SOURCE TEST REPORT
2nd QUARTER 2019 RAA TESTING
GENERAL MOTORS
TECH CENTER
BOILERS 1, 2, AND 3
WARREN, MICHIGAN

Prepared For:

General Motors
30001 Van Dyke Road
Warren, MI 48093

For Submittal To:

Michigan Department of Environment, Great Lakes, and Energy
South East Michigan District Office
27700 Donald Court
Warren, MI 48092

Prepared By:

Montrose Air Quality Services, LLC
4949 Fernlee Avenue
Royal Oak, MI 48073

Document Number: **049AS-569030-RT-94**
Test Dates: **June 28, 2019 and July 22, 2019**
Submittal Date: **July ~~29~~ 29, 2019**

STAC STACK TESTING ACCREDITATION COUNCIL
A2LA ACCREDITED TO ASTM D7036 ONLY CERT #3925.01

MONTROSE AIR QUALITY SERVICES

TABLE OF CONTENTS

TABLES

FIGURES

APPENDICES

Executive Summary

Montrose Air Quality Services (MAQS) was retained by General Motors to conduct a Relative Accuracy Audit (RAA) of the nitrogen oxides (NOx) Predictive Emissions Monitoring Systems (PEMS) serving boilers 1, 2, and 3 at the General Motors Tech Center facility located in Warren, Michigan. The boilers fire natural gas and are designated EUBOILER1, EUBOILER2, and EUBOILER3. The RAA testing on EUBOILER2 and EUBOILER3 was conducted on June 28, 2019 and the testing on EUBOILER 1 was done on July 22, 2019.

The RAA testing was conducted to satisfy the requirements of Performance Specification 16 (PS-16, *"Specifications and Test Procedures for Predictive Emission Monitoring Systems in Stationary Sources"*) codified at Title 40, Part 60, Appendix B of the Code of Federal Regulations. Testing of each boiler consisted of three, 30-minute test runs at normal load conditions while combusting pipeline natural gas.

The results of the RAA test program are summarized in the following Executive Summary Table E-1.

Table E-1
Summary of GM Tech Center Boilers Warren, Michigan
NOx lb/MMBtu PEMS RAA Results
Test Date: June 28, 2019, July 22, 2019

Source Name	RM NOx lb/MMBtu	PEMS NOx lb/MMBtu	% Relative Accuracy Audit	40 CFR Part 60 % Relative Accuracy Limit
EUBOILER1	0.031	0.032	1.1	20
EUBOILER2	0.029	0.031	5.4	20
EUBOILER3	0.041	0.042	2.9	20

1.0 Introduction

Montrose Air Quality Services (MAQS) was retained by General Motors to conduct a Relative Accuracy Audit (RAA) of the nitrogen oxides (NOx) Predictive Emissions Monitoring Systems (PEMS) serving boilers 1, 2, and 3 at the General Motors Tech Center facility located in Warren, Michigan. The boilers fire natural gas and are designated EUBOILER1, EUBOILER2, and EUBOILER3.

The testing was performed to demonstrate compliance with the Michigan Department of Environmental Quality (MDEQ) Permit No. MI-PTIB4049-102-16 and in accordance with Appendix A, 40 CFR, Part 60, subpart Db, U.S. EPA Reference Methods 3A and 7E found in 40 CFR, Part 60, Appendix A and Performance Specifications (PS) 2, 3 and 16 specified by 40 CFR, Part 60, Appendix B. The testing of the boilers consisted of three, 30-minute test runs while combusting pipeline NG. The test runs were performed to be in accordance with Performance Specification 16 "Specifications and Test Procedures for Predictive Emission Monitoring Systems in Stationary Sources".

The RAA testing on EUBOILER2 and EUBOILER3 was conducted on June 28, 2019 and the testing on EUBOILER1 was conducted on July 22, 2019. EUBOILER1 was done on a later date due to a faulty oxygen sensor on the boiler on June 28, 2019. Mr. Mason Sakshaug and Mr. Josh Boulianne with MAQS performed the testing. Lisa Parks, Marianne Secrest, and Scott Cahoon of GM assisted the study by coordinating process test times and gathering PEMS data.

2.0 Process Description

Boilers 1-3 generate steam for use by the WTC operations. The new boiler is rated for a maximum heat input capacity of 108 MMBtu/hr and is equipped with low-NOx burners and flue gas recirculation for NOx emissions control. Boiler process data includes steam generation and NG fuel flow. The Boiler process data can be found in Appendix B

2.1 Predictive Emissions Monitoring System (PEMS) Description

The SmartCEMS®-60 Predictive Emission Monitoring System (PEMS) provides continuous data recording and report generation for compliance with 40 CFR Part 60 regulations under PS-16. SmartCEMS is the statistical hybrid PEMS engine, configured with a formulaic model for parametric applications using site specific data for continuous monitoring application under 40 CFR Part 60. CMC Solutions also provides the site with Data eLements, for continuous data recording and report generation for compliance with 40 CFR regulations. The data acquisition system provides a secure and reliable means of collecting and retrieving compliance data.

SmartCEMS with Data eLements operates on a server class computer with a standard interface to the relational database. The application itself consists of two independent databases and three configurable application modules along with associated services and toolset. The first database is secured and contains only data (both raw collected data that is not editable and historical data formatted as specified by the applicable regulations) as well as a compliance message archive with operator comments. The second database contains compliance reporting data including collections statuses, summarized and calculated fields, and formatted components for electronic reporting.

The first application is the data acquisition module that runs on startup of the system and collects the data continuously providing compliance emissions data for reporting purposes. There are two other independent SmartCEMS components that work with the data acquisition service. The second application provides the operator interface for display of real-time data, display and acknowledgement of compliance alarms, and input of operator data including gas sampling results and certification test results. The third application provides the reporting and aggregate emission data with electronic data report generation capacities. These applications support the operator interface and can be run from any workstation on the local area network providing information on the compliance status of the units in real-time.

Data eLements provides a compliance and process database that is secure and includes standard and customized reporting with a rich set of visualization tools. The user can create custom visualization components know as Data eLements (dashboards with components) that display process or emission data in tabular, 2D, 3D, and raw or filtered data reports - all customizable by the end user. A group of Data eLements can be gathered together, named, and saved for future reference. All of these components and groups are collectively known as the Data eLements. Common Data eLements can be created by engineers in model build and by operators for visualization of the critical parameters both on the process side for safety and optimization and on the emission side for compliance. Both real-time and historical data averaged over one minute, 15 minute, or hour intervals and complete unit emission profiles can be visualized with Data eLements to improve understanding of the process and reduce excess emission events.

3.0 Sampling and Analytical Methodologies

Sampling and analytical methodologies are summarized in Sections 3.1 through 3.3. A Schematic drawing of MAQS's continuous emissions monitoring system is presented as Figure 1.

3.1 Continuous Emissions Monitoring

Measurement of exhaust gas concentrations was conducted utilizing the following reference test methods and performance specifications codified at 40 CFR 60, Appendices A and B:

- Method 3A- Determinations of Oxygen and Carbon Dioxide Concentrations in Emissions From Stationary Sources;
- Method 7E - Determination of Nitrogen Oxides Emissions from Stationary Sources;
- Performance Specification 2 – Specifications and Test Procedures for SO_2 and NO_x Continuous Emission Monitoring Systems in Stationary Sources;
- Performance Specification 3 – Specifications and Test Procedures for O_2 and CO_2 Continuous Emission Monitoring Systems in Stationary Sources;
- Performance Specification 16 – For Predictive Emissions Monitoring Systems and Amendments to Testing and Monitoring Provisions;

MAQS's extractive monitors require that the effluent gas sample be conditioned to eliminate any possible interference (i.e., water vapor and/or particulate matter) before being transported and injected into each analyzer. All components of the sampling system that contact the sample were constructed of Type 316 stainless-steel, Pyrex glass or Teflon®. The output signal from each monitor was recorded at 4-second intervals on a PC equipped with data acquisition software. The samples were extracted from the stack using a stainless-steel probe assembly, heated sample line, stack gas conditioner with a Teflon diaphragm pump and routed through a distribution manifold for delivery to the analyzers. The configuration of the sampling system allowed for the injection of calibration gases directly to the analyzers or through the sampling system. All monitors in use were calibrated with U.S. EPA Protocol No. 1 calibration gases and operated to ensure that zero drift, calibration gas drift, and calibration error met the specified method requirements. Copies of the Protocol gas certificates can be found in Appendix C.

The sample gas was extracted at three points through a stainless-steel probe positioned at approximately 16.7%, 50% and 83.3% of the sample stream diameter as described by 40 CFR Part 60, Appendix B Performance Specification 2 Section 8.1.3.2. Three 30-minute test runs were conducted on the PEM system. A diagram of the reference monitoring system is illustrated in Figure 1.

The boiler NO_X concentrations were measured in parts per million (ppm), converted to an emission rate and reported as Lb/MMBtu, using equation 19-1 of U.S. EPA Method 19 of Appendix A, 40 CFR 60. Oxygen concentrations are reported in percent (%).

3.2 Oxygen (USEPA Method 3A)

A M&C non-dispersive infra-red (NDIR) analyzer was used to measure O_2 concentrations following the guidelines of U.S. EPA Method 3A, "Determination of Oxygen and Carbon Dioxide Concentrations in Emissions from a Stationary Source (Instrumental Analyzer Procedure)", in conjunction with Performance Specification No. 2 of Appendix B, 40 CFR 60. The analyzer was set at 25% instrument span and calibrated before the RAA with zero nitrogen and high range USEPA Protocol 1 span gas (80 to 100% of span). Following calibration, a mid range USEPA Protocol 1 gas (40 to 60% of span) was introduced. The response error did not exceed 2% of the instrument span, as required by the method. Calibration error results are presented in Appendix A. Calibration drift checks were performed at the completion of each test run.

3.3 Nitrogen Oxides (USEPA Method 7E)

A Teledyne T200H Chemiluminescence analyzer was used to measure parts per million of nitrogen oxides in the dry sample gas following the guidelines of U.S. EPA Method 7E, "Determination of Nitrogen Oxides from Stationary Sources (Instrumental Analyzer Procedure)", in conjunction with Performance Specification No. 2 of Appendix B, 40 CFR 60. The analyzer measures the concentration of NO_x by converting NO_x to NO and then measuring the light emitted by the reaction of NO with ozone. The NO_x analyzer was set at 0-100 ppm instrument span during the RAA. The NO_x sampling system was calibrated at three points: zero, mid range (40-60% of span), and high range (80-100% of span) with USEPA Protocol 1 calibration gases. MAQS conducted a NO_2 to NO conversion efficiency tests, as specified in U.S. EPA Method 7E on the analyzer. The results of the NO_2 to NO conversion efficiency test can be found on the enclosed compact disc.

4.0 Test Results

The PEMS associated with the boilers tested at the GM Tech Center in Warren, Michigan passed the Relative Accuracy Audit. The results of all testing are presented in Tables 1-3.

The following information is appended:

A MAQS Calibration Error and Drift Correction Data
B GM Tech Center PEMS RAA Data
C MAQS Field Data and Span Gas Certification Documentation
D Compact Disc with all MAQS CEMS Data Files

Quality Statement

Montrose is qualified to conduct this test program and has established a quality management system that led to accreditation with ASTM Standard D-7036 (Standard Practice for Competence of Air Emission Testing Bodies). Montrose completed multiple functional assessments for ASTM D7036-04 which were conducted by the American Association for Laboratory Accreditation (A2LA). All testing is overseen and supervised on site by at least one Qualified Individual (QI), as defined in 40 CFR 72.2.

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 General Motors. MAQS will not distribute or publish this report without General Motors' consent except as required by law or court order. MAQS 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: _____
Mason Sakshaug
Field Project Manager

This report was reviewed by: _____
Steven Smith
Client Project Manager

Tables

Table 1
Boiler 1 PEMS RAA Results Summary
GM Tech Center
Warren, Michigan
Test Date: July 22, 2019

Test Run	RM NOx Concentration (ppmv)	PEMS NOx Concentration (ppmv)	RM O_2 Concentration (%)	PEMS O_2 Concentration (%)	RM NOx Emission Rate (lbs/MMBtu)	PEMS NOx Emission Rate (lbs/MMBtu)	Run Differences NOx Emission Rate (lbs/MMBtu)
1	22.62	23.53	4.95	4.70	0.031	0.032	-0.001
2	23.06	23.68	4.61	4.50	0.031	0.031	0.000
3	23.90	23.73	4.85	4.60	0.032	0.032	0.000
Averages:	23.19	23.65	4.81	4.60	0.031	0.032	0.000

Parameter	Relative Accuracy (RA)
NOx Emission Rate	1.1

F-Factor = 8710

40 CFR 60, Appendix B, Performance Specification 16, Equation 16-9:

$$RAA = \frac{(PEMS\ Avg. - RM\ Avg.)}{(RM\ Avg.)} \times 100$$

Table 2
Boiler 2 PEMS RAA Results Summary
GM Tech Center
Warren, Michigan
Test Date: June 28, 2019

Test Run	RM NOx Concentration (ppmv)	PEMS NOx Concentration (ppmv)	RM O_2 Concentration (%)	PEMS O_2 Concentration (%)	RM NOx Emission Rate (lbs/MMBtu)	PEMS NOx Emission Rate (lbs/MMBtu)	Run Differences NOx Emission Rate (lbs/MMBtu)
1	21.60	22.18	4.39	4.80	0.028	0.030	-0.002
2	21.71	22.35	4.91	5.00	0.030	0.031	-0.001
3	21.95	22.81	4.65	5.10	0.029	0.031	-0.002
Averages:	21.75	22.45	4.65	4.97	0.029	0.031	-0.002

Parameter	Relative Accuracy (RA)
NOx Emission Rate	5.4

F-Factor = 8710

40 CFR 60, Appendix B, Performance Specification 16, Equation 16-9:

$$RAA = \frac{(PEMS\ Avg. - RM\ Avg.)}{(RM\ Avg.)} \times 100$$

Table 3
Boiler 3 PEMS RAA Results Summary
GM Tech Center
Warren, Michigan
Test Date: June 28, 2019

Test Run	RM NOx Concentration (ppmv)	PEMS NOx Concentration (ppmv)	RM O_2 Concentration (%)	PEMS O_2 Concentration (%)	RM NOx Emission Rate (lbs/MMBtu)	PEMS NOx Emission Rate (lbs/MMBtu)	Run Differences NOx Emission Rate (lbs/MMBtu)
1	28.14	31.00	5.00	4.70	0.038	0.042	-0.004
2	30.89	30.98	4.79	4.70	0.042	0.042	0.000
3	31.38	30.98	4.80	4.70	0.042	0.042	0.000
Averages:	30.14	30.99	4.86	4.70	0.041	0.042	-0.001

Parameter	Relative Accuracy (RA)
NOx Emission Rate	2.9

F-Factor = 8710

40 CFR 60, Appendix B, Performance Specification 16, Equation 16-9:

$$RAA = \frac{(\text{PEMS Avg.} - \text{RM Avg.})}{(\text{RM Avg.})} \times 100$$

Figures

MONTROSE
AIR QUALITY SERVICES

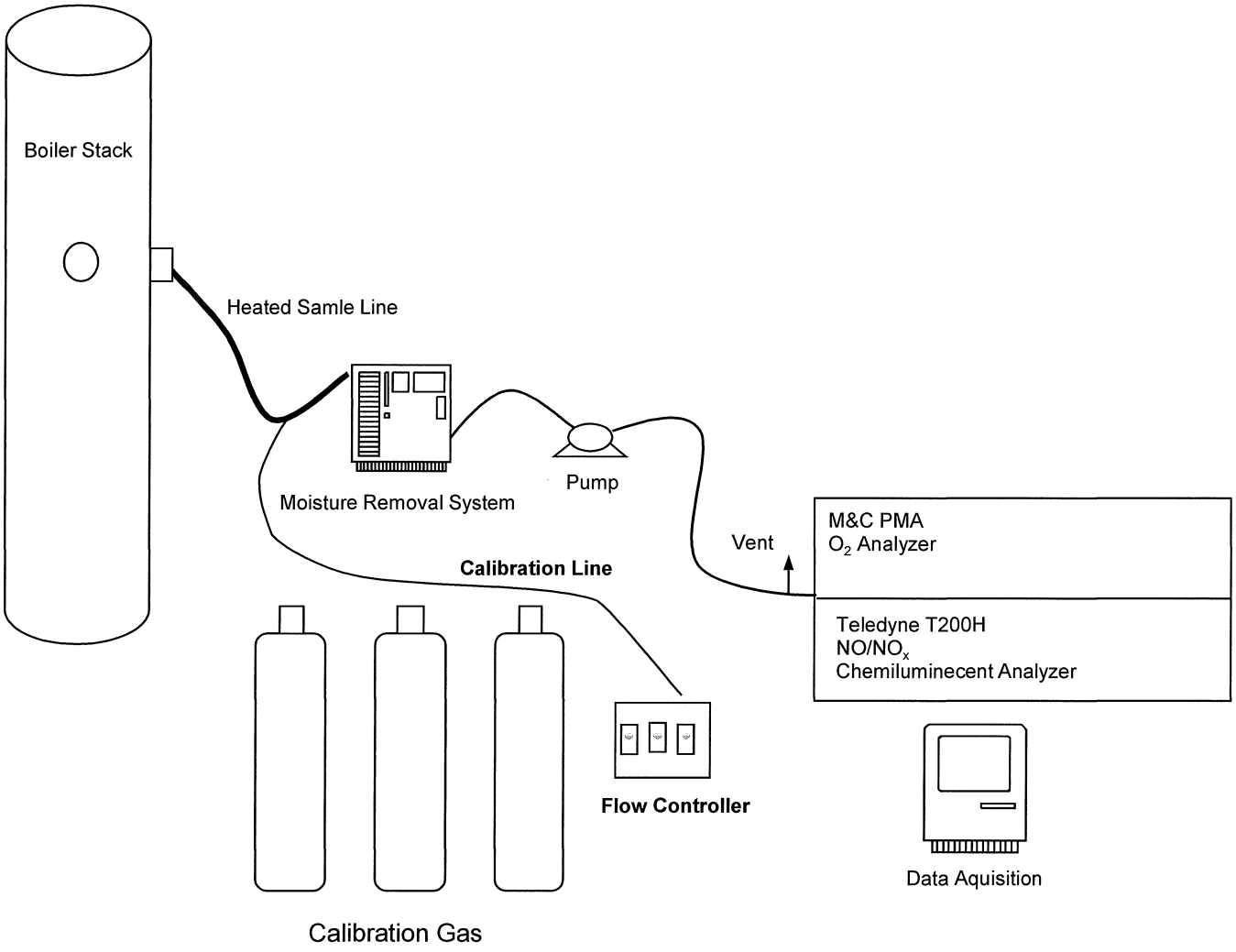
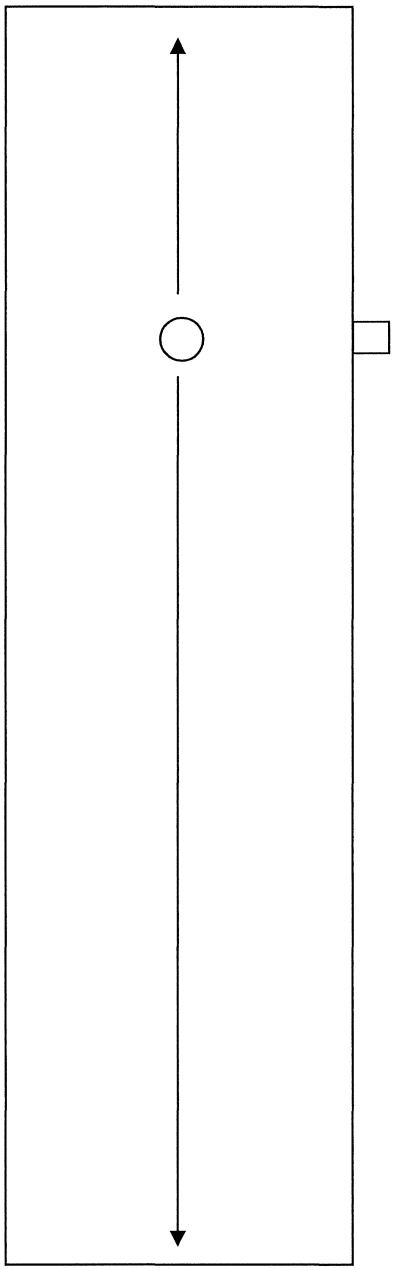


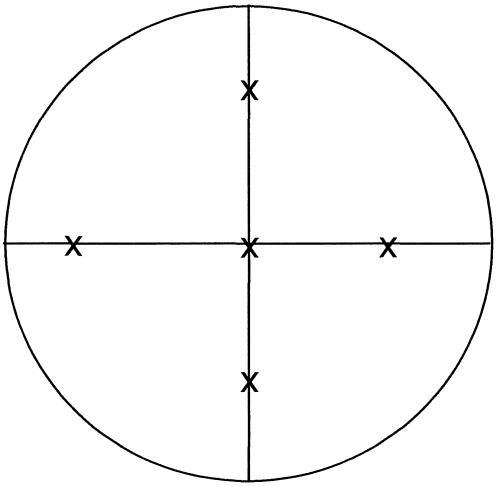
Figure No. 1

Site: **USEPA Method 3A & 7E** **Boilers 1-3** **GM Tech Center** **Warren, Michigan**	**Sampling Date:** **June 28, 2019** **July 22, 2019**	**Montrose Air Quality Services** **4949 Fernlee Avevue** **Royal Oak, MI 48073**

MONTROSE
AIR QUALITY SERVICES

diameter = 40"





Not to Scale

Points	Distance "
1	6.7
2	20.0
3	33.3

Figure No. 2

Site: **Boiler Stacks 1, 2, and 3** **GM Tech Center** **Warren, Michigan**	**Sampling Date:** **June 28, 2019** **July 22, 2019**	**Montrose Air Quality Services** **4949 Fernlee Avenue** **Royal Oak, Michigan 48073**