

Relative Accuracy Test Audit Test Report

Michigan State University T.B. Simon Power Plant Unit 1 Outlet Duct East Lansing, Michigan February 21, 2017

Report Submittal Date April 26, 2017

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Project No. M170605A

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

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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 1 Outlet Duct on February 21, 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 1 Outlet Duct	February 21, 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 1 Outlet Duct CO_2 , NO_x , and volumetric flow 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 1 Outlet Duct	2/21/17	NOx	lb/mmBtu	≤ 7.5 % of the mean reference value	1.91%	1.013				
		CO ₂	% wet	≤ 7.5 % of the mean reference value	2.63%	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			
NOx	Airgas	CC135830	0.0 ppm	9/21/2024			
NOx	Airgas	CC490411	92.92 ppm	10/31/2024			
NOx	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 test protocol, 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.

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

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

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 and 40 Code of Federal Regulations (40CFR60) Appendix A, in addition to the Mostardi Platt Quality Manual and the Mostardi Platt test protocol. Schematics of the test section diagram 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 (CO₂) 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 NO₂ molecules decay to lower energy states. Specifically,

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

Nitrogen dioxide (NO₂) must first be transformed into NO before it can be measured using the chemiluminescent reaction. NO₂ is converted to NO by a molybdenum NO₂-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 NO₂-to-NO converter and then to the reaction chamber (NO 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 NO₂ 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 NO₂ concentration. The Model 42i outputs NO, NO₂, 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					Location: Unit 1 Outlet Duct Mid Load					
Facility: T.B. Simon Power Plant				Date: 2/21/17						
Project #: M170605			Test Method: 7E, 3A							
Fuel Type: Natural Gas			Fuel Factor: 1040							
NO, Ib/mmBtu RATA						u RATA				
CEM Monitor Information										
NO _x Monitor/Model:			TEI	TEI 42C NO _x Serial # :		75776-381				
	C	O₂ Moni	tor/Model:	TEI 41CHL			CO ₂ Serial # :	75681-680		
							[(RM-CEM)	(RM-CEM)	
1=accept	Test	КРРН	Test Date	Start Time	End Time	RM NO _x	CEM NO _x	Difference	Difference ²	
0=reject	Run					lb/mmBtu	lb/mmBtu	(di)	(di ²)	
0	1	159.9	02/21/17	15:00	15.20	0 147	0.143	0.004	0.000	
1	2	160.0	02/21/17	15:34	15:54	0.145	0.143	0.007	0.000	
1	3	159.9	02/21/17	16:05	16:25	0.142	0.143	-0.002	0.000	
1	4	159.9	02/21/17	16:39	16:59	0.144	0.142	0.002	0.000	
1	5	159.3	02/21/17	17:10	17:30	0.145	0.143	0.002	0.000	
1	6	159.5	02/21/17	17:43	18:03	0.146	0.144	0.002	0.000	
1	7	160.1	02/21/17	18:14	18:34	0.146	0.144	0.002	0.000	
1	8	160.1	02/21/17	18:46	19:06	0.148	0.145	0.003	0.000	
1	9	160.4	02/21/17	19:17	19:37	0.148	0.145	0.003	0.000	
0	10	160.3	02/21/17	19:49	20:09	0.148	0.145	0.003	0.000	
1	11	160.8	02/21/17	20:21	20:41	0.147	0.145	0.002	0.000	
0	12	160.3	02/21/17	20:52	21:12	0.148	0.145	0.003	0.000	
					n	9				
					t(0.025)	2.3	06			
			Mean F	Reference M	ethod Value	0.146		RM avg		
				Mean	CEM Value	0.144		CEM avg		
Sum of Differences					0.0	0.017 di				
Mean Difference					0.002		d			
Sum of Differences Squared					0.000 di ²					
Standard Deviation					0.001 sd		sd	1		
Confidence Coefficient 2.5% Error (1-tail)					0.0					
					1.	1.91 KA				
Bias Adjustment Factor					1.0	713	DAF			

Client: Michigan State University Facility: T.B. Simon Power Plant					Location: Unit 1 Outlet Duct Mid Load Date: 2/21/17				
Project #: M170605						Test Method: 3A			
CO ₂ % (wet) RATA									
CEM Monitor Information									
CO2 Monitor/Model: TEI 41CHL					1CHL	CO2 Serial # : 75681-680			1-680
1=accept	Test		Test	Ctaut Time	End Time	RM CO ₂ %	CEM CO ₂ %	(RM-CEM)	(RM-CEM)
0=reject	Run	лгрп	Date	Start Time	Ena rime	(wet)	(wet)	(di)	(dí ²)
0	1	159.9	02/21/17	15:00	15:20	7.5	7.4	0.1	0.01
0	2	160.0	02/21/17	15:34	15:54	7.5	7.4	0.1	0.01
1	3	159.9	02/21/17	16:05	16:25	7.6	7.4	0.2	0.04
1	4	159.9	02/21/17	16:39	16:59	7.6	7.4	0.2	0.04
0	5	159.3	02/21/17	17:10	17:30	7.6	7.3	0.3	0.09
1	6	159.5	02/21/17	17:43	18:03	7.6	7.4	0.2	0.04
1	7	160.1	02/21/17	18:14	18:34	7.6	7.4	0.2	0.04
1	8	160.1	02/21/17	18:46	19:06	7.6	7.4	0.2	0.04
1	9	160.4	02/21/17	1 9 :17	19:37	7.6	7.4	0.2	0.04
1	10	160.3	02/21/17	19:49	20:09	7.6	7.4	0.2	0.04
1	11	160.8	02/21/17	20:21	20:41	7.6	7.4	0.2	0.04
1	12	160.3	02/21/17	20:52	21:12	7.6	7.4	0.2	0.04
					n)		
					t(0.025)	2.3	06		
			Mean F	Reference M	ethod Value	7.600		RM avg	
				Mean	CEM Value	7.400		CEM avg	
Sum of Differences					1.800		dí		
Mean Difference					0.200		d		
			Sum	of Difference	es Squared	0.3	0.360 di ²		
Standard Deviation					0.000 sd				
Confidence Coefficient 2.5% Error (1-tail)					0.0	0.000 cc			
	Relative Accuracy						63	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

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Quality Assurance