Consumers Energy

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40 CFR Part 60, Subpart KKKK Test Report

EUTURBINE2-2

Consumers Energy Company
Muskegon River Compressor Station
8613 Pine Road
Marion, MI 49665
SRN: N2901

March 28, 2022

Test Date: March 10, 2022

Test Performed by the Consumers Energy Company
Regulatory Compliance Testing Section
Air Emissions Testing Body
Laboratory Services Section
Work Order No. 34297585
Version No.: 0

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EXECUTIVE SUMMARY

Consumers Energy Company (Consumers Energy) Regulatory Compliance Testing Section (RCTS) conducted nitrogen oxides (NO_x) testing at the exhaust location of one (1) natural gas-fired Solar Taurus 70 combustion turbine-driven compressor unit designated as EUTURBINE2-2, installed and operating at the Muskegon River Compressor Station (MRCS) in Marion, Michigan. EUTURBINE2-2 is a simple cycle turbine identified within the Michigan Department of Environment, Great Lakes and Energy (EGLE) Air Quality Division (AQD) Permit to Install (PTI) 16-21.

The test program was conducted on March 10, 2022, to (1) verify compliance with NO_x emission limits and (2) verify that continuously operating in SoLoNO_x mode will ensure compliance with applicable NO_x emission limits from 40 CFR Part 60, Subpart KKKK, Table 1 and PTI 16-21. A test protocol was submitted to EGLE on January 18, 2022 and subsequently approved by Mr. Jeremy Howe, Environmental Quality Analyst, in his letter dated February 11, 2022.

40 CFR Part 60, Subpart KKKK, §60.4400(b) states that the performance test must be done at any load condition within plus or minus 25 percent of 100 percent of peak load, while testing may be conducted at the highest achievable load point, if at least 75 percent of peak load cannot be achieved in practice. Therefore, NO_x concentrations were measured with the unit operating at minimum and maximum achievable GPS, (expressed as a percentage of maximum speed). NO_x and oxygen (O_2) concentrations were measured to calculate NOx ppmvd @ 15% O_2, while NOx concentrations and natural gas fuel flow rates were used to calculate NOx pound per hour (lb/hr) and ton per year (Ton/yr) emission rates.

Triplicate 60-minute test runs were conducted at the turbine exhaust at the lower (98%) and upper (100%) GPS following the United States Environmental Protection Agency (USEPA) 40 CFR Part 60, Appendix A, Reference Methods (RM) 1, 3A, 7E, and 19. The results summarized in Table E-1 indicate EUTURBINE2-2 is operating in compliance with 40 CFR Part 60, Subpart KKKK and PTI 16-21 Limits.

Table E-1
Summary of Test Results

Parameter	Unit	98% GPS Result	100% GPS Result	Emission Limit	
				40 CFR 60, Subpart KKKK	PTI 16-21
NO_x	ppmvd @ 15% O_2	7.8	5.4	25[a]	
	Lb/hr	1.8	1.8		5.3
	Ton/yr	7.9	7.8		23.5

NO_x: Nitrogen Oxides

[a]Please note that 40 CFR Part 60 Subpart KKKK, Table 1 allows for 150 ppmvd NO_x at 15 percent O_2 when the turbine is operating at less than 75 percent of peak load.

Detailed results are presented in Appendix Table 1 and 2. Sample calculations, field data sheets, and system operating data are presented in Appendices A, B, and C. Supporting documentation is provided in Appendice D.

1.0 INTRODUCTION

This report summarizes the results of compliance air emissions testing conducted March 10, 2022 at the exhaust location of natural gas-fired Solar Taurus 70 combustion turbine-driven compressor unit designated as EUTURBINE2-2.

This document is compiled using the Michigan Department of Environment, Great Lakes and Energy (EGLE) reference document *Format for Submittal of Source Emission Test Plans and Reports*, dated November 2019. Reproducing portions of this document may cause omissions or contextual misinformation to occur. If any portion is reproduced, please exercise due care in this regard.

1.1 IDENTIFICATION, LOCATION, AND DATES OF TESTS

EUTURBINE2-2 is a simple cycle turbine identified within the EGLE Air Quality Division (AQD) Permit to Install (PTI) 16-21. The turbine is installed and operating at the Muskegon River Compressor Station (MRCS) in Marion, Michigan.

The test program was conducted on March 10, 2022. A test protocol was submitted to EGLE on January 18, 2022 and subsequently approved by Mr. Jeremy Howe, Environmental Quality Analyst, in his letter dated February 11, 2022.

1.2 PURPOSE OF TESTING

The purpose of the test was to (1) verify compliance with nitrogen oxide (NO_x) emission limits and (2) verify that continuously operaring in SoLoNO_x mode will ensure compliance with applicable NO_x emission limits from 40 CFR Part 60, Subpart KKKK, Table 1 and PTI 16-21. The applicable emission limits are presented in Table 1-1.

Table 1-1
EUTURBINE2-2 Emission Limits

Parameter	Unit	Emission Limit	
		40 CFR 60, Subpart KKKK	PTI 16-21
NO_x	ppmvd @ 15% O_2	25[a]	
	Lb/hr		5.3
	Ton/yr		23.5

1.3 BRIEF DESCRIPTION OF SOURCE

The Muskegon River Compressor Station operates EUTURBINE2-2 to compress and transport natural gas in and out of storage fields and along natural gas pipeline systems. The Solar Taurus 70 combustion turbine-driven compressor unit is limited to a maximum output of approximately 11,419 horsepower, which equates to approximately 96.5 million Btu/hr heat input rating.

1.4 Contact Information

Table 1-2 presents the contact information of personnel involved in the test event.

Table 1-2
Contact Information

Program Role	Contact	Address
Regulatory Agency Representative	Technical Programs Unit Supervisor c/o Diane Eisinger 517-242-3299 EisingerD1@michigan.gov	EGLE-Air Quality Division Technical Programs Unit 525 W. Allegan, Constitution Hall, 2nd Floor S Lansing, Michigan 48933
State Regulatory Inspector	Mr. Nathanael Gentle Environmental Quality Analyst 989-778-0025 GentleN@michigan.gov	EGLE Bay City District 401 Ketchum Street, Suite B Bay City, Michigan 48708
Responsible Official	Mr. Avelock Robinson, Director Gas Compression Operations 586-716-3326 avelock.robinson@cmsenergy.com	Consumers Energy Company St. Clair Compressor Station 10021 Marine City Highway Ira, Michigan 48023
Corporate Air Quality Contact	Ms. Amy Kapuga Senior Engineer 517-788-2201 amy.kapuga@cmsenergy.com	Consumers Energy Company Environmental Services Department 1945 West Parnall Road Jackson, Michigan 49201
Facility Contact	Mr. Parish Geers, Field Leader 231-743-410 parish.geers@cmsenergy.com	Consumers Energy Company Muskegon River Compressor Station 8613 Pine Road Marion, MI 49665
Field Environmental Coordinator	Ms. Janet Zondlak Sr. Environmental Analyst Lead 231-557-5646 janet.zondlak@cmsenergy.com	Consumers Energy Company Marion Production Office 7950 Partridge Ave. Marion, MI 49665
Test Team Representative	Mr. Joe Mason, QSTI Sr. Engineering Technical Analyst 231-720-4856 joe.mason@cmsenergy.com	Consumers Energy Company D.E. Karn Generating Complex 2742 N. Weadock Hwy, ESD Trailer #4 Essexville, Michigan 48732

2.0 SUMMARY OF RESULTS

2.1 Operating Data

Operating data collected during the test runs (Attachment C of this report) includes horsepower, percent power turbine and gas producer speed, fuel gas pressure (psi), SoLoNO$_x$ operation (in or out of service), fuel gas flow (thousand standard cubic feet per day), fuel heat content, British thermal unit (Btu) basis, suction and discharge psi, barometric pressure (inches mercury) and ambient temperature (°Fahrenheit).

2.2 Applicable Permit Information

The Muskegon River Compressor Station, State of Michigan Registration Number (SRN) N2901, operates in accordance with air emissions permit *MI-ROP-N2901-2020* and EUTURBINE2-2 is the simple cycle turbine identified within EGLE AQD PTI 16-21.

2.3 Results

The test results in Table 2-1 indicate EUTURBINE2-2 is compliant with the applicable emission limits while operating in SoLoNO$_x$ mode.

Table 2-1
Summary of Test Results

Parameter	Unit	98% GPS Result	100% GPS Result	Emission Limit	
				40 CFR 60, Subpart KKKK	PTI 16-21
NO_x	ppmvd @ 15% O_2	7.8	5.4	25[a]	
	Lb/hr	1.8	1.8		5.3
	Ton/yr	7.9	7.8		23.5

Detailed results are presented in Appendix Table 1 and 2. A results discussion is presented in Section 5.0. Sample calculations, field data sheets, and system operating data are presented in Appendices A, B, and C. Supporting documentation is provided in Appendix D.

3.0 SOURCE DESCRIPTION

3.1 Process

The Muskegon River Compressor Station operates EUTURBINE2-2 to compress and transport natural gas in and out of storage fields and along natural gas pipeline systems.

3.2 Process Flow

As natural gas enters the compressor station from the storage field, it passes through a scrubber vessel designed to remove free liquids, dirt or other particulates from the gas stream before entering the compressor. Water and natural gas liquids removed by the scrubber are sent to a double-walled holding tank for further processing or disposal.

The compressor re-pressurizes the natural gas using an impellor mechanically coupled to the turbine, which is fired by a portion of the natural gas that flows through the pipeline. State-of-the-art control systems monitor compressor operations, turbine and yard piping system interactions, and fault conditions generating a shut down if fault conditions exist. Detailed operating data recorded during testing are provided in Appendix C.

3.3 Materials Processed

The turbine fires natural gas containing ≤5 gr/100 scf sulfur content with a total heat value per cubic foot between 950 and 1,100 Btu.

3.4 Rated Capacity

The Solar Taurus 70 combustion turbine-driven compressor unit is limited to a maximum output of approximately 11,419 horsepower, which equates to approximately 96.5 million Btu/hr heat input rating.

3.5 Process Instrumentation

Fuel metering and other test program specific devices were calibrated prior to the test event according to the manufacturer recommendations. Process data collected during each test run was logged, correlated to each test run time stamp and averaged.

4.0 SAMPLING AND ANALYTICAL PROCEDURES

Consumers Energy RCTS tested for nitrogen oxides (NO_x), oxygen (O_2), and carbon dioxide (CO_2) concentrations using the United States Environmental Protection Agency (USEPA) test methods presented in Table 4-1. Please note that NO_x and O_2 were the primary measurement indices; CO_2 was an ancillary measurement collected in the event the O_2 analyzer became inoperative. The sampling and analytical procedures associated with each parameter are described in the following sections.

Table 4-1
Test Methods

Parameter	Method	USEPA Title
Sample traverses	1	*Sample and Velocity Traverses for Stationary Sources*
Oxygen/Carbon Dioxide	3A	*Determination of Oxygen and Carbon Dioxide Concentrations in Emissions from Stationary Sources (Instrumental Analyzer Procedure)*
Oxides of Nitrogen	EPA 7E	*Determination of Nitrogen Oxides Emissions from Stationary Sources (Instrumental Analyzer Procedure)*
Emission rates	EPA 19	*Determination of Sulfur Dioxide Removal Efficiency and Particulate Matter, Sulfur Dioxide, and Nitrogen Oxide Emission Rates*

4.1 Description of Sampling Train and Field Procedures

The test matrix presented in Table 4-2 summarizes the sampling and analytical methods performed for the specified test parameters.

Table 4-2
EUTURBINE2-2 Test Matrix

Date	GPS (%)	Run	Sample Type	Start Time (EST)	Stop Time (EST)	Test Duration (min)	EPA Test Method	Comment
March 10, 2022	100	1	NOx O_2/CO_2	08:58	09:59	60	1 3A 7E 19	12-Point Stratification Test
		2		10:30	11:29	60		Sampled from Single Point
		3		11:40	12:39	60		Sampled from Single Point
	98	1		13:10	14:09	60		Sampled from Single Point
		2		14:20	15:19	60		Sampled from Single Point
		3		15:32	16:31	60		Sampled from Single Point

4.2 Sample Location and Traverse Points (USEPA Method 1)

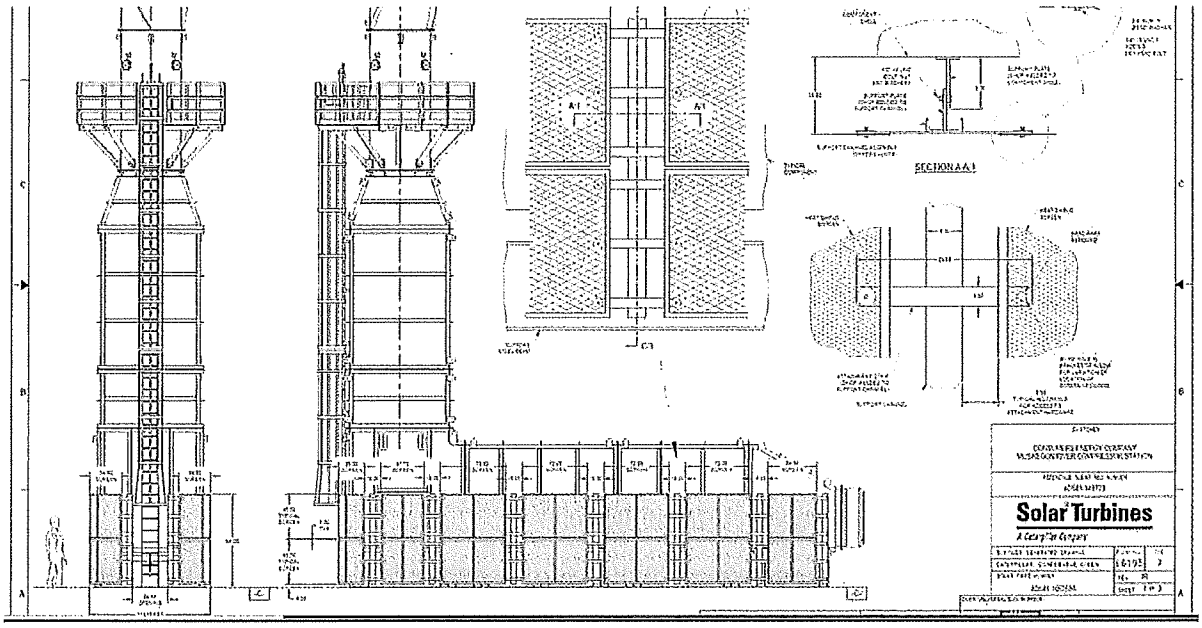
The number and location of traverse points were evaluated according to the requirements in 40 CFR Part 60, USEPA Method 1, *Sample and Velocity Traverses for Stationary Sources.* The EUTURBINE2-2 exhaust stack is 54 inches in diameter and the sample ports are 6-inch in diameter, extending 11.5 inches beyond the stack wall. The sampling location is:

- Approximately 108-inches or 2.0 duct diameters downstream from stack confluence, and
- Approximately 179-inches or 3.3 duct diameters upstream of the stack exit.

Since the sample port locations meet the minimum 2-diameter upstream and ½ diameter downstream diameter requirements in Method 1, § 11.1.1, a 12-point stratification test was performed @ 100% GPS following 40 CFR, Part 60, Subpart KKKK, Section 60.4400 requirements in accordance with 40 CFR, Part 75, Appendix A, Section 6.5.6.1 (a) through (e). The twelve points were located according to Method 1 and samples were collected for a minimum of 5 minutes at each traverse point.

Stratification test traverses were conducted and completed during the first 1-hour test run @ 100% GPS. Each of the individual traverse point NO_x concentrations were within ±5 percent of the mean concentration for all traverse points, and the diluent concentrations differed by no more than ±0.3% from the mean; therefore, all subsequent sampling was conducted at a single traverse point located at the exhaust stack centroid location following guidance in 40 CFR, part 60, Subpart KKKK, Section 60.400(3)(i)(B) and (ii)(B).

Figure 4-1. EUTURBINE2-2 Exhaust Stack Sample Port Location



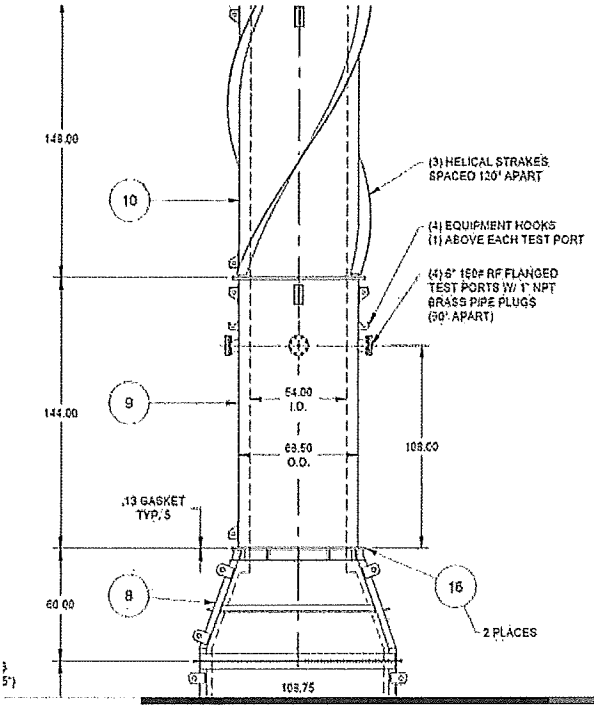


TABLE #1

ITEM	QTY/SYSTEM	DESCRIPTION	SOLAR
1	1	HOT-TO-COLD EXPANSION JOINT	TB
2	1	HORIZONTAL TRANSITION DUCT	TB
3	1	HORIZONTAL SILENCER "A"	TB
4	1	HORIZONTAL SILENCER "B"	TB
5	1	BASE SECTION	TB
6	1	VERTICAL DUCT "A"	TB
7	1	VERTICAL SILENCER	TB
8	1	VERTICAL TRANSITION DUCT	TB
9	1	VERTICAL DUCT "B" W/PORTS	TB
10	1	VERTICAL DUCT "C"	TB
11	1	SUPPORT STEEL	TB
12	1	45" NOM. DIA. HARDWARE KIT	TB
13	1	57" NOM. DIA. HARDWARE KIT	TB
14	5	108" X 108" NOM. HARDWARE KIT W/2.00" LG. BOLTS	TB
15	1	108" X 108" NOM. HARDWARE KIT W/2.25" LG. BOLTS	TB
16	2	66" NOM. DIA. HARDWARE KIT	TB
			TOTAL SYSTEM V

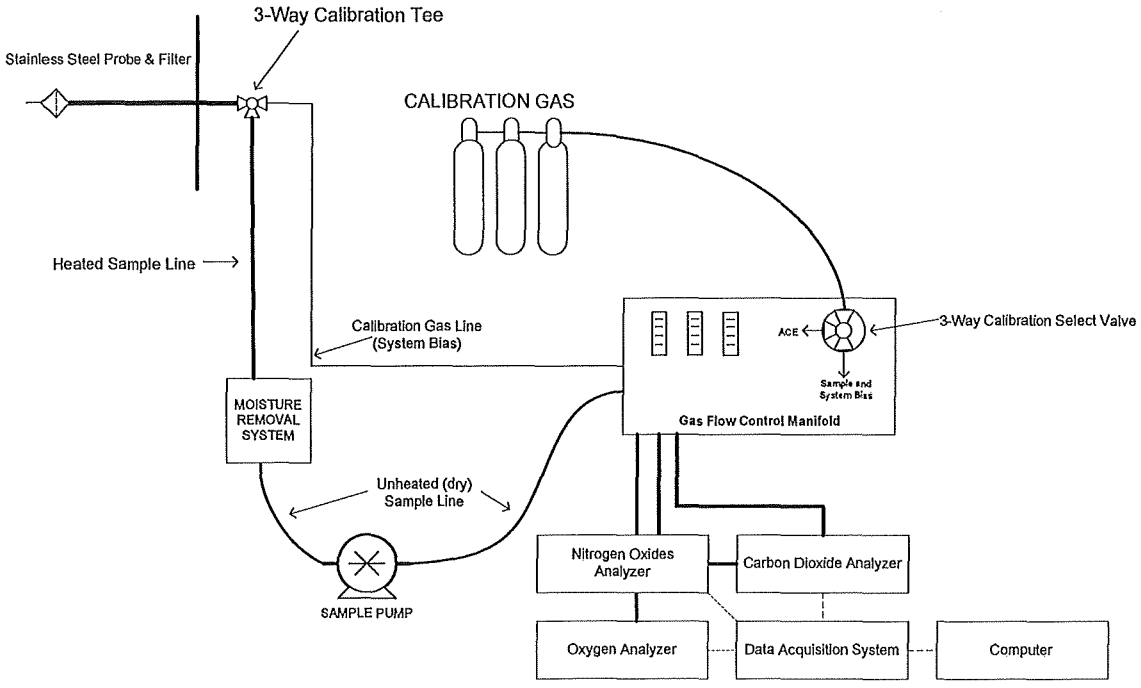
4.3 O_2, CO_2, NO_X (USEPA Methods 3A and 7E)

Oxygen, carbon dioxide and nitrogen oxides concentrations were measured using the following sampling and analytical procedures:

- USEPA Method 3A, *Determination of Oxygen and Carbon Dioxide Concentrations in Emissions from Stationary Sources (Instrumental Analyzer Procedure),*
- USEPA Method 7E, *Determination of Nitrogen Oxides Emissions from Stationary Sources (Instrumental Analyzer Procedure)*

Exhaust gas is extracted from the stack through a stainless-steel probe, heated Teflon® sample line, and a gas conditioning system to remove water and dry the sample before entering a sample pump, gas flow control manifold, and gas analyzers (Figure 4-2).

Figure 4-2. USEPA Methods 3A and 7E Sample System



The sampling procedures of the methods are similar apart from the analyzers and analytical technique used to quantify the parameters of interest. The measured O_2 or CO_2 concentrations are used to adjust pollutant concentrations to 15% O_2 and calculate pollutant emission rates.

Prior to sampling, the analyzers are calibrated by performing an analyzer calibration error (ACE) test where zero-, mid-, and high-level (equivalent to instrument span) calibration gases are introduced directly to the back of the analyzers. The ACE verifies the analyzer responses are within ±2.0% of calibration span, after which a NO_x analyzer NO_2 to NO conversion efficiency (CE) test is performed to verify the instrument's ability to convert NO_2 to NO, as required by RM7E, Section 8.2.4.

Following the CE, an initial measurement system-bias test is performed where the zero- and mid- or high- calibration gases are introduced at the sample probe to verify the measurement system response is within ±5.0% of span.

Upon successful completion of the CE and initial system bias tests, sample flow rates and component temperatures are verified, and the probe is inserted into the stack at the appropriate traverse point. After confirming the unit is operating at established conditions, the test run commences. Gas concentrations are recorded at 1-minute intervals throughout each test run.

At the conclusion of each test run, a final system bias check is performed to verify analyzer drift is within ±3.0% and measurement system bias is within ±5.0% of span. The analyzer responses are then used to correct measured gas concentrations for drift.

4.4 Emission Rates (USEPA Method 19)

USEPA Method 19, *Determination of Sulfur Dioxide Removal Efficiency and Particulate Matter, Sulfur Dioxide, and Nitrogen Oxide Emission Rates*, was used to develop lb/mmBtu emission rates based on measured oxygen concentrations and F factors (ratios of combustion gas volumes to heat inputs) using equation 19-1 (Figure 4-3):

Figure 4-3. USEPA Method 19 Equation 19-1

$$E = C_d F_d \frac{20.9}{(20.9 - \%O_{2d})}$$

Where:

E	=	Pollutant emission rate (lb/mmBtu)
C_d	=	Pollutant concentration, dry basis (lb/dscf)
F_d	=	Volumes of combustion components per unit of heat content 8,710 dscf/mmBtu for natural gas
$\%O_{2d}$	=	Concentration of oxygen on a dry basis (%, dry)

5.0 Test Results and Discussion

The test program was conducted on March 10, 2022 to to (1) verify compliance with NO_x emission limits and (2) establish minimum and maximum gas producer speed (GPS) range at which the turbine can continuously operate while complying with applicable NO_x emission limits from 40 CFR Part 60, Subpart KKKK, Table 1 and PTI 16-21.

5.1 Tabulation of Results

The test results indicate EUTURBINE2-2 is compliant with applicable emissions limits as summarized in Table 2-1. Appendix Tables 1 and 2 contain detailed results tabulation, process operating conditions, and exhaust gas conditions.

5.2 Significance of Results

The test results indicate compliance with the turbine operating at the minimum and maximum GPS of 98% and 100%.

5.3 Variations from Sampling or Operating Conditions

No operating condition variations were observed during the test program.

EGLE representative Mr. Jeremy Howe's protocol approval email correspondence dated February 11, 2022 drew attention to the NO_2 – NO converter efficiency (CE) gas concentration used, stating that *The NO2 cylinder used for the NOX converter check will need to be within the range of* (analyzer) *calibration.*

The NO_2 gas cylinder concentration for this test event was 52.07 ppm, which meets USEPA Method 7E, Section 7.1.4 guidance for a CE gas between 40 to 60 ppm; however since the maximum EUTURBINE2-2 NO_x concentration is 25 ppmvd @ 15%, RCTS planned to use a 50 ppm range of calibration, or slightly less than the NO_2 gas concentration. Therefore, to ensure the NOx analyzer CE requirement was thoroughly satisfied, two differing NO_2 – NO converter checks were conducted following Method 7E Section 8.2.4.1, using the 52.07 NO_2 gas with the analyzer span at 99 ppm and again using the alternative NO_2 to NO CE Tedlar bag procedure in Method 7E, Section 16.2 at 50 ppm analyzer span. Both CE checks met the respective Method 7E Section criteria, as shown in Appendix D.

5.4 Process or Control Equipment Upset Conditions

No process or control equipment upset conditions were observed during the test program.

5.5 Air Pollution Control Device Maintenance

No significant maintenance had been performed in the three months prior to the test program.

5.6 Re-Test Discussion

Based on the results of this test program, a re-test is not required.

5.7 Results of Audit Samples

Audit samples are not available from USEPA Stationary Source Audit Sample Program providers for this test program, however the reference methods performed clearly indicate that reliable results are obtained by persons equipped with a thorough knowledge of the techniques associated with each method. Field measurement error factors are therefore minimized by implementing quality control (QC) and assurance (QA) programs into the applicable field-test components. The primary field QA/QC activities used are summarized in Table 5-1. Refer to Appendix D for additional supporting documentation.

Table 5-1
QA/QC Procedures

QA/QC Activity	Purpose	Procedure	Frequency	Acceptance Criteria
M1: Sampling Location	Evaluates if the sampling location is suitable for sampling	Measure up- and downstream distance from ports to flow disturbances	Pre-test	≥2 diameters downstream; ≥0.5 diameter upstream.
M1: Duct diameter/ dimensions	Verifies area of stack is accurately measured	Review as-built drawings and field measurement	Pre-test	Field measurement agreement with as-built drawings
M3A, 7E: Calibration gas standards	Ensure accurate calibration standards	Traceability protocol of calibration gases	Pre-test	Calibration gas uncertainty ≤2.0%
M3A, 7E: Calibration Error	Evaluates operation of analyzers	Calibration gases introduces directly into analyzers	Pre-test	±2.0% of the calibration span
M7E: NO_2-NO converter test	Evaluate ability of analyzer to convert NO2 to NO	Introduce NO2 calibration gas	Pre- or Post-test	≥90% NO_x response
M3A, 7E: System bias and analyzer drift	Evaluates sample system stack gas delivery to analyzers	Calibration gases introduced through sample system	Pre- and Post-test	Bias: ±5.0% of analyzer span Drift: ±3.0% of analyzer span

5.8 Calibration Sheets

Calibration sheets, including gas protocol sheets and analyzer QA/QC data are presented in Appendix D.

5.9 Sample Calculations

Sample calculations and formulas used to compute emissions data are presented in Appendix A.

5.10 Field Data Sheets

Field data sheets are presented in Appendix B.

5.11 Laboratory Quality Assurance / Quality Control Procedures

The method specific QA/QC procedures employed during this test program were followed without deviation. There were no laboratory procedures employed.

5.12 QA/QC Blanks

No reagent or media blanks were used.