COMPLIANCE STACK EMISSIONS TEST REPORT

ENGINE DYNAMOMETER TEST CELL (EU-RACINGTC2)

Determination of Nitrogen Oxides Emissions

Utilizing US EPA Methods 3A, 7E, and 19

Test Date(s): June 12, 2019
Facility ID: B4302
Source Location: Pontiac, Michigan
Permit: EGLE ROP No. MI-ROP-B4032-2014e

Prepared For:

General Motors - Pontiac Engineering Center
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Prepared By:

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STAC STACK TESTING ACCREDITATION COUNCIL

ACCREDITED TO ASTM D7036 ONLY CERT #3925.01

MONTROSE AIR QUALITY SERVICES

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TEST RESULTS SUMMARY

Source Name:	**Engine Dynamometer Test Cell No. 2**
Source ID Number:	**EU-RACINGTC2**
Test Date:	**June 12, 2019**
Sampling Location:	**COMBINED EXHAUST DUCTS**
Engine Dynamometer Fuel Flow (gram/second)*	**19.81**
Combined Nitrogen Oxides Emissions (lb/hr) (as NO_2)	**4.22**
Permit Limit - Nitrogen Oxides Emissions (lb/hr) (as NO_2) †	*73.90*
Emission Results Above Permit Limit	*No*
EGLE Renewable Operating Permit No.:	**MI-ROP-B4032-2014e**

REVIEW AND CERTIFICATION

The results of the Compliance Test conducted on June 12, 2019 are a product of the application of the United States Environmental Protection Agency (US EPA) Stationary Source Sampling Methods listed in 40 CFR Part 60, Appendix A, that were in effect at the time of this test.

All work, calculations, and other activities and tasks performed and presented in this document were carried out by me or under my direction and supervision. I hereby certify that, to the best of my knowledge, Montrose operated in conformance with the requirements of the Montrose Quality Management System and ASTM D7036-04 during this test project.

Signature: [signature] Date: 7-29-19

Name: Mason Sakshaug Title: Field Project Manager

I have reviewed, technically and editorially, details, calculations, results, conclusions, and other appropriate written materials contained herein. I hereby certify that, to the best of my knowledge, the presented material is authentic, accurate, and conforms to the requirements of the Montrose Quality Management System and ASTM D7036-04.

Signature: [signature] Date: 7-29-19

Name: Randal Tysar Title: District Manager

1.0 INTRODUCTION

1.1 SUMMARY OF TEST PROGRAM

The General Motors - Pontiac Engineering Center (Facility ID: B4302), located in Pontiac, Michigan, contracted Montrose Air Quality Services, LLC (Montrose) of Detroit, Michigan, to conduct compliance stack emission testing for their Engine Dynamometer Test Cell (EU-RACINGTC2) part of flexible group FG-RACINGTCS. Testing was performed to satisfy the emissions testing requirements pursuant to Michigan Department of Environment, Great Lakes, and Energy (EGLE) Permit No. MI-ROP-B4032-2014e. The testing was performed on June 12, 2019.

Sampling was performed at the EU-RACINGTC2 Exhaust Duct A and EU-RACINGTC2 Exhaust Duct B to determine the emissions of nitrogen oxides (NO_x) (as NO_2). Testing was conducted during representative normal operations. During this test emissions from EU-RACINGTC2 were uncontrolled.

The test methods that were conducted during this test were US EPA Methods 3A, 7E, and 19.

1.2 KEY PERSONNEL

The key personnel who coordinated this test program (and their phone numbers) were:

- Jessica Alderton, Senior Environmental Project Engineer, General Motors, LLC, 586-863-8490
- Bethany Gunnels, Environmental Engineer, Pontiac Engineering Center, 248-520-2396
- Mason Sakshaug QI, Field Project Manager, Montrose, 248-548-7980

2.0 SUMMARY AND DISCUSSION OF TEST RESULTS

2.1 OBJECTIVES AND TEST MATRIX

The purpose of this test was to determine the emissions of NO_x (as NO_2) at the EU-RACINGTC2 Exhaust Duct A and EU-RACINGTC2 Exhaust Duct B during representative normal operations. Testing was performed to satisfy the emissions testing requirements pursuant to EGLE Permit No. MI-ROP-B4032-2014e. The testing was performed on June 12, 2019.

The specific test objectives for this test were as follows:

- Measure the concentration of oxygen (O_2) and NO_x at the EU-RACINGTC2 Exhaust Duct A and EU-RACINGTC2 Exhaust Duct B.
- Utilize the above variables and results from the analysis of the fuel used during the test to determine the emissions of NO_x (as NO_2) at the EU-RACINGTC2 Exhaust Duct A and EU-RACINGTC2 Exhaust Duct B during representative normal operations.

Table 2.1 presents the sampling matrix log for this test.

2.2 FIELD TEST CHANGES AND PROBLEMS

No field test changes or problems occurred during the performance of this test that would bias the accuracy of the results of this test.

2.3 PRESENTATION OF RESULTS

A single sampling train was utilized during each run at the EU-RACINGTC2 Exhaust Duct A and EU-RACINGTC2 Exhaust Duct B to determine the emissions of NO_x (as NO_2). This sampling train measured the concentrations of O_2 and NO_x.

Table 2.2 displays the combined emissions of NO_x (as NO_2) measured at the EU-RACINGTC2 Exhaust Duct A and EU-RACINGTC2 Exhaust Duct B during representative normal operations.

Table 2.3 displays the emissions of NO_x (as NO_2) measured at the EU-RACINGTC2 Exhaust Duct A and EU-RACINGTC2 Exhaust Duct B during representative normal operations.

The graphs that present the raw, uncorrected concentration data measured in the field by the US EPA Methods 3A and 7E sampling systems at the EU-RACINGTC2 Exhaust Duct are located in the Field Data section of the Appendix.

TABLE 2.1
SAMPLING MATRIX OF TEST METHODS UTILIZED

Date	Run No.	Sampling Location	US EPA METHOD 3A (O_2/CO_2) Sampling Time / Duration (min)	US EPA METHOD 7E (NO_x) Sampling Time / Duration (min)
6/12/2019	1	EU-RACINGTC2 EXHAUST DUCT A	10:18 - 10:50 / 32	10:18 - 10:50 / 32
6/12/2019	2	EU-RACINGTC2 EXHAUST DUCT A	12:19 - 12:51 / 32	12:19 - 12:51 / 32
6/12/2019	3	EU-RACINGTC2 EXHAUST DUCT A	13:45 - 14:17 / 32	13:45 - 14:17 / 32
6/12/2019	1	EU-RACINGTC2 EXHAUST DUCT B	11:01 - 11:33 / 32	11:01 - 11:33 / 32
6/12/2019	2	EU-RACINGTC2 EXHAUST DUCT B	13:00 - 13:32 / 32	13:00 - 13:32 / 32
6/12/2019	3	EU-RACINGTC2 EXHAUST DUCT B	14:58 - 15:04 / 32	14:58 - 15:04 / 32

All times are Eastern Daylight Time.

TABLE 2.2
COMBINED EMISSION RESULTS

Parameter	COMBINED EXHAUST DUCTS			
	Run 1	Run 2	Run 3	Average
Fuel Flow to Test Cell (gram/second)*	19.78	19.83	19.82	19.81
Nitrogen Oxides Emissions (lb/hr) (as NO_2)	4.15	4.27	4.23	4.22

* Process data was provided by General Motors - Pontiac Engineering Center personnel.

TABLE 2.3
EMISSION RESULTS

Parameter	EU-RACINGTC2 EXHAUST DUCT A				EU-RACINGTC2 EXHAUST DUCT B			
	Run 1	Run 2	Run 3	Average	Run 1	Run 2	Run 3	Average
Nitrogen Oxides Emissions (lb/hr) (as NO_2)	2.07	2.10	2.13	2.10	2.09	2.16	2.10	2.12
Nitrogen Oxides Concentration (ppmvd)	1,011	1,020	1,036	1,022	1,033	1,054	1,031	1,039
Percent by Volume Oxygen in Stack Gas (%-dry)	4.70	4.82	4.74	4.75	4.53	4.70	4.61	4.61

3.0 PLANT AND SAMPLING LOCATION DESCRIPTIONS

3.1 PROCESS DESCRIPTION AND OPERATION

3.1.1 Process Description

General Motors owns and operates an extensive engine testing facility for research and development of internal combustion engines using a wide variety of fuels and test protocols mandated by the United States Environmental Protection Agency (US EPA). Depending on the engine type, the engines can be fueled by unleaded gasoline, leaded gasoline, and other fuels running a variety of tests on engines and engine components. A variety of test cycles are used depending on the purpose of the test program and the type of the engine. The engines are tested with or without control equipment, such as catalytic converters and particulate traps.

3.1.2 Process Flow Diagram

Figure 3.1 schematically depicts the sampling location.

3.1.3 Type and Quantity of Raw Materials

The facility is designed to supply unleaded gasoline, leaded gasoline, ethanol, natural gas, methanol, propane, liquefied petroleum gas, and hydrogen for engine testing. The engine fuel used during the emissions test program was commercial E-20 gasoline only. The racing dynamometers are not set up to run diesel engines at this time. No catalytic converters or particulate traps were used during the emissions test program.

3.1.4 Batch Operations

The racing test cells consist of three engine dynamometer test cell stands that are used for the testing of internal combustion high performance engines for automotive motor vehicles. The engine sizes vary and the engine tested will be fueled by gasoline.

3.1.5 Process Regulation

The basic operating parameters are the fuels used, the type of engine, and the test run at a given time.

3.1.6 Process Rating

The total combined spark-ignited fuel usage for FG-RACINGTCS is limited to 3,616 MMBTU per 12-month rolling time period and of the 3,616 MMBTU, the permittee is limited to 767 MMBTU of leaded gasoline per 12-month rolling time period.

The total combined diesel fuel usage for FG-RACINGTCS is limited to 767 MMBTU per 12-month rolling time period. The racing test cells are configured to run diesel engines, but do not, and do not have plans to run diesel engines in the future. Therefore, this will not be included in this test cycle.

3.2 CONTROL EQUIPMENT DESCRIPTION

During this test, emissions from EU-RACINGTC2 were uncontrolled.

3.3 SAMPLING LOCATION

3.3.1 EU-RACINGTCS1 EXHAUST DUCT A

The EU-RACINGTC2 Exhaust Duct A had an inner diameter of approximately 4.0-inches, was oriented in the horizontal plane, and was accessed from the ground. During emissions sampling a single point, located within the central 10% of the stack cross-sectional area, was utilized for NO_x concentration determination.

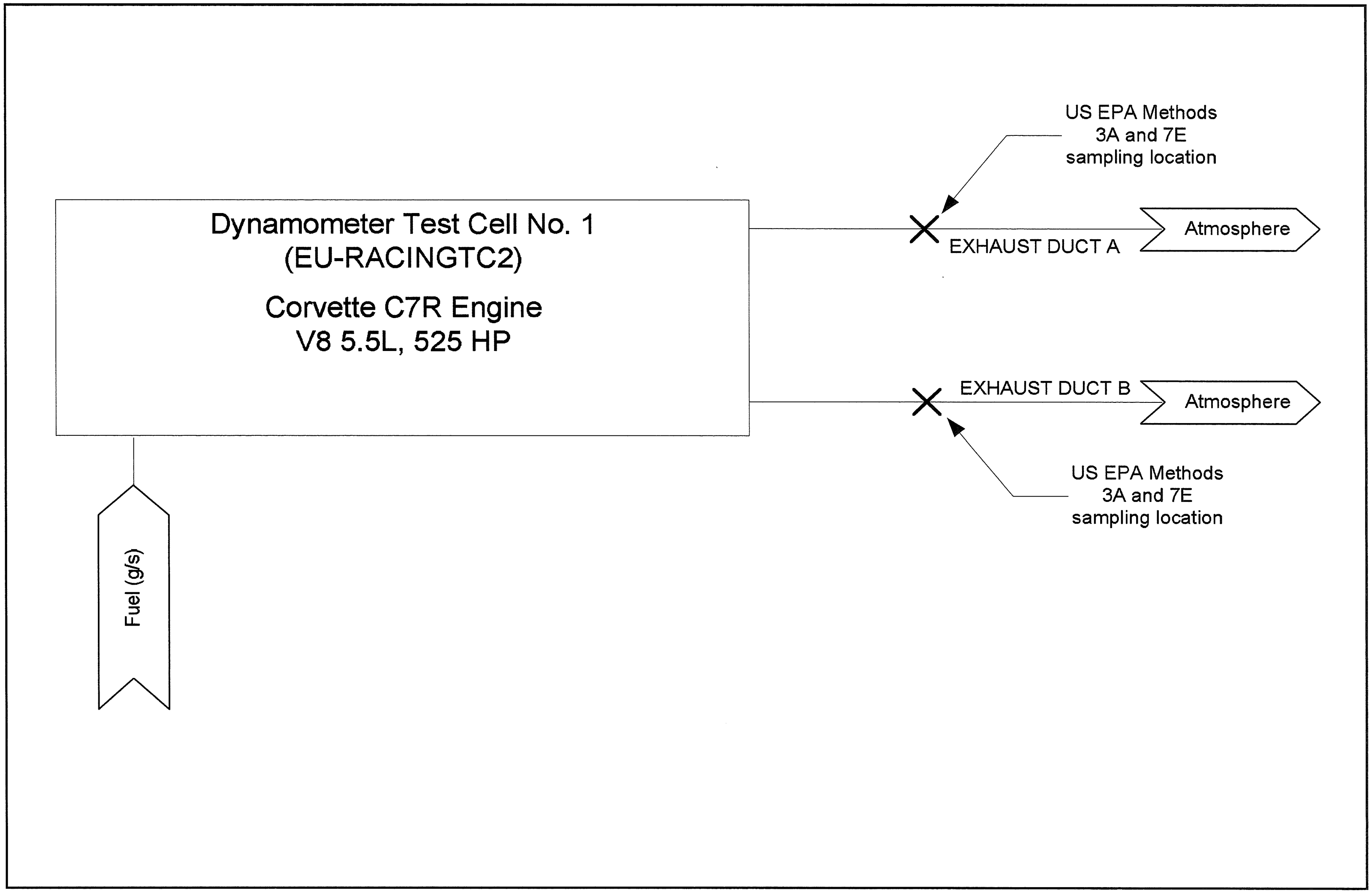
3.3.2 EU-RACINGTCS1 EXHAUST DUCT B

The EU-RACINGTC2 Exhaust Duct B had an inner diameter of approximately 4.0-inches, was oriented in the horizontal plane, and was accessed from the ground. During emissions sampling a single point, located within the central 10% of the stack cross-sectional area, was utilized for NO_x concentration determination.

3.4 PROCESS SAMPLING LOCATION(S)

Fuel samples were collected by General Motors - Pontiac Engineering Center personnel and analyzed for NO_x emissions determination.

FIGURE 3.1
EU-RACINGTC1 PROCESS AND SAMPLING LOCATION SCHEMATIC



4.0 SAMPLING AND ANALYTICAL PROCEDURES

4.1 TEST METHODS

4.1.1 US EPA Method 3A: "Determination of Oxygen and Carbon Dioxide Concentrations in Emissions from Stationary Sources (Instrumental Analyzer Procedure)"

Principle: A gas sample is continuously extracted from the effluent stream. A portion of the sample stream is conveyed to an instrumental analyzer(s) for determination of O_2 and CO_2 concentration(s). For this test, only O_2 was analyzed. Performance specifications and test procedures are provided to ensure reliable data. This method was utilized in its entirety as per the procedures outlined in 40 CFR Part 60, Appendix A.

4.1.2 US EPA Method 7E: "Determination of Nitrogen Oxides Emissions from Stationary Sources (Instrumental Analyzer Procedure)"

Principle: A gas sample is continuously extracted from the effluent stream. A portion of the sample stream is conveyed to an instrumental analyzer for the determination of NO_x concentration. NO and NO_2 may be measured separately or simultaneously. For the purposes of this method, NO_x is the sum of NO and NO_2. Performance specifications and test procedures are provided to ensure reliable data. This method was utilized in its entirety as per the procedures outlined in 40 CFR Part 60, Appendix A.

4.1.3 US EPA Method 19: "Determination of Sulfur Dioxide Removal Efficiency and Particulate Matter, Sulfur Dioxide, and Nitrogen Oxides Emission Rates"

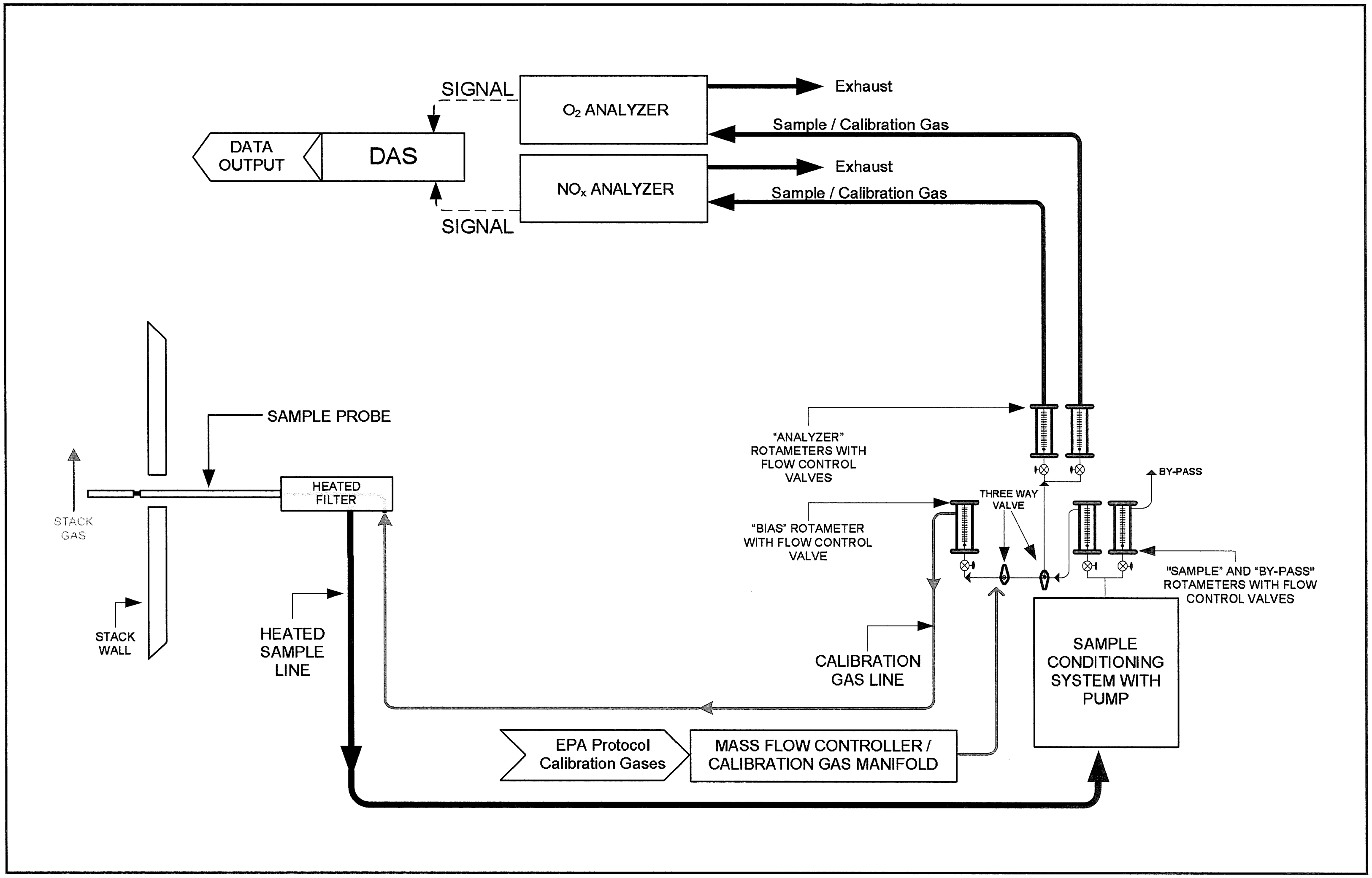
Principle: Oxygen (O_2) or carbon dioxide (CO_2) concentrations and appropriate F factors (ratios of combustion gas volumes to heat inputs) are used to calculate pollutant emission rates from pollutant concentrations. For this test, only O_2 was used to calculate pollutant emission rates.

The sampling train utilized during this testing project is depicted in Figure 4.1.

4.2 PROCEDURES FOR OBTAINING PROCESS DATA

Process data was recorded by General Motors - Pontiac Engineering Center personnel utilizing their typical record keeping procedures. Recorded process data was provided to Montrose personnel at the conclusion of this test event. The process data is displayed in Table 2.2 and located in the Appendix.

FIGURE 4.1
US EPA METHOD 3A AND 7E SAMPLING TRAIN SCHEMATIC



5.0 INTERNAL QA/QC ACTIVITIES

5.1 QA AUDITS

Tables 5.1 to 5.3 illustrate the QA audits that were performed during this test.

Tables 5.1 and 5.2 illustrate the O_2 and NO_x calibration audits which were performed during this test (and integral to performing US EPA Method 3A and 7E correctly) were all within the Measurement System Performance Specifications of ±3% of span for the Zero and Calibration Drift Checks, ±5% of span for the System Calibration Bias Checks, and ±2% of span for the Calibration Error Checks.

Table 5.3 displays the NO_2 to NO Converter Efficiency Check. The Converter Efficiency Check was conducted as per the procedures contained in US EPA Method 7E, Section 8.2.4.2 and 16.2.2 (Tedlar Bag Procedure) which requires a mid-level gas be recorded for at least 30-minutes and the final NO_x value to be within 2% of the peak NO_x value. As shown, a difference of 1.18% was achieved. Therefore, the NO_x Converter Efficiency was acceptable.

5.2 QA/QC PROBLEMS

No QA/QC problems occurred during this test event.

5.3 QUALITY STATEMENT

Montrose is qualified to conduct this test program and has established a quality management system that led to accreditation with ASTM Standard D7036-04 (Standard Practice for Competence of Air Emission Testing Bodies). Montrose participates in annual functional assessments for conformance with D7036-04 which are conducted by the American Association for Laboratory Accreditation (A2LA). All testing performed by Montrose is supervised on site by at least one Qualified Individual (QI) as defined in D7036-04 Section 8.3.2. Data quality objectives for estimating measurement uncertainty within the documented limits in the test methods are met by using approved test protocols for each project as defined in D7036-04 Sections 7.2.1 and 12.10. Additional quality assurance information is presented in the report appendices.

TABLE 5.1
US EPA METHOD 3A (O_2) ANALYZER CALIBRATION AND QA

OXYGEN ANALYZER	RUN 1	Acceptable	RUN 2	Acceptable	RUN 3	Acceptable
Analyzer Span During Test Run (%)	20.26	YES	20.26	YES	20.26	YES
Initial System Calibration Response for Zero Gas (%)	0.08	N/A	0.08	N/A	0.08	N/A
Final System Calibration Response for Zero Gas (%)	0.08	N/A	0.08	N/A	0.07	N/A
Actual Concentration of the Upscale Calibration Gas (%)	10.03	N/A	10.03	N/A	10.03	N/A
Initial System Calibration Response for Upscale Gas (%)	10.00	N/A	10.00	N/A	9.93	N/A
Final System Calibration Response for Upscale Gas (%)	9.96	N/A	9.96	N/A	9.92	N/A
Initial System Calibration Bias for Zero Gas (% of Span)	0.15	YES	0.15	YES	0.15	YES
Final System Calibration Bias for Zero Gas (% of Span)	0.15	YES	0.15	YES	0.10	YES
Initial System Calibration Bias for Upscale Gas (% of Span)	-0.35	YES	-0.54	YES	-0.69	YES
Final System Calibration Bias for Upscale Gas (% of Span)	-0.54	YES	-0.69	YES	-0.74	YES
System Drift for Zero Gas (% of Span)	0.00	YES	0.00	YES	-0.05	YES
System Drift for Upscale Gas (% of Span)	-0.20	YES	-0.20	YES	-0.05	YES
Analyzer Calibration Error for Zero Gas (% of Span)	0.25	YES	0.25	YES	0.25	YES
Analyzer Calibration Error for Mid-Level Gas (% of Span)	0.20	YES	0.20	YES	0.20	YES
Analyzer Calibration Error for High-Level Gas (% of Span)	0.05	YES	0.05	YES	0.05	YES

TABLE 5.2
US EPA METHOD 7E ANALYZER CALIBRATION AND QA

NITROGEN OXIDES ANALYZER	RUN 1	Acceptable	RUN 2	Acceptable	RUN 3	Acceptable
Analyzer Span During Test Run (ppm)	1987	YES	1987	YES	1987	YES
Initial System Calibration Response for Zero Gas (ppm)	0.41	N/A	0.41	N/A	4.42	N/A
Final System Calibration Response for Zero Gas (ppm)	4.42	N/A	4.42	N/A	2.40	N/A
Actual Concentration of the Upscale Calibration Gas (ppm)	946.0	N/A	946.0	N/A	946.0	N/A
Initial System Calibration Response for Upscale Gas (ppm)	920.1	N/A	920.1	N/A	921.9	N/A
Final System Calibration Response for Upscale Gas (ppm)	921.9	N/A	921.9	N/A	912.3	N/A
Initial System Calibration Bias for Zero Gas (% of Span)	0.00	YES	0.20	YES	0.10	YES
Final System Calibration Bias for Zero Gas (% of Span)	0.20	YES	0.10	YES	0.10	YES
Initial System Calibration Bias for Upscale Gas (% of Span)	-0.63	YES	-0.63	YES	-1.03	YES
Final System Calibration Bias for Upscale Gas (% of Span)	-0.54	YES	-1.03	YES	-0.23	YES
System Drift for Zero Gas (% of Span)	0.20	YES	-0.10	YES	0.00	YES
System Drift for Upscale Gas (% of Span)	0.09	YES	-0.48	YES	0.20	YES
Analyzer Calibration Error for Zero Gas (% of Span)	0.02	YES	0.02	YES	0.02	YES
Analyzer Calibration Error for Mid-Level Gas (% of Span)	-0.67	YES	-0.67	YES	-0.67	YES
Analyzer Calibration Error for High-Level Gas (% of Span)	0.28	YES	0.28	YES	0.28	YES

TABLE 5.3
US EPA METHOD 7E ALTERNATIVE NO_x CONVERTER CHECK

Average Analyzer Concentration (ppm NO_x)	1,406.42
Maximum Analyzer Concentration (ppm NO_{xPeak})	1,412.00
Final Analyzer Concentration (ppm NO_{xFinal})	1,395.39
Absolute Drift from NO_{xPeak} to NO_{xFinal} (%)	1.18
Acceptable per EPA Method 7E *(Acceptable if Absolute Drift ≤ 2.0%)*	Yes

Analyzer Serial Number: 0519