mostardi platt

Relative Accuracy Test Audit
Test Report

Michigan State University
T.B. Simon Power Plant
Unit 2 Outlet Duct
East Lansing, Michigan
February 20, 2017

Report Submittal Date
April 26, 2017

Project No. M170605B

888 Industrial Drive
Elmhurst, Illinois 60126
630-993-2100

1.0 EXECUTIVE SUMMARY

MOSTARDI PLATT conducted a Continuous Emissions Monitoring System (CEMS) Relative Accuracy Test Audit (RATA) test program for Michigan State University at the T.B. Simon Power Plant in East Lansing, Michigan, on the Unit 2 Outlet Duct on February 20, 2017. This report summarizes the results of the test program and test methods used in accordance with the Mostardi Platt Protocol M170605 Rev. 2 dated February 2, 2017. Mostardi Platt is a self-certified air emissions testing body (AETB). A copy of Mostardi Platt's self-certification can be found in Appendix A.

The test location, test dates, and test parameters are summarized below.

TEST INFORMATION		
Test Location	**Test Dates**	**Test Parameters**
Unit 2 Outlet Duct	February 20, 2017	Carbon Dioxide (CO_2) and Nitrogen Oxides (NO_x)

The purpose of the test program was to demonstrate the relative accuracies of the Unit 2 Outlet Duct CO_2 and NO_x analyzers during the specified operating conditions. The test results from this test program indicate that each CEMS component meets the United States Environmental Protection Agency (USEPA) annual performance specification for relative accuracy as published in 40 Code of Federal Regulations Part 75 (40CFR75).

RATA RESULTS						
Test Location	**Date**	**Parameter**	**Units**	**Relative Accuracy Acceptance Criteria**	**Relative Accuracy (RA)**	**Bias Adjustment Factor (BAF)**
Unit 2 Outlet Duct	2/20/17	NO_x	lb/mmBtu	≤ 7.5 % of the mean reference value	0.62%	1.000
		CO_2	% wet	≤ 7.5 % of the mean reference value	6.23%	N/A

The gas cylinders used to perform the RATA are summarized below.

GAS CYLINDER INFORMATION				
Parameter	**Gas Vendor**	**Cylinder Serial Number**	**Cylinder Value**	**Expiration Date**
NO_x	Airgas	CC135830	0.0 ppm	9/21/2024
NO_x	Airgas	CC490411	92.92 ppm	10/31/2024
NO_x	Airgas	CC417164	181.0 ppm	10/21/2024
CO_2	Airgas	CC490411	0.00 %	10/31/2024
CO_2	Airgas	CC135830	10.20 %	9/21/2024
CO_2	Airgas	EB0075821	19.70 %	2/1/2024

No deviations, additions, or exclusions from the site specific test plan, test methods, the Mostardi Platt Quality Manual, or the ASTM D7036-12 occurred. The specific test conditions encountered did not interfere with the collection of the data.

The identifications of the individuals associated with the test program are summarized below.

TEST PERSONNEL INFORMATION		
Location	**Address**	**Contact**
Test Facility	Michigan State University 354 Service Rd East Lansing, MI 48824	Mr. Rick Johnson Electrical Engineer (517) 884-7108 (phone) rjohnson@ipf.msu.edu
Testing Company Supervisor	Mostardi Platt 888 Industrial Drive Elmhurst, Illinois 60126	Mr. Stuart L. Burton Senior Project Manager 630-993-2100 (phone) sburton@mp-mail.com QI Group V (certified on 2/1/13)
Testing Company Personnel		Mr. David Dixon Test Technician

Copies of the QI certifications for test personnel are included in Appendix B.

2.0 TEST METHODOLOGY

Emission testing was conducted following the United States Environmental Protection Agency (USEPA) methods specified in 40CFR75, 40 Code of Federal Regulations (40CFR60) Appendix A, and ASTM E337-02 in addition to the Mostardi Platt Quality Manual and the Mostardi Platt test protocol. Schematics of the test section diagrams and sampling trains used are included in Appendix C and D respectively. Calculation and nomenclature are included in Appendix E. Copies of analyzer print-outs for each test run are included in Appendix F. CEM data and process data as provided by Michigan State University are included in Appendix G.

The following methodologies were used during the test program:

Method 3A Carbon Dioxide (CO_2) Determination

Stack gas CO_2 concentrations were determined in accordance with USEPA Method 3A, 40CFR60, Appendix A. A Thermo Scientific Model 41C Gas Filter Correlation Carbon Dioxide Analyzer was used to determine carbon dioxide concentrations in the manner specified in the Method. The instrument has a nondispersive infrared-based detector and operated in the nominal range of 0% to 20% with the specific range determined by the high-level span calibration gas of 19.70%.

The Model 41C High Level is based on the principle that CO_2 absorbs infrared radiation. Because infrared absorption is a non-linear measurement technique, it is necessary for the instrument electronics to transform the basic analyzer signal into a linear output. The analyzer uses an exact calibration curve to accurately linearize the instrument output over any range up to a concentration of 2000 ppm.

The sample is drawn into the analyzer through the sample bulkhead. The sample flows through the optical bench. Radiation from an infrared source is chopped and then passed through a gas filter alternating between CO_2 and N_2. The radiation then passes through a narrow bandpass interference filter and enters the optical bench where absorption by the sample gas occurs. The infrared radiation then exits the optical bench and falls on an infrared detector.

The CO_2 side of the filter wheel acts to produce a reference beam which cannot be further attenuated by CO_2 in the sample cell. The N_2 side of the filter wheel is transparent to the infrared radiation and therefore produces a measure beam which can be absorbed by CO_2 in the cell. The rotating gas filter wheel causes the detector signal to be modulated. The amplitude of the detector signal is directly proportional to the concentration of CO_2 in the sample cell. Gases other than CO_2 do not cause modulation of the detector signal since they absorb the reference and measure beams equally. Thus the GFC system responds specifically to CO_2. The Model 41C High Level outputs the CO_2 concentration to the front panel display and the analog outputs.

Stack gas was delivered to the analyzer through an EPM in-situ dilution sampling system. Stack gas concentrations were diluted at a nominal 100:1 ratio utilizing purified dilution air. The entire system was calibrated in accordance with the Method, using USEPA Protocol gases introduced at the probe, before and after each test run.

A list of calibration gases used and the results of all calibration and other required quality assurance checks are found in Appendix H. Copies of the gas cylinder certifications are found in Appendix I. This testing met the performance specifications as outlined in the Method.

Method 7E Nitrogen Oxides (NO_x) Determination

Stack gas NO_x concentrations and emission rates were determined in accordance with USEPA Method 7E, 40CFR60, Appendix A. A Thermo Scientific Model 42i Chemiluminescence Nitrogen Oxides Analyzer was used to determine nitrogen oxides concentrations, in the manner specified in the Method. The instrument operated in the nominal range of 0 ppm to 200 ppm with the specific range determined by the high-level span calibration gas of 181.0 ppm.

The Model 42i operates on the principle that nitric oxide (NO) and ozone (O_3) react to produce a characteristic luminescence with an intensity linearly proportional to the NO concentration. Infrared light emission results when electronically excited NO_2 molecules decay to lower energy states. Specifically,

$$NO+O_3 \rightarrow NO_2+O_2+hv$$

Nitrogen dioxide (NO_2) must first be transformed into NO before it can be measured using the chemiluminescent reaction. NO_2 is converted to NO by a molybdenum NO_2-to-NO converter heated to about 339 °C. The flue gas sample is drawn into the Model 42*i* through the sample bulkhead. The sample flows through a capillary, and then to the mode solenoid valve. The solenoid valve routes the sample either straight to the reaction chamber (NO mode) or through the NO_2-to-NO converter and then to the reaction chamber (NO_x mode). A flow sensor prior to the reaction chamber measures the sample flow. Dry air enters the Model 42*i* through the dry air bulkhead, passes through a flow switch, and then through a silent discharge ozonator. The ozonator generates the ozone needed for the chemiluminescent reaction. At the reaction chamber, the ozone reacts with the NO in the sample to produce excited NO_2 molecules. A photomultiplier tube (PMT) housed in a thermoelectric cooler detects the luminescence

generated during this reaction. From the reaction chamber, the exhaust travels through the ozone (O_3) converter to the pump, and is released through the vent.

The NO and NO_x concentrations calculated in the NO and NO_x modes are stored in memory. The difference between the concentrations is used to calculate the NO_2 concentration. The Model 42i outputs NO, NO_2, and NO_x concentrations to the front panel display, the analog outputs, and also makes the data available over the serial or ethernet connection.

Stack gas was delivered to the analyzer through an EPM in-situ dilution sampling system. Stack gas concentrations were diluted at a nominal 100:1 ratio utilizing purified dilution air. The entire system was calibrated in accordance with the Method, using USEPA Protocol gases introduced at the probe, before and after each test run.

A list of calibration gases used and the results of all calibration and other required quality assurance checks are found in Appendix H. Copies of the gas cylinder certifications are found in Appendix I. The NO_2 to NO converter test can be found in Appendix J. This testing met the performance specifications as outlined in the Method.

3.0 TEST RESULT SUMMARIES

Client: Michigan State University
Facility: T.B. Simon Power Plant
Project #: M170605
Fuel Type: Natural Gas

Location: Unit 2 Outlet Duct Mid Load
Date: 2/20/17
Test Method: 7E, 3A
Fuel Factor: 1040

NO_x lb/mmBtu RATA

CEM Monitor Information

NO_x Monitor/Model:	TEI 42C	**NO_x Serial # :**	75777-380
CO_2 Monitor/Model:	TEI 41CHL	**CO_2 Serial # :**	5682380

1=accept 0=reject	Test Run	KPPH	Test Date	Start Time	End Time	RM NO_x lb/mmBtu	CEM NO_x lb/mmBtu	(RM-CEM) Difference (di)	(RM-CEM) Difference^2 (di^2)
0	1	159.0	02/20/17	12:12	12:32	0.124	0.121	0.003	0.000
0	2	158.7	02/20/17	12:42	13:02	0.123	0.121	0.002	0.000
1	3	158.4	02/20/17	13:14	13:34	0.122	0.121	0.001	0.000
1	4	158.5	02/20/17	13:46	14:06	0.121	0.121	0.000	0.000
1	5	158.0	02/20/17	14:18	14:38	0.122	0.122	0.000	0.000
1	6	157.9	02/20/17	14:50	15:10	0.122	0.121	0.001	0.000
1	7	157.7	02/20/17	15:26	15:46	0.122	0.121	0.001	0.000
1	8	158.3	02/20/17	16:00	16:20	0.122	0.121	0.001	0.000
1	9	158.6	02/20/17	16:34	16:54	0.120	0.121	-0.001	0.000
1	10	158.6	02/20/17	17:10	17:30	0.120	0.121	-0.001	0.000
1	11	159.1	02/20/17	17:43	18:03	0.121	0.121	0.000	0.000
1	12	159.2	02/20/17	18:15	18:35	0.119	0.121	-0.002	0.000

n	**10**	
t(0.025)	**2.262**	
Mean Reference Method Value	**0.121**	**RM avg**
Mean CEM Value	**0.121**	**CEM avg**
Sum of Differences	**0.000**	**di**
Mean Difference	**0.000**	**d**
Sum of Differences Squared	**0.000**	**di^2**
Standard Deviation	**0.001**	**sd**
Confidence Coefficient 2.5% Error (1-tail)	**0.001**	**cc**
Relative Accuracy	**0.62**	**RA**
Bias Adjustment Factor	**1.000**	**BAF**

Client: Michigan State University
Facility: T.B. Simon Power Plant
Project #: M170605

Location: Unit 2 Outlet Duct Mid Load
Date: 2/20/17
Test Method: 3A

CO_2 % (wet) RATA

CEM Monitor Information

CO2 Monitor/Model:				TEI 41CHL		CO2 Serial # :		5682380	
1=accept 0=reject	Test Run	KPPH	Test Date	Start Time	End Time	RM CO_2 % (wet)	CEM CO_2 % (wet)	(RM-CEM) Difference (di)	(RM-CEM) Difference^2 (di^2)
1	1	159.0	02/20/17	12:12	12:32	7.3	6.9	0.4	0.16
1	2	158.7	02/20/17	12:42	13:02	7.3	6.9	0.4	0.16
1	3	158.4	02/20/17	13:14	13:34	7.3	6.9	0.4	0.16
1	4	158.5	02/20/17	13:46	14:06	7.3	6.9	0.4	0.16
1	5	158.0	02/20/17	14:18	14:38	7.3	6.9	0.4	0.16
1	6	157.9	02/20/17	14:50	15:10	7.3	6.9	0.4	0.16
1	7	157.7	02/20/17	15:26	15:46	7.3	6.9	0.4	0.16
0	8	158.3	02/20/17	16:00	16:20	7.3	6.8	0.5	0.25
1	9	158.6	02/20/17	16:34	16:54	7.4	6.9	0.5	0.25
0	10	158.6	02/20/17	17:10	17:30	7.4	6.8	0.6	0.36
1	11	159.1	02/20/17	17:43	18:03	7.4	6.9	0.5	0.25
0	12	159.2	02/20/17	18:15	18:35	7.4	6.8	0.6	0.36

1	9	
t(0.025)	2.306	
Mean Reference Method Value	7.322	RM avg
Mean CEM Value	6.900	CEM avg
Sum of Differences	3.800	di
Mean Difference	0.422	d
Sum of Differences Squared	1.620	di^2
Standard Deviation	0.044	sd
Confidence Coefficient 2.5% Error (1-tail)	0.034	cc
Relative Accuracy	6.23	RA

4.0 CERTIFICATION

MOSTARDI PLATT is pleased to have been of service to Michigan State University. If you have any questions regarding this test report, please do not hesitate to contact us at 630-993-2100.

CERTIFICATION

As the program manager, I hereby certify that this test report represents a true and accurate summary of emissions test results and the methodologies employed to obtain those results. The test program was performed in accordance with the test protocol, test methods, the Mostardi Platt Quality Manual, and the ASTM D7036-12, as applicable.

MOSTARDI PLATT

Program Manager

Stuart L. Burton

Quality Assurance

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