FINAL REPORT

UNITED STATES STEEL CORPORATION

ECORSE, MICHIGAN

COMPLIANCE TESTING REPORT:
CGL ANNEALING FURNACE – NOX AND AMMONIA

RWDI #2302716
May 6, 2023

SUBMITTED TO

Nathan Ganhs
Coordinating Manager-Environmental
Naganhs@uss.com

United States Steel Corporation
1 Quality Drive
Ecorse, Michigan 48229

Dr. April Wendling
EGLE, Air Quality Division
Cadillac Place
3058 West Grand Boulevard
Suite 2-300
Detroit, Michigan 48202-6058

TPU Supervisor
EGLE, Air Quality Division
Constitution Hall, 2nd Floor South
525 West Allegan Street
Lansing, MI 48933

SUBMITTED BY

Steve Smith, QSTI
Project Manager
Steve.Smith@rwdi.com | ext. 3706

Mason Sakshaug, QSTI
Technical Supervisor | Associate
Mason.Sakshaug@rwdi.com | ext. 3703

RWDI USA LLC
Consulting Engineers & Scientists
2239 Star Court
Rochester Hills, Michigan 48309

T: 248.841.8442
F: 519.823.1316

EXECUTIVE SUMMARY

RWDI USA LLC (RWDI) has been retained by United States Steel Corporation (US Steel) to complete the emission sampling program at the Great Lakes Works facility located at 1 Quality Drive, Ecorse, Michigan 48229. US Steel operates a steel manufacturing facility that produces steel coils and flat rolled sheet steel. The operation includes the Continuous Galvanizing Line (CGL) annealing furnace (SV CONGALVGNCE) under Emission Unit EUCON-GALV-LINE-51. Testing consisted of emissions for nitrogen oxides (NO_x) and ammonia (NH_3). The testing was required Michigan Department of Environment, Great Lakes, and Energy (EGLE) Permit to Install MI-PTI-219-06B and 98-15.

Compliance testing was completed for the Annealing Furnace was completed on March 23, 2023.

Executive Table i: Results Summary – Annealing Furnace

Source	Analyte	Units	Average	Limit
Annealing Furnace	NO_x	$ppmv_d$	1.23	-
		lb/hr	0.24	6.6
	NH_3	$ppmv_d$	9.96	-
		lb/hr	0.71	1.44

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1 INTRODUCTION

RWDI USA LLC (RWDI) has been retained by United States Steel Corporation (US Steel) to complete the emission sampling program at the Great Lakes Works facility located at 1 Quality Drive, Ecorse, Michigan 48229. US Steel operates a steel manufacturing facility that produces steel coils and flat rolled sheet steel. The operation includes the Continuous Galvanizing Line (CGL) annealing furnace (SV CONGALVGNCE) under Emission Unit EUCON-GALV-LINE-51. Testing consisted of emissions for nitrogen oxides (NO_x) and ammonia (NH_3). The testing was required Michigan Department of Environment, Great Lakes, and Energy (EGLE) Permit to Install MI-PTI-219-06B and 98-15.

1.1 Location and Date of Testing

The testing program was completed on March 23, 2023, at the US Steel Great Lakes Works facility located at 1 Quality Drive, Ecorse, Michigan.

1.2 Purpose of the Testing

The testing was required Michigan Department of Environment, Great Lakes, and Energy (EGLE) Permit to Install MI-PTI-219-06B and 98-15.

1.3 Description of the Source

US Steel Great Lakes Works is a steel manufacturing facility producing steel coils and flat rolled sheet steel. The Continuous Galvanizing Line is where steel coils are galvanized. The coils of steel are loaded into the entry end of the process and are uncoiled and straightened. Each leading edge of the next coil is welded to the preceding coil to allow the process to run continuously while production is occurring. In the Pre-Cleaner section of the CGL process, the straightened coils are cleaned within caustic solution tanks, which are heated by a hot water and heat exchanger system. Emissions of dilute caustic generated in the cleaning process tanks are controlled by a mist eliminator and a scrubber before being exhausted to the outer atmosphere through the Pre-Cleaner stack.

After cleaning and rinsing, the coil is dried with hot air. After drying, the coil enters the Annealing Furnace. The coil is heated according to required specifications within the Annealing Furnace and then proceeds to the zinc pot where the steel is given a zinc coating (i.e. galvanized). Excess zinc is removed immediately upon exit of the molten zinc pot, and the zinc-coated steel strip is allowed to dry as it travels in a vertical direction. After air cooling, the strip is quenched in water, dried, inspected, and packaged for customer delivery.

1.4 Personnel Involved in Testing

Table 1.4.1: List of Testing Personnel

Nathan Ganhs Coordinating Manager - Environmental NAganhs@uss.com	**US Steel Corporation** 1 Quality Drive Ecorse, MI 48229	(313) 749-3857
Andrew Riley Air Quality Division RileyA8@michigan.gov	**State of Michigan** EGLE Air Quality	(586) 565-7379
Mason Sakshaug Technical Supervisor Mason.Sakshaug@rwdi.com	**RWDI USA LLC** 2239 Star Court Rochester Hills, MI 48309	(989) 323-0355
Ben Durham Senior Field Technician Ben.Durham@rwdi.com		(734) 474-1731

2 SUMMARY OF RESULTS

2.1 Operating Data

Operational data collected during the testing included the following (found in **Appendix A**):

- NO_x ppm
- O_2 %
- Natural gas usage in the annealing furnace
- Natural gas usage by the edge burners
- Amount of urea injected
- Gas inlet temperature to the SCR; and
- Amount of galvanized steel produced.

2.2 Applicable Permit Number

The testing was required Michigan Department of Environment, Great Lakes, and Energy (EGLE) Permit to Install MI-PTI-219-06B and 98-15.

3 SOURCE DESCRIPTION

3.1 Description of Process and Emission Control Equipment

Refer to Section 1.3 for a description of the process. Emissions are controlled by a single selective catalytic reduction (SCR) system with a duct burner servicing the annealing furnace.

3.2 Process Flow Sheet or Diagram

A process schematic can be provided upon request.

3.3 Type and Quantity of Raw and Finished Materials

Cold rolled steel is uncoiled, welded together, and cleaned prior to entering the annealing furnace.

3.4 Normal Rated Capacity of Process

The maximum rated capacity of the line is 850,000 tons per year and 838.6 million cubic feet per year of natural gas from the edge burners and annealing furnace. Tons of steel and natural gas usage is based on a 12-month rolling average.

3.5 Process Instrumentation Monitored During the Testing

Annealing Furnace parameters included the following:

- NO_x ppm
- O_2 %
- Natural gas usage in the annealing furnace
- Natural gas usage by the edge burners
- Amount of urea injected
- Gas inlet temperature to the SCR; and
- Amount of galvanized steel produced.

4 POLLUTANTS TO BE MEASURED

Testing consisted of emissions for nitrogen oxides (NO_x) and ammonia (NH_3).

5 SAMPLING AND ANALYSIS PROCEDURES

The following section provides brief descriptions of the proposed sampling methods and discusses any proposed modifications to the reference test methods.

5.1 Stack Velocity, Temperature, and Volumetric Flow Rate Determination

The exhaust velocities and flow rates were determined following the USEPA Method 2, "Determination of Stack Gas Velocity and Flow Rate (Type S Pitot Tube)" from the outlet only. Velocity measurements were taken with a pre-calibrated S-Type pitot tube and incline manometer. Volumetric flow rates were determined following the equal area method as outlined in US EPA Method 2. Temperature measurements were made simultaneously with the velocity measurements and were conducted using a chromel-alumel type "k" thermocouple in conjunction with a digital temperature indicator.

The dry molecular weight of the stack gas was determined following calculations outlined in US EPA Method 3A "Determination of Molecular Weight of Dry Stack Gas" for O_2. USEPA Method 320 was used for CO_2 content.

Stack moisture content was determined in accordance with USEPA Method 320.

5.2 NO_x and NH_3 by USEPA Method 320

Emissions testing was performed at the outlet of the annealing furnace. Pollutant concentrations was determined utilizing RWDI's continuous emissions monitoring system (CEM) which consists of the FTIR and oxygen analyzer (measuring on wet basis).

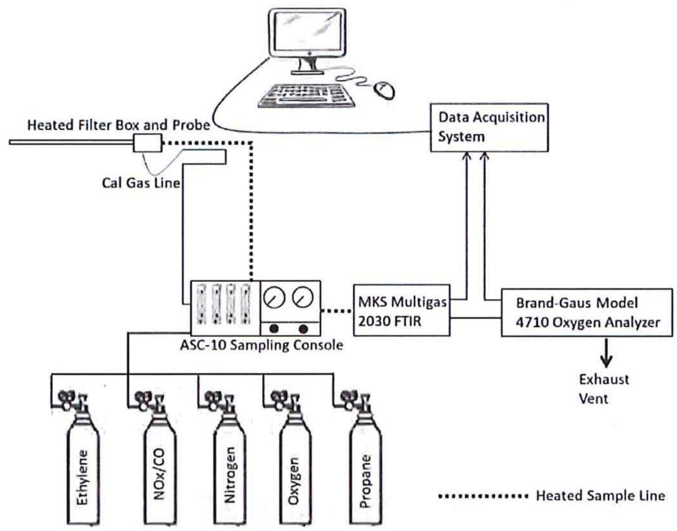
Stack gas concentrations for NO_x, NH_3, and O_2 were measured using EPA Reference Methods 320 and 3A.

Oxygen measurements were taken continuously following USEPA Method 3A on the outlet (using a wet oxygen analyzer or equivalent). Stratification checks using O_2 as the surrogate for all pollutants, was completed on the exhaust of the annealing furnance at three points (16.7%, 50% and 83.3% of inner diameter) on a line passing through the centroidal area, as per the alternative approach in EPA Method 7E Section 8.1.2.

Regular performance checks on the CEMS were carried out by zero and span calibration checks on the oxygen analyzer and necessary QA procedures on the FTIR using USEPA Protocol calibration gases. These checks will verify the ongoing precision of the FTIR with time by introducing pollutant-free (zero) air followed by known calibration gas (span) into the FTIR. The response of the monitor to pollutant-free air and the corresponding sensitivity to the span gases was reviewed frequently as an ongoing indication of analyzer performance.

Monitoring was conducted by drawing a sample stream of flue gases through a stainless-steel probe attached to a heated filter and a heated sample line that is attached to the MAX Analytical ASC-10ST sampling console. Lengths of unheated sample line was kept to a minimum and insulated. The ASC-10ST sampling console delivers a continuous sample to the MKS MultiGas 2030 FTIR and oxygen analyzer for analysis. The heated filter and line were maintained at approximately 191°C (375°F) and the MKS MultiGas 2030 FTIR and ASC-10ST gas components were kept at 191°C (375°F). The end of the probe was connected to a heated Teflon sample line, which will deliver the sample gases from the stack to the FTIR system. The heated sample line was designed to maintain the gas temperature at approximately 375°F to prevent condensation of stack gas moisture within the line and condition air to the same temperature as the FTIR. A schematic of the sampling system setup is depicted in **Figure 5.2a.**

Figure 5.2a: MKS 2030 Multigas FTIR/ASC-10ST/Model 4710 Oxygen Analyzer Sampling System Schematic



The ASC-10ST was used to deliver calibration gases (Calibration Transfer Standard (CTS), QA Spike and Nitrogen) to the FTIR in direct (to analyzer) and system (to probe) modes.

A laptop computer was utilized for operating the MKS MultiGas 2030 FTIR and MAX Analytical ASC-10ST sampling console and logging the multi-gas FTIR data. Data was logged as one-minute averages for the actual test period (FTIR PRN files and Spectra). All concentration data was determined using the MKS 2030 MultiGas FTIR software. A typical MKS 2030 FTIR and ASC-10 ST configuration is depicted in **Figure 5.2b**

For oxygen measurement only, prior to testing, a 3-point analyzer calibration error check was conducted using USEPA protocol gases. The calibration error check was performed by introducing zero, mid and high-level calibration gases directly into the analyzer. The calibration error check was performed to confirm that the analyzer response is within ±2% of the certified calibration gas introduced. Prior to each test run, a system-bias test was performed where known concentrations of calibration gases were introduced at the probe tip to measure if the analyzers response was within ±5% of the introduced calibration gas concentrations. At the conclusion of each test run a system-bias check was performed to evaluate the percent drift from pre and post-test system bias checks. The system bias checks were used to confirm that the analyzer did not drift greater than ±3% throughout a test run. The analyzer will measure the respective gas concentrations on a wet volumetric basis which was converted to a dry volumetric number.

The probe tip was equipped with a heated filter for particulate removal. The end of the probe was connected to a heated Teflon sample line, which will deliver the sample gases from the stack to the FTIR/4710 Oxygen analyzer system. The heated sample line was designed to maintain the gas temperature at approximately 375°F to prevent condensation of stack gas moisture within the line.

Figure 5.2b: Typical MKS 2030 Multigas FTIR and ASC-10ST Configuration

6 NUMBER AND LENGTH OF SAMPLING RUNS

Testing consisted of triplicate 1-hour tests.

7 STACK INFORMATION

Table 7.1: Summary of the Stack Characteristics

Source	Diameter	Approximate Duct Diameters from Flow Disturbance	Number of Ports	Points per Traverse	Total Points per Test
Annealing Furnace	58.5	2.05 downstream 4.10 upstream	2	8	16 Flow

8 FLUE GAS CONDITIONS

Table 8.1: Flue Gas Conditions

Parameter	Flue Gas Conditions		
	Stack Temperature	Flow Rate	Percent Moisture
Annealing Furnace	608	27,005 dscfm	12%

9 TEST RESULTS AND DISCUSSION

9.1 Detailed Results

Detailed results for all analytes are provided in **Appendix B**.

Table 9.1.1: Results Summary – Annealing Furnace

Source	Analyte	Units	Average	Limit
Annealing Furnace	NO_x	$ppmv_d$	1.23	-
		lb/hr	0.24	6.6
	NH_3	$ppmv_d$	9.96	-
		lb/hr	0.71	1.44

9.2 Discussion of Results

The detailed results of individual tests can be found in **Appendix B** and detailed flow data can be found in **Appendix C**. All field sheets can be found in **Appendix D.**

9.3 Variations in Testing Procedures

Due to the port projecting into the stack, the flow point closest to the port could not be used so an alternative point between point 2 and the port was used for the final point.

9.4 Process Upset Conditions During Testing

There were no upsets in the process during testing.

9.5 Maintenance Performed in Last Three Months

All maintenance in the last three months has been routine.

9.6 Re-Test

This was not a retest.

9.7 Audit Samples

This test did not require any audit samples.

9.8 Process Data

Process data can be found in **Appendix A**.

9.9 Calibration Data

Calibration can be found in **Appendix E**.

9.10 Example Calculations

Example calculations can be found in **Appendix F**.

9.11 Laboratory Data

There was no laboratory data affiliated with this testing.

9.12 Source Testing Plan and EGLE Correspondence

Copy of the correspondence received from the Source Testing Plan from EGLE and the Source Testing Plan submitted can be found in **Appendix G**.

TABLES

Table 1: Summary of Emissions - Annealing Furnace

US Steel

Facility: Great Lakes Works
City: Ecorse, MI
Source: Annealing Furnace
Date: 3/23/2023

	Symbol	Units	Test 1	Test 2	Test 3	Average	Limits
Nitrogen Oxides Concentration	NO_x	ppmvd	1.13	1.57	1.01	1.23	-
Ammonia Concentration	NH_3	ppmvd	11.12	11.00	7.77	9.96	-
Oxygen Concentration	O_2	$\%_{wet}$	8.29	8.59	9.28	8.72	-
Oxygen Concentration	O_2	$\%_{dry}$	9.48	9.78	10.48	9.92	-
Nitrogen Oxides Emission Rate	NO_x	pph	0.22	0.30	0.19	0.24	6.6
Ammonia Emission Rate	NH_3	pph	0.82	0.78	0.54	0.71	1.44

Table 2: Annealing Furnace Flow Measurements

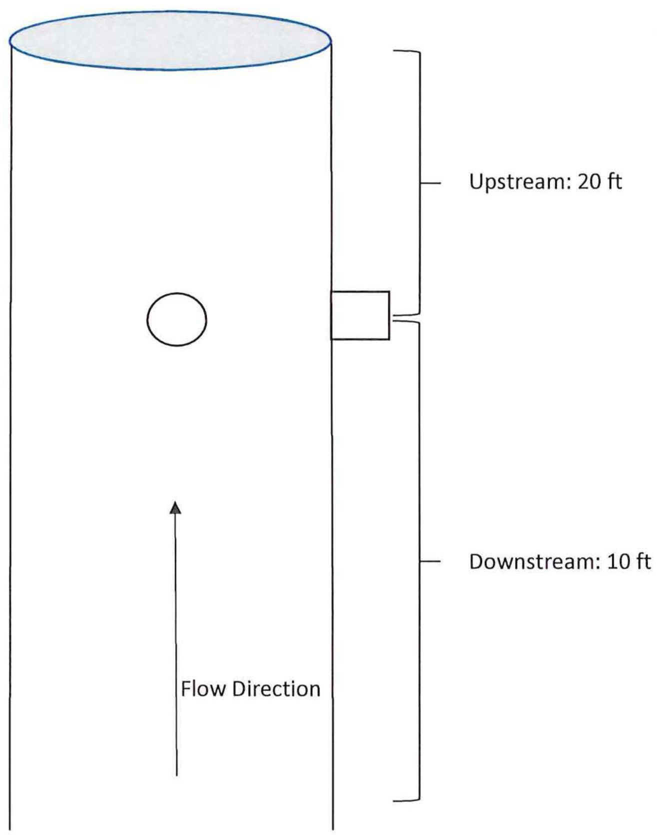
US Steel

Facility: Great Lakes Works
City: Ecorse, MI
Source: Annealing Furnace
Date: 3/23/23

Parameter	Units	Test 1	Test 2	Test 3	Average
Stack Gas Temperature	°F	607	605	612	608.1
Stack Gas Moisture	%	12.61%	12.21%	11.44%	12.09%
Velocity	ft/sec	58.9	56.3	55.7	57.0
Actual Flowrate	acfm	65,958	63,000	62,420	63,793
Dry Reference Flowrate	dscfm	27,753	26,690	26,504	26,982
Dry Reference Flowrate	m^3/s	13.10	12.60	12.51	12.74

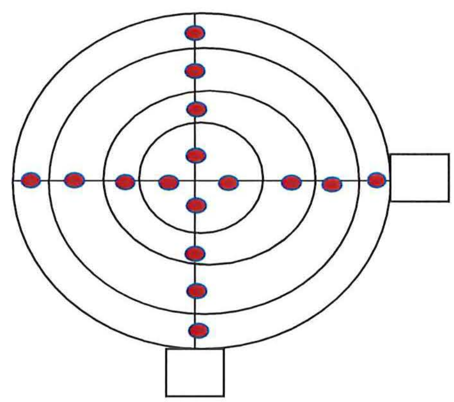
FIGURES

Figure No. 1: Annealing Furnace Exhaust Stack Diagram



Diameter: 58.5

Sampling Points (in.)	
1	1.90
2	6.10
3	11.30
4	18.70
5	39.30
6	46.80
7	51.90
8	56.10



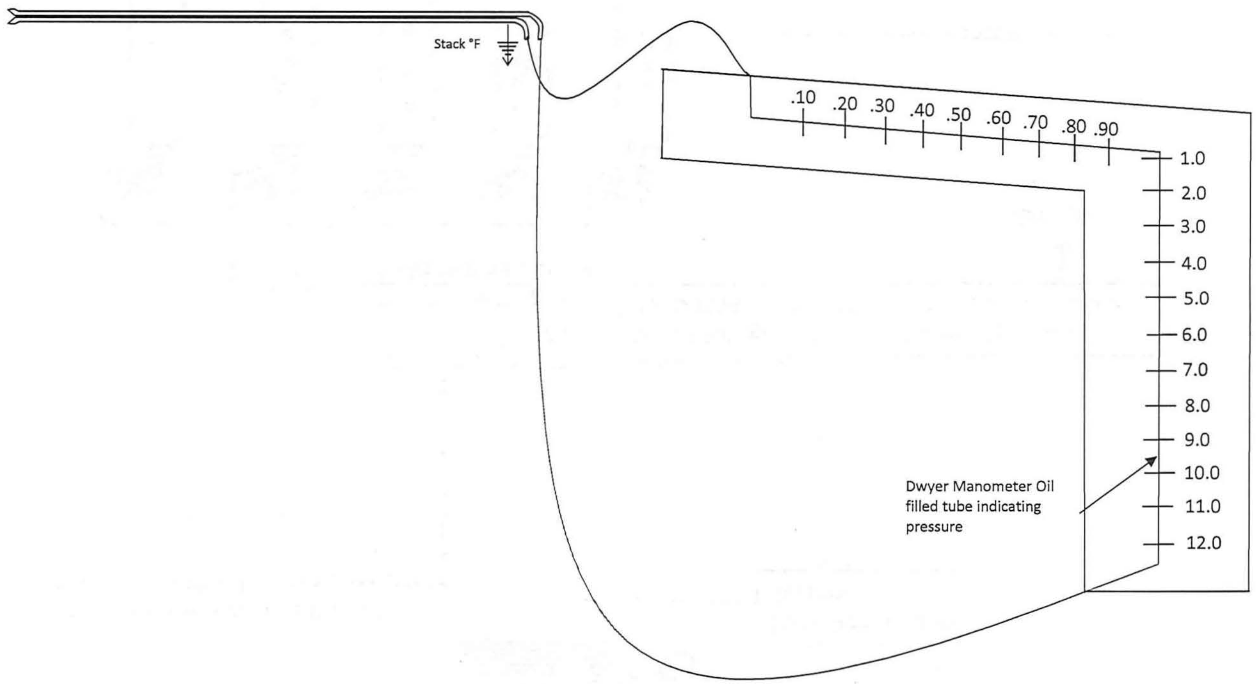
Not to Scale

Source
US Steel
Great Lakes Works
Ecorse, Michigan

Date:
23-Mar-23

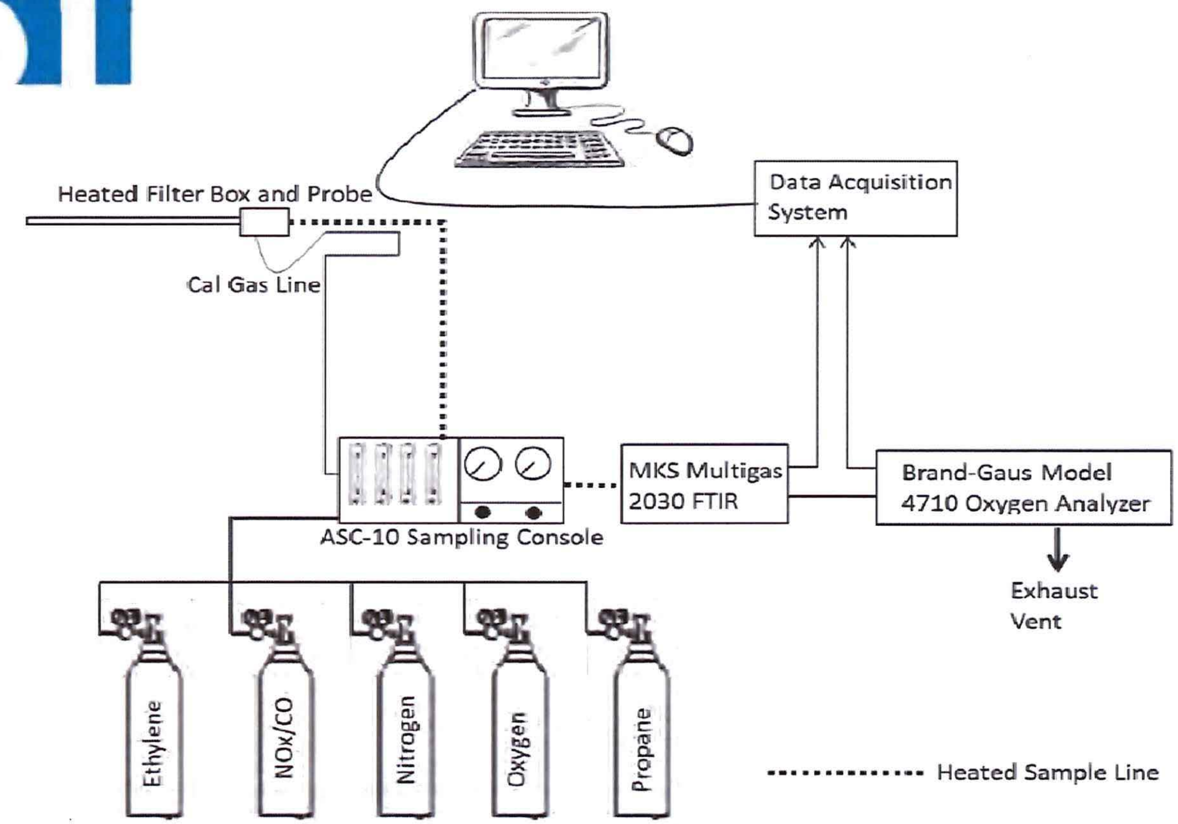
RWDI USA LLC
2239 Star Court
Rochester Hills, MI 48309

Figure No. 2: USEPA Method 2



USEPA Method 2 **US Steel** Great Lakes Works Annealing Furnace Ecorse, Michigan Project #2302716	**Figure No. 2** **Date: March 23, 2023**	

Figure No. 3: USEPA Method 320/3A



USEPA Method 320

US Steel
Great Lakes Works
Annealing Furnace
Ecorse, Michigan

Project# 2302716

Date: March 23, 2023