COMPLIANCE STACK EMISSIONS TEST REPORT

WING 3

Determination of Nitrogen Oxides Emissions

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

Test Date(s): October 29-30, 2019
State Registration Number: B4302
Source Location: Pontiac, Michigan
Permit: EGLE Permit to Install No. 198-18

Prepared For:

General Motors - Pontiac Engineering Center
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ACCREDITED
TO ASTM D7036 ONLY

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TEST RESULTS SUMMARY

Source Name	**Wing 3 Engine Dynamometer**		**Wing 3 Engine Dynamometer**
Source ID Number	**D301**		**D302**
Test Date	**October 29, 2019**		**October 30, 2019**
Sampling Location	**Exhaust Duct**		**Exhaust Duct**
Engine Dynamometer Fuel Type Utilized*	**Gasoline**		**Diesel**
Engine Dynamometer Fuel Flow (gram/second)*	0.608		1.706
Engine Dynamometer Load (MMBtu/hr)*	0.092		0.264
Nitrogen Oxides (NO_x) Emissions (lb/hr) (as NO_2) per Dynamometer†	*0.16*		*0.20*
Fd-Based Nitrogen Oxides Emissions (lb/MMBtu) (as NO_2)	*1.78*		*0.74*
Nitrogen Oxides Concentration (ppmvd)	*1,559*		*296*
Wing 3 FG-Testcells Annual Average Fuel Rate (MMBtu/hr)*	**0.15**		**0.08**
Scaled-up Wing 3 FG-Testcells NO_x Emissions (lb/hr) (as NO_2)§	**0.27**		**0.06**
Combined Wing 3 FG-Testcells NO_x Emissions (lb/hr) (as NO_2)		**0.33**	
Combined FG-Testcells Permit Limit - NO_x Emissions (lb/hr)		*24.5*	
Emission Results Below Permit Limit		*YES*	
Permit No.:	**EGLE Permit to Install No. 198-18**		

* Process data was provided by General Motors - Pontiac Engineering Center personnel during the test event.
† Example calculations are located in Appendices C.1 and C.2 of this report.
§ The scaled-up lb/hr NO_x (as NO_2) emissions for the FG-Testcell utilizing gasoline or diesel is calculated using the facility provided Annual Average Fuel Rate (lb/MMBtu) multiplied by the Engine Dynamometer Load (MMBtu/hr) as stated in the test plan.

REVIEW AND CERTIFICATION

The results of the Compliance Test conducted on October 29-30, 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: _____ Date: 12-16-19

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: _____ Date: 12-16-19

Name: Matthew Young Title: Client Project Manager

1.0 INTRODUCTION

1.1 SUMMARY OF TEST PROGRAM

The General Motors - Pontiac Engineering Center (State Registration Number: B4302), located in Pontiac, Michigan, contracted Montrose Air Quality Services, LLC (Montrose) of Detroit, Michigan, to conduct compliance stack emission testing for their FG-Testcells. Testing was performed to satisfy the emissions testing requirements pursuant to Michigan Department of Environment, Great Lakes, and Energy (EGLE) Permit to Install No.198-18, FG-Testcells, SC V.2. The testing was performed on October 29-30, 2019.

Sampling was performed at the FG-Testcell D301 Exhaust Duct to determine the emissions of nitrogen oxides (NO_x) (as NO_2) during representative normal operations while utilizing a 1.5 liter gasoline engine and gasoline as fuel. Sampling was also performed at the FG-Testcell D302 Exhaust Duct to determine the emissions of NO_x (as NO_2) during representative normal operations while utilizing a 6.6 liter engine and ultra low sulfur diesel as fuel. During this test, emissions from D301 and D302 were uncontrolled at their respective sampling locations.

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, General Motors - Pontiac Engineering Center, 248-520-2396
- Tom Gasloli, Technical Programs Unit, Michigan Department of Environment, Great Lakes and Energy (EGLE), 517-284-6778
- Adam Bognar, Environmental Engineer, EGLE, 586-753-3744
- Iranna Konanahalli, Environmental Engineer, EGLE, 586-753-3741
- 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 D301 Exhaust Duct during representative normal operations while utilizing a 1.5 liter gasoline engline and gasoline as fuel. The purpose of this test was also to determine the emissions of NO_x (as NO_2) at the D302 Exhaust Duct during representative normal operations while utilizing a 6.6 liter diesel engine and ultra low sulfur diesel as fuel. Testing was performed to satisfy the emissions testing requirements pursuant to EGLE Permit to Install No. 198-18, FG-Testcells, SC V.2.

The specific test objectives for this test were as follows:

- Measure the concentration of oxygen (O_2), carbon dioxide (CO_2) and NO_x at the D301 Exhaust Duct and D302 Exhaust Duct.
- 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 D301 Exhaust Duct and D302 Exhaust Duct during representative normal operations.
- Utilize the gasoline and diesel representative tests and the average annual fuel rate of each fuel in Test Wing 3 to determine the overall Test Wing 3 NO_x (as NO_2) emission rate (pph) as stated in the test plan.

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 D301 Exhaust Duct and D302 Exhaust Duct to determine the emissions of NO_x (as NO_2). This sampling train measured the concentrations of O_2, CO_2, and NO_x.

Table 2.2 displays the emissions of NO_x (as NO_2) measured at the D301 Exhaust Duct during representative normal operations.

Table 2.3 displays the emissions of NO_x (as NO_2) measured at the D302 Exhaust Duct 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 D301 Exhaust Duct and D302 Exhaust Duct are located in the Appendix C of this report.

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)
10/29/2019	1	D301 Exhaust Duct	10:55 - 12:04 / 69	10:55 - 12:04 / 69
10/29/2019	2	D301 Exhaust Duct	12:16 - 13:25 / 69	12:16 - 13:25 / 69
10/29/2019	3	D301 Exhaust Duct	13:34 - 14:43 / 69	13:34 - 14:43 / 69
10/30/2019	1	D302 Exhaust Duct	8:31 - 9:37 / 66	8:31 - 9:37 / 66
10/30/2019	2	D302 Exhaust Duct	9:46 - 10:52 / 66	9:46 - 10:52 / 66
10/30/2019	3	D302 Exhaust Duct	11:00 - 12:06 / 66	11:00 - 12:06 / 66

All times are Eastern Daylight Time.

TABLE 2.2
EMISSION RESULTS

Parameter	D301 Exhaust Duct			
	Run 1	Run 2	Run 3	Average
Engine Dynamometer Fuel (Gasoline) Flow (gram/second)*	0.608	0.607	0.609	0.608
Engine Load (MMBtu/hr)*	0.0924	0.0923	0.0926	0.0924
Nitrogen Oxides Emissions (lb/hr (as NO_2)	0.162	0.162	0.168	0.164
Fd-Based Nitrogen Oxides Emissions (lb/MMBtu) (as NO_2)	1.75	1.76	1.82	1.78
Nitrogen Oxides Concentration (ppmvd)	1,594	1,544	1,594	1,559
Percent by Volume Carbon Dioxide in Stack Gas (%-dry)	13.90	13.90	13.90	13.89
Percent by Volume Oxygen in Stack Gas (%-dry)	0.89	0.89	0.89	0.90

TABLE 2.3
EMISSION RESULTS

Parameter	D302 Exhaust Duct			
	Run 1	Run 2	Run 3	Average
Engine Dynamometer Fuel (Diesel) Flow (gram/second)*	1.73	1.69	1.69	1.71
Engine Load (MMBtu/hr)*	0.269	0.262	0.263	0.264
Nitrogen Oxides Emissions (lb/hr (as NO_2)	0.189	0.199	0.202	0.196
Fd-Based Nitrogen Oxides Emissions (lb/MMBtu) (as NO_2)	0.70	0.76	0.77	0.74
Nitrogen Oxides Concentration (ppmvd)	281	303	305	296
Percent by Volume Carbon Dioxide in Stack Gas (%-dry)	6.76	6.69	6.76	6.74
Percent by Volume Oxygen in Stack Gas (%-dry)	11.67	11.70	11.72	11.70

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

3.0 PLANT AND SAMPLING LOCATION DESCRIPTIONS

3.1 PROCESS DESCRIPTION AND OPERATION

3.1.1 Process Description

The General Motors Pontiac Engineering Center operates an extensive engine test facility to test internal combustion engines for research and development purposes using a wide variety of fuels and test protocols. A variety of test cycles are used depending on the purpose of the test program and the type of 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

Gasoline and Diesel were the engine fuels used during the Wing 3 Dynamometers D301 and D302 emissions test program. General Motors personnel collected one sample of each type of fuel for laboratory analysis and BTU determination.

3.1.4 Batch Operations

Wing 3 test cell operations consist of nineteen (19) dynamometers, of which nine (9) are firing, capable engine test cells that perform various development program testing. Test cell utilization varies with testing demand.

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 Wing 3 equivalent fuel consumption is limited to 23,312 MMBtu per 12-month rolling time period for spark-ignited fuels, and 6,732 MMBtu per 12-month rolling time period for diesel fuel, as determined at the end of each calendar month.

3.2 CONTROL EQUIPMENT DESCRIPTION

During this test, emissions from D301 and D302 were uncontrolled at the sampling location.

3.3 SAMPLING LOCATION

3.3.1 D301 EXHAUST DUCT

The D301 Exhaust Duct 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.

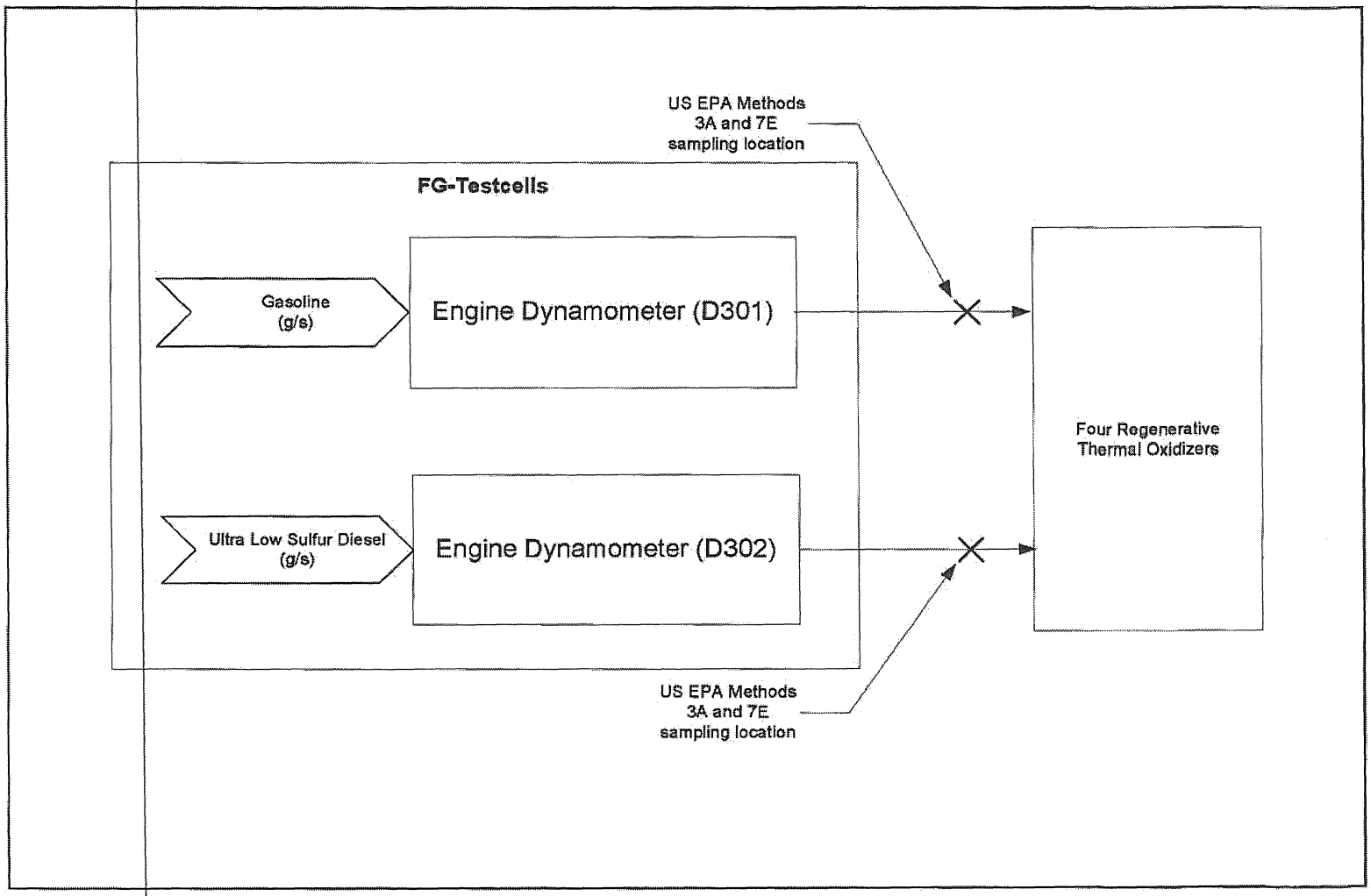
3.3.2 D302 EXHAUST DUCT

The D302 Exhaust Duct 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 (Gasoline and Diesel) samples were collected by General Motors - Pontiac Engineering Center personnel and submitted to Paragon Laboratories of Livonia, Michigan for fuel analysis. The lab report from Paragon Laboratories of the fuel analyses is located in Appendix B of this report.

FIGURE 3.1
D301 AND D302 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"

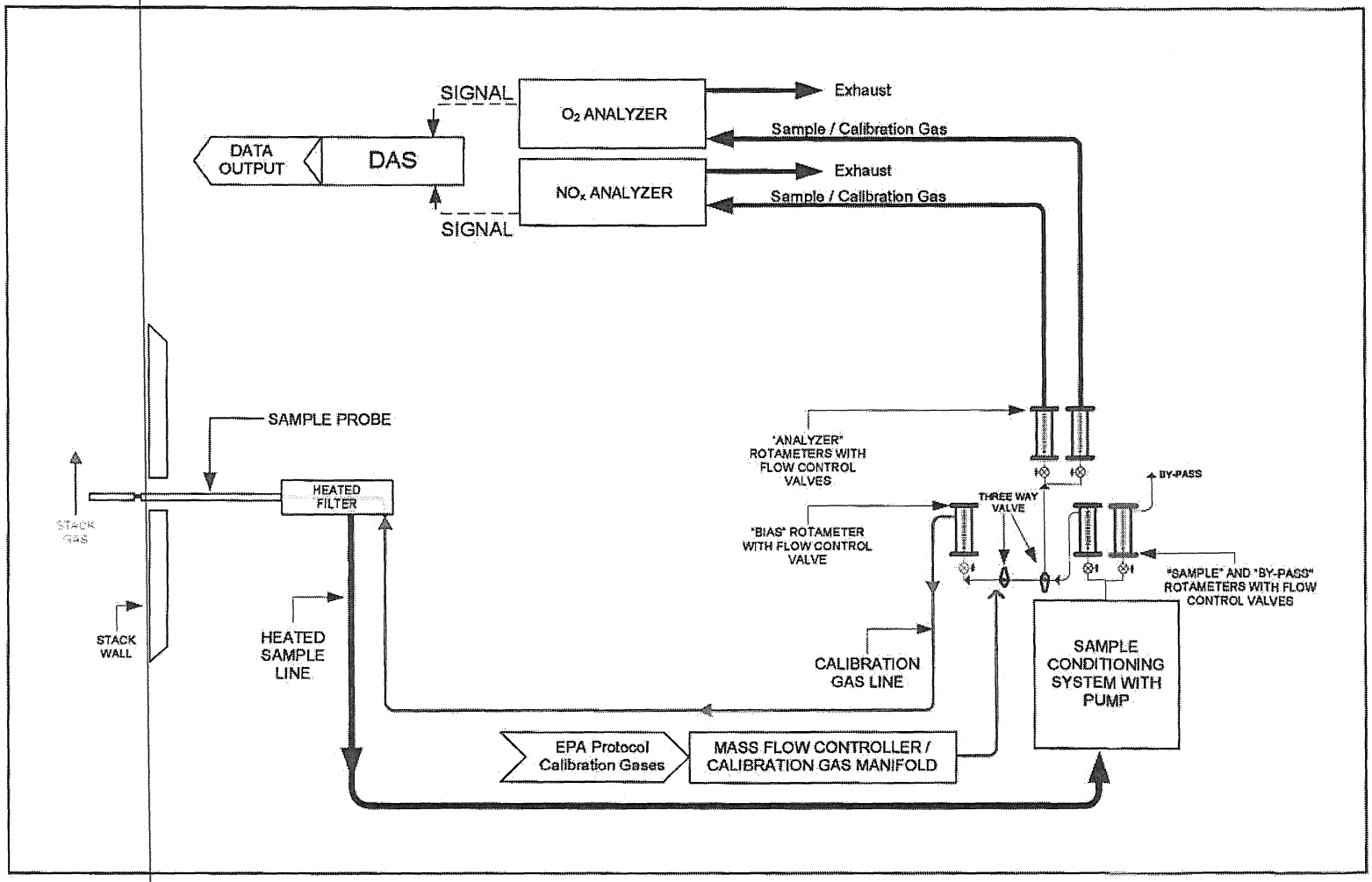
Principle: Oxygen (O_2) or carbon dioxide (CO_2) concentrations and appropriate F factors (ratios of combustion gas volumes to heat inputs) are used to calculate pollutant emission rates from pollutant concentrations. For this test, only O_2 was used to calculate pollutant emission rates.

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, Table 2.3, and in Appendix A of this report.

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 5.5 illustrate the QA audits that were performed during this test.

Tables 5.1 to 5.4 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 5.5 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 8.2.4.1 which requires a conversion of at least 90%. As shown an average converter efficiency of 103.5% was achieved for the NO_x analyzer utilized at the D301 Exhaust Duct and D302 Exhaust Duct.

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.