gases"*

Stack gas velocity traverses were conducted in accordance with the procedures outlined in Method 1 and Method 2 (see Figure 1 for a traverse point diagram). An S-type pitot tube with a thermocouple assembly, calibrated in accordance with Method 2, Section 4.1.1, was used to measure exhaust gas velocity pressures (using a manometer) and temperatures during testing. The S-type pitot tube dimensions were within specified limits, therefore, a baseline pitot tube coefficient of 0.84 (dimensionless) was assigned. Flowrates were not performed on the inlet stack.

Molecular weight was determined according to USEPA Method 3, "Gas Analysis for the Determination of Dry Molecular Weight." The equipment used for this evaluation consisted of a one-way squeeze bulb with connecting tubing and a set of Fyrite® combustion gas analyzers. Carbon dioxide and oxygen content were analyzed using the Fyrite® procedure.

Exhaust gas moisture content was evaluated utilizing USEPA Method 4, "Determination of Moisture Content in Stack Gases." Exhaust gas was extracted as part of the Method 26A sampling trains (see Figure 2 for a schematic of the sampling train). Exhaust gas was extracted and passed through (i) two impingers, each with 100 ml of 0.1N H_2SO_4, (ii) a third impinger that was empty and (iii) a fourth impinger filled with silica gel. Exhaust gas moisture content was then determined gravimetrically.

3.2 Hydrogen Chloride Concentrations

Measurement of HCl concentrations was conducted using the following reference test methods codified at 40 CFR 60, Appendix A:

- Method 26A - *"Determination of Hydrogen Halide and Halogen Emissions from Stationary Sources (isokinetic method)"*

The Method 26A sampling train consists of: (1) a heated borosilicate or quartz probe liner; (2) a heated borosilicate or quartz glass filter holder containing a pre-weighed 110-mm diameter washed teflon filter with Teflon filter support; (3) a set of two Greensburg-Smith (GS) impingers each of which contained 100 ml of 0.1 Normal Sulfuric Acid (0.1 N H_2SO_4), (4) a modified GS impinger that was empty as a knock out impinger, (5) a modified GS impinger containing a known weight of silica gel desiccant; (6) a length of sample line, and (7) a Nutech control case equipped with a pump, dry gas meter, and calibrated orifice. Figure 2 provides an illustration of the Method 26A sample train. The sampling at the inlet stack was performed non-isokinetically and flowrates were not measured.

After completion of the final leak test for each test run, the impinger train was carefully disassembled. The liquid volume of each impinger was measured gravimetrically and any volume increase was noted on field sheets. The impinger catch solution was then transferred to pre-cleaned sample containers. The impingers were then triple rinsed with deionized water (DI H_2O), and the rinses added to the H_2SO_4 sample containers. The back-half of the filter holder was rinsed and added to the H_2SO_4 sample container. The containers were labeled with the test number, test location, test date, and the level of liquid was marked on the outside of each container. Immediately after recovery, the sample containers were placed in a sealed cooler for storage.

The samples were submitted to the contract laboratory. Chain of Custody (COC) forms for the field samples were completed on-site. Maxxam Analytics' laboratories located in Mississauga, Ontario, Canada performed the analysis. All appropriate QA/QC measures were strictly adhered to. Results of the laboratory tests are included in Appendix C.

4.0 Test Results

Table 1
Test Program Results Summary
No. 5 Pickle Line Scrubber
September 27, 2018

Unit	Emission Rates		Permit Limit	
	HCl (lb/hr)	HCl (PPMV, dry)	HCl (lb/hr)	HCl (PPMV, dry)
Pickle Line - Inlet	87.37	1,665.9		
Pickle Line - Outlet	0.21	4.1	1.64	18

Overall results of the emissions test program are summarized by Table 1. Detailed results for each source are presented in Tables 2-3. Field and computer-generated data sheets are provided in Appendix A. Equipment calibration information and U. S. Steel process documentation is presented in Appendix B and laboratory analytical reports are provided as Appendix C. Example calculations for equations used to determine emission rates are presented in Appendix D. Process data is presented in Appendix E.

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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, Montrose Air Quality Services, LLC, (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

All testing performed was done in conformance to the ASTM D7036-04 standard. The information and opinions rendered in this report are exclusively for use by United States Steel Corporation. BTEC will not distribute or publish this report without United States Steel Corporation's consent except as required by law or court order. BTEC 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: _____ P.E.
Todd Wessel
Client Project Manager

This report was reviewed by: _____
Brandon Chase
QA/QC Manager

Table 2
Pickle Line Inlet HCl Emission Rates

Company	US Steel			
Source Designation	Pickle Inlet			
Test Date	9/27/2018	9/27/2018	9/27/2018	
Meter/Nozzle Information	**P-1**	**P-2**	**P-3**	**Average**
Meter Temperature Tm (F)	78.5	83.0	86.5	82.7
Meter Pressure - Pm (in. Hg)	29.7	29.7	29.7	29.7
Measured Sample Volume (Vm)	47.0	47.6	47.8	47.5
Sample Volume (Vm-Std ft3)	45.5	45.7	45.6	45.6
Sample Volume (Vm-Std m3)	1.29	1.30	1.29	1.29
Condensate Volume (Vw-std)	10.184	10.326	9.760	10.090
Gas Density (Ps(std) lbs/ft3) (wet)	0.0694	0.0694	0.0696	0.0695
Gas Density (Ps(std) lbs/ft3) (dry)	0.0745	0.0745	0.0745	0.0745
Total weight of sampled gas (m g lbs) (wet)	3.86	3.89	3.85	3.87
Total weight of sampled gas (m g lbs) (dry)	3.39	3.41	3.40	3.40
Stack Data				
Molecular Weight Stack Gas- dry (Md)	28.8	28.8	28.8	28.8
Molecular Weight Stack Gas-wet (Ms)	26.9	26.8	26.9	26.9
Stack Gas Specific Gravity (Gs)	0.927	0.927	0.930	0.928
Percent Moisture (Bws)	18.29	18.41	17.63	18.11
Water Vapor Volume (fraction)	0.1829	0.1841	0.1763	0.1811
Pressure - Ps ("Hg)	29.6	29.6	29.6	29.6
Area of Stack (ft2)	5.6	5.6	5.6	5.6
Exhaust Gas Flowrate				
	Inlet flows not performed. Flows are assumed equal to the exhaust.			
Flowrate ft^3(Actual)	11,305	11,292	11,365	11,321
Flowrate ft^3 (Standard Wet)	10,123	10,085	10,180	10,129
Flowrate ft^3 (Standard Dry)	8,971	8,902	8,825	8,900
Flowrate m^3 (standard dry)	254	252	250	252
Total HCl Weight (ug)				
Total	3,607,757	3,535,137	3,006,794	3,383,229
Total HCl Concentration				
lb/1000 lb (wet)	2.058	2.003	1.721	1.928
lb/1000 lb (dry)	2.346	2.286	1.951	2.194
mg/dscm (dry)	2,801.1	2,728.8	2,329.0	2,619.6
PPM (dry)	1,794.1	1,733.6	1,469.9	1,665.9
Total HCl Emission Rate				
lb/ hr	94.12	90.99	76.99	87.37

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Table 3
Pickle Line Exhuast HCl Emission Rates

Company	USS			
Source Designation	Pickle Out			
Test Date	9/27/2018	9/27/2018	9/27/2018	
Meter/Nozzle Information	P-1	P-2	P-3	Average
Meter Temperature Tm (F)	67.5	82.0	86.5	78.7
Meter Pressure - Pm (in. Hg)	29.6	29.6	29.6	29.6
Measured Sample Volume (Vm)	53.9	55.7	56.0	55.2
Sample Volume (Vm-Std ft3)	53.2	53.6	53.5	53.4
Sample Volume (Vm-Std m3)	1.51	1.52	1.51	1.51
Condensate Volume (Vw-std)	6.837	7.120	8.204	7.387
Gas Density (Ps(std) lbs/ft3) (wet)	0.0713	0.0712	0.0708	0.0711
Gas Density (Ps(std) lbs/ft3) (dry)	0.0745	0.0745	0.0745	0.0745
Total weight of sampled gas (m g lbs) (wet)	4.29	4.33	4.37	4.33
Total weight of sampled gas (m g lbs) (dry)	3.97	3.99	3.98	3.98
Nozzle Size - An (sq. ft.)	0.000552	0.000552	0.000552	0.000552
Isokinetic Variation - I	99.5	100.9	101.6	100.7
Stack Data				
Average Stack Temperature - Ts (F)	120.3	121.8	120.2	120.8
Molecular Weight Stack Gas- dry (Md)	28.8	28.8	28.8	28.8
Molecular Weight Stack Gas-wet (Ms)	27.6	27.6	27.4	27.5
Stack Gas Specific Gravity (Gs)	0.953	0.952	0.946	0.950
Percent Moisture (Bws)	11.38	11.73	13.30	12.14
Water Vapor Volume (fraction)	0.1138	0.1173	0.1330	0.1214
Pressure - Ps ("Hg)	29.4	29.4	29.4	29.4
Average Stack Velocity -Vs (ft/sec)	34.0	33.9	34.1	34.0
Area of Stack (ft2)	5.5	5.5	5.5	5.5
Exhaust Gas Flowrate				
Flowrate ft^3(Actual)	11,305	11,292	11,365	11,321
Flowrate ft^3 (Standard Wet)	10,123	10,085	10,180	10,129
Flowrate ft^3 (Standard Dry)	8,971	8,902	8,825	8,900
Flowrate m^3 (standard dry)	254	252	250	252
Total HCl Weight (ug)				
Total	8,849	9,067	9,938	9,285
Total HCl Concentration				
lb/1000 lb (wet)	0.005	0.005	0.005	0.005
lb/1000 lb (dry)	0.005	0.005	0.005	0.005
mg/dscm (dry)	5.9	6.0	6.6	6.1
PPM	3.9	4.0	4.3	4.1
Total HCl Emission Rate				
lb/ hr	0.20	0.20	0.22	0.21

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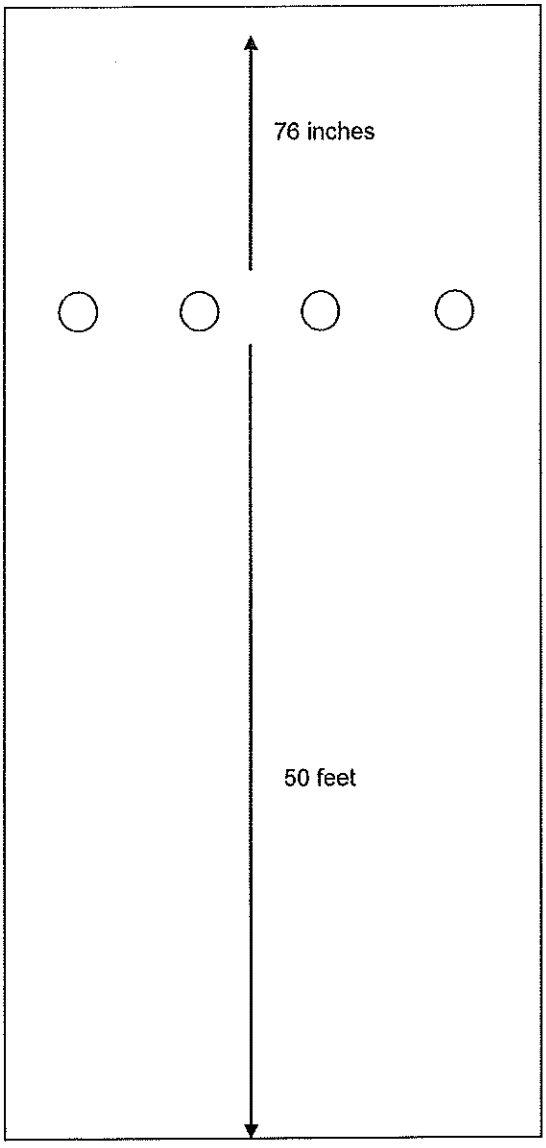

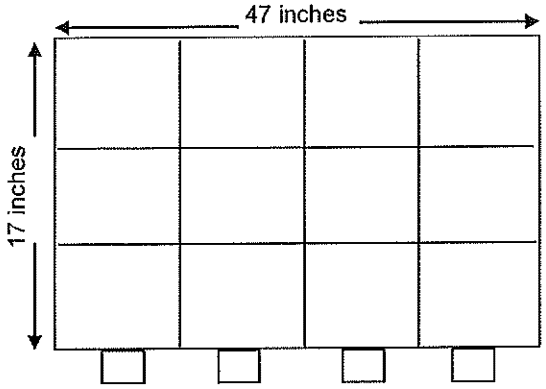

Not to Scale

Points	Distance "
1	2.8
2	8.5
3	14.2

Figure 1

Site: **No. 5 Pickle Line Exhaust** **US Steel** **Ecorse, Michigan**	**Sampling Date:** **September 27, 2018**	**BT Environmental Consulting, Inc.** **4949 Fernlee Ave** **Royal Oak, Michigan**

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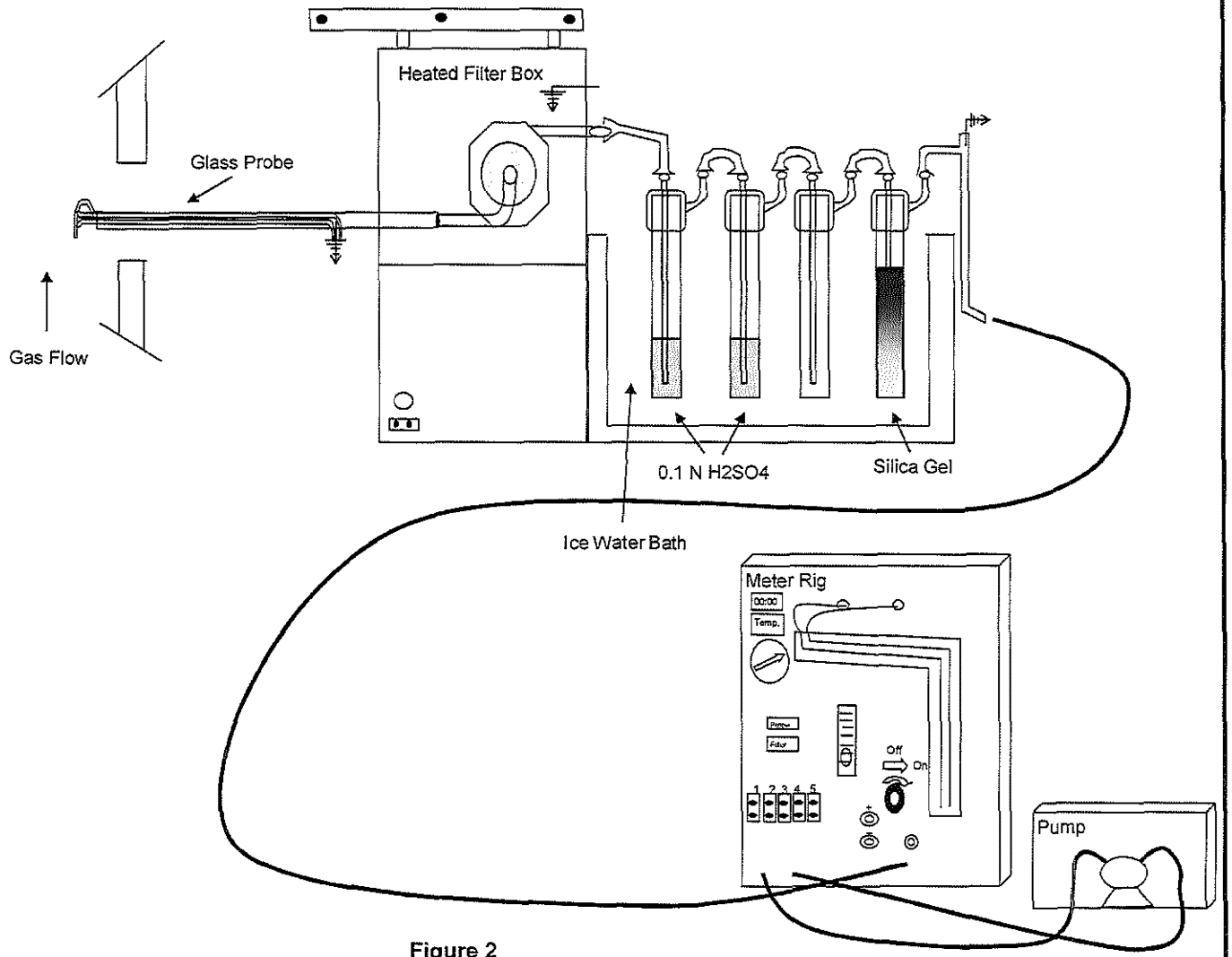

Figure 2

Site:	Sampling Date:	
USEPA Method 26A Sampling Train United States Steel Ecorse, MI	September 27, 2018	BT Environmental Consulting, Inc. 4949 Fernlee Ave Royal Oak, Michigan