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Test Report

EUTURBINE2-2

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

February 5, 2024

Test Date: January 16, 2024

Test Performed by the Consumers Energy Company
Regulatory Compliance Testing Section
Air Emissions Testing Body
Laboratory Services Section
Work Order No. 42357539

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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 natural gas-fired Solar Taurus 70 combustion turbine 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) 16-21A and subject to state and federal air emissions requirements.

The test program was conducted on January 16, 2024, to evaluate compliance with NO_x emission limits in 40 CFR Part 60, Subpart KKKK, Table 1 and PTI 16-21A. A test protocol was submitted to EGLE on December 11, 2023, and subsequently approved by Daniel Droste, Environmental Quality Analyst with EGLE, in a letter dated January 18, 2024.

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 maximum achievable gas producer turbine speed (% NGP). NO_x and oxygen (O_2) concentrations were measured to 1) calculate NO_x emissions as parts per million, dry, corrected to 15% oxygen (ppmvd @ 15% O_2), 2) NO_x pound per million British thermal unit (lb/MMBtu), and 3) NO_x pound per hour (lb/hr) and ton per year (ton/yr) emission rates using natural gas fuel flow rates.

Triplicate 60-minute test runs were conducted at the turbine exhaust at maximum achievable % NGP 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 16-21A air emission limits. Pursuant to §60.4340, since the NO_x emission result from the performance test is less than 75 percent of the NO_x emission limit for the turbine, the frequency of subsequent performance tests is reduced from annually to once every 2 years (no more than 26 calendar months following the previous performance test). Refer to Table E-1 for a Summary of the Test Results.

Table E-1
Summary of Test Results

Parameter	Units	Average Result	Emission Limit	
			40 CFR 60, Subpart KKKK	PTI 16-21A
NO_x	ppmvd @ 15% O_2	7.2	25	
	lb/hr	2.1		5.3
	ton/yr	9.0		23.5

NO_x: Nitrogen oxides

The results verified compliance with the NOx emission limits. Pursuant to §60.4340(a), if stack test results are ≤75% of the NOx limit in SC I.1 (25 ppmvd), the test plan can be changed to once every two years. Based on the results of this test program, periodic performance tests are required every two years (at least every 26 calendar months).

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

1.0 INTRODUCTION

This report summarizes the results of compliance air emissions testing conducted January 16, 2024, at the exhaust location of natural gas-fired Solar Taurus 70 combustion turbine designated as EUTURBINE2-2 at the Muskegon River Compressor Station in Marion, Michigan.

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) 16-21A. The turbine is installed and operating at the Muskegon River Compressor Station (MRCS) in Marion, Michigan.

The test program was conducted on January 16, 2024. A test protocol was submitted to EGLE on December 11, 2023, and subsequently approved by Daniel Droste, Environmental Quality Analyst, in a letter dated January 18, 2024. A clarification to the Test Protocol was communicated on January 11, 2024. In the test protocol that was submitted on December 11, 2023, it was stated that "*NO_x concentrations will be measured with the unit operating at a minimum achievable GPS and again at maximum achievable GPS, (expressed as a percentage of maximum speed)*". However, since Consumers Energy is demonstrating continuous compliance using performance testing [§60.4340(a)], and not an alternative method [§60.4340(b)], only one load point is required for the annual/biennial performance test. Therefore, NO_x concentrations were measured at a single load condition with the unit operating within ±25% of 100% peak load [§60.4400(b)]. Appendix D presents the Test Protocol correspondence.

1.2 PURPOSE OF TESTING

The purpose of the test was to evaluate compliance with NO_x emission limits in 40 CFR Part 60, Subpart KKKK, Table 1 and PTI 16-21A. The applicable emission limits are presented in Table 1-1.

Table 1-1
EUTURBINE2-2 Emission Limits

Parameter	Units	Emission Limit	
		40 CFR 60, Subpart KKKK	PTI 16-21A
NO_x	ppmvd @ 15% O_2	25	
	lb/hr		5.3
	ton/yr		23.5

NO_x: Nitrogen oxides

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 (nameplated at 11,107 HP), 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
EGLE AQD - Technical Programs Unit Supervisor	Jeremy Howe Technical Programs Unit Environmental Manager 517-878-6687 howej1@michigan.gov	EGLE Technical Programs Unit 525 W. Allegan, Constitution Hall, 2nd Floor S Lansing, Michigan 48933
EGLE AQD - Technical Programs Unit Inspector	Daniel Droste Environmental Quality Analyst 989-225-6052 drosted3@michigan.gov	EGLE AQD - Bay City District 401 Ketchum Street, Suite B Bay City, Michigan 48708
EGLE AQD – District Inspector	Nathanael Gentle Environmental Quality Analyst 989-894-6219 gentlen@michigan.gov	EGLE AQD - Bay City District 401 Ketchum Street, Suite B Bay City, Michigan 48708
Responsible Official	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	Amy Kapuga Principal Environmental Engineer 517-788-2201 amy.kapuga@cmsenergy.com	Consumers Energy Company Environmental Services Department 1945 West Parnall Road Jackson, Michigan 49201
Field Environmental Coordinator	Janet Zondlak Manager Environmental Compliance 616-738-3702 janet.zondlak@cmsenergy.com	Consumers Energy Company Marion Production (MCS-100A-REM) 7950 Partridge Ave. Marion, Michigan 49665
Field Manager	Janet Simon Manager of Gas Compression 989-466-4215 janet.simon@cmsenergy.com	Consumers Energy Company Lansing Service Center (LAN-131B-NOA) 530 W. Willow Avenue Lansing, Michigan 48906
Field Leader	Dawn Biering Supervisor Gas Compression 231-743-4101 dawn.biering@cmsenergy.com	Consumers Energy Company Muskegon River Compressor Station 8613 Pine Road Marion, Michigan 49665
Test Team Representative	Thomas Schmelter, QSTI Sr. Engineering Technical Analyst 616-738-3234 thomas.schmelter@cmsenergy.com	Consumers Energy Company L&D Training Center 17010 Croswell Street West Olive, Michigan 49460

2.0 SUMMARY OF RESULTS

2.1 OPERATING DATA

Operating data was collected at 15-minute intervals during the test runs and includes:

- Engine Power Full Load (HP)
- Fuel Gas Flow (lb/hr, scfm)
- Fuel Supply Pressure (PSI)
- Gas Producer Compressor Discharge Pressure (PSI)
- Gas Producer Speed (%)
- Barometric Pressure (in Hg)
- SoLoNO$_x$ Mode (on/off)
- Ambient Temperature (°F)
- T5 Temperature Average (°F)
- Fuel Gas Total Flow (SCFM)

Refer to Appendix C for the Daily Emissions Report operating data.

2.2 APPLICABLE PERMIT INFORMATION

The Muskegon River Compressor Station operates under State of Michigan Registration Number (SRN) N2901 and renewable operating permit MI-ROP-N2901-2020 effective January 22, 2020. EUTURBINE2-2 is the emission unit identified within EGLE AQD PTI 16-21A approved on August 30, 2022. PTI 16-21A incorporates the operating and emission limit requirements of 40 CFR Part 60, Subpart KKKK, "Standards of Performance for Stationary Combustion Turbines."

2.3 RESULTS

The test results in Table 2-1 indicate EUTURBINE2-2 is compliant with the applicable emission limits.

Table 2-1
Summary of Test Results

Parameter	Units	Average Result	Emission Limit	
			40 CFR 60, Subpart KKKK	PTI 16-21A
NO$_x$	ppmvd @ 15% O$_2$	7.2	25	
	lb/hr	2.1		5.3
	ton/yr	9.0		23.5

The results verified compliance with the NOx emission limits. Pursuant to §60.4340(a), if stack test results are ≤75% of the NOx limit in SC I.1 (25 ppmvd), the test plan can be changed to once every two years. Based on the results of this test program, periodic performance tests are required every two years (at least every 26 calendar months).

Detailed results are presented in Appendix Table 1. 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 gas enters the compressor station from the conveyance pipeline(s), it passes through a scrubber designed to remove free liquids, dirt, and other particulates from the gas stream before entering the turbine's combustor. Air is drawn into a multi-stage compressor and then directed into a combustion chamber. The natural gas is injected and mixed with the compressed air and ignited during the start cycle. The hot pressurized gas from the combustor expands through and drives the turbine, dropping in pressure and temperature as it exits the turbine. This process converts the energy in the fuel into kinetic rotating power at the turbine output shaft. A compressor pressurizes the pipeline gas using an impeller mechanically coupled to the turbine's output shaft.

State-of-the-art control systems monitor compressor operations, turbine and yard piping system interactions, and fault conditions. 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 1,110 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 (nameplated at 11,107 HP), 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 inspected and/or calibrated prior to the test event according to the manufacturer recommendations. Process data collected during each test run was logged, correlated to run times, and averaged.

4.0 SAMPLING AND ANALYTICAL PROCEDURES

Consumers Energy RCTS tested for nitrogen oxides (NO_x) and oxygen (O_2) concentrations using the United States Environmental Protection Agency (USEPA) test methods presented in Table 4-1. The sampling and analytical procedures associated with each parameter are described in the following sections.

Table 4-1
Test Methods

Parameter	Method	Title
Sample traverse	1	Sample and Velocity Traverses for Stationary Sources
Oxygen	3A	Determination of Oxygen and Carbon Dioxide Concentrations in Emissions from Stationary Sources (Instrumental Analyzer Procedure)
Oxides of Nitrogen	7E	Determination of Nitrogen Oxides Emissions from Stationary Sources (Instrumental Analyzer Procedure)
Emission rates	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

Run	Sample Type	Start Time (EST)	Stop Time (EST)	Test Duration (min)	EPA Test Method	Comment
1†	NO_x O_2	08:15 09:20	08:54 09:39	60	1 3A 7E 19	3-Point Stratification Test
2		10:00	10:59	60		Sampled from Single Point
3		11:45	12:44	60		Sampled from Single Point

† Run 1 was paused from 08:55 to 09:19 due to reduced sample flow caused by ice within the sampling system

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 16.5 inches beyond the stack wall. The sampling location is:

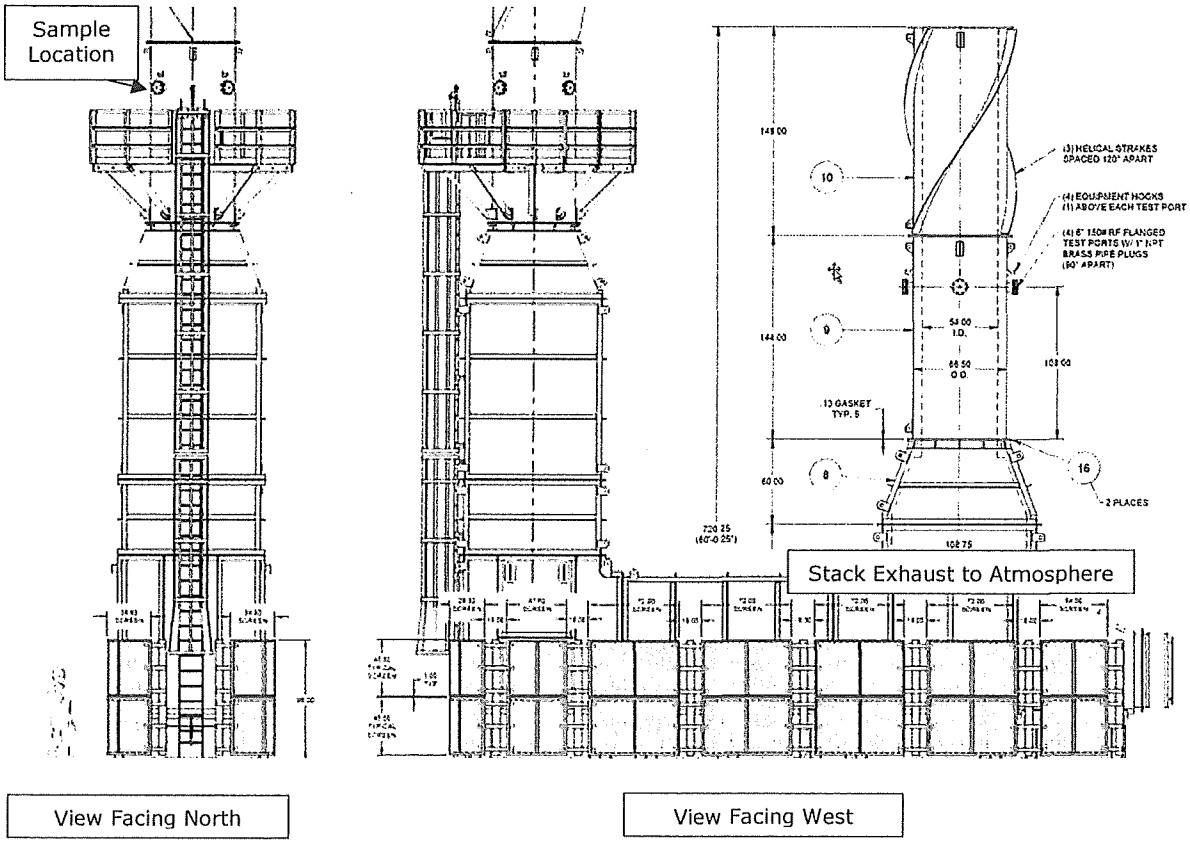
- Approximately 108-inches or 2.0 duct diameters downstream from stack confluence, and
- Approximately 184-inches or 3.4 duct diameters upstream of the stack exit.

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 previously performed on March 10, 2022, following 40 CFR, Part 60, Subpart KKKK, Section 60.4400 requirements and in accordance with 40 CFR, Part 75, Appendix A, Section 6.5.6.1 (a) through (e). An abbreviated stratification test traverse, in accordance with 40 CFR, Part 75, Appendix A, Section 6.5.6.2 (a) through (e) with points located at points 16.7 percent, 50.0 percent, and 83.3 percent of the way across the stack, was conducted and completed during the first 1-hour test run on January 16, 2024. Each of

the individual traverse point 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 60.4400(a)(3).

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



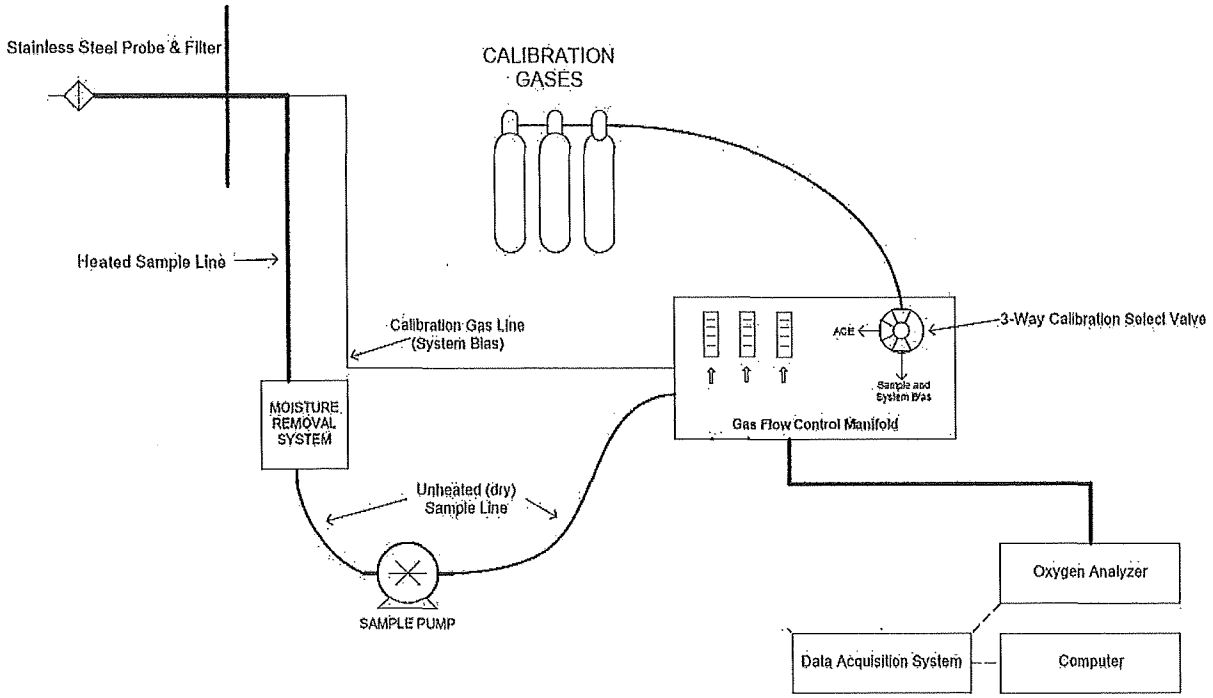
4.3 O_2 AND NO_X (USEPA METHODS 3A AND 7E)

Oxygen 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 was 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 concentrations were used to adjust pollutant concentrations to 15% O_2 and calculate pollutant emission rates.

Prior to sampling, the analyzers were calibrated by performing an analyzer calibration error (ACE) test where zero-, mid-, and high-level (equivalent to instrument span) calibration gases were introduced directly to the back of the analyzers. The ACE verified the analyzer responses were within ±2.0% of calibration span, after which a NO_x analyzer NO_2 to NO conversion efficiency (CE) test was performed to verify the instrument's ability to convert NO_2 to NO, as required by RM 7E, Section 8.2.4.

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

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

At the conclusion of each test run, a final system bias check was performed to verify analyzer drift was within ±3.0% and measurement system bias was within ±5.0% of span. The analyzer responses were 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 calculate lb/MMBtu

emission rates based on measured oxygen concentrations and F-factors (ratios of combustion gas volumes to heat inputs) using equation 19-1:

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
$\%O_{2d}$	=	Concentration of oxygen on a dry basis (%, dry)

5.0 TEST RESULTS AND DISCUSSION

The test program was conducted on January 16, 2024, to evaluate compliance with NO_x emission limits in 40 CFR Part 60, Subpart KKKK, Table 1 and PTI 16-21A.

5.1 Tabulation of Results

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

5.2 Significance of Results

The test results indicate compliance with 40 CFR Part 60, Subpart KKKK, Table 1 and PTI 16-21A. Pursuant to §60.4340, since the NO_x emission result from the performance test is less than 75 percent of the NO_x emission limit for the turbine, the frequency of subsequent performance tests is reduced from annually to once every 2 years (no more than 26 calendar months following the previous performance test).

5.3 Variations from Sampling or Operating Conditions

No turbine operating condition variations were observed during the test program. Run 1 was paused from 08:55 to 09:19 due to reduced sample flow caused by ice within the sampling system. After resolving the issue, the test resumed at 09:20 and Run 1 data was averaged 08:55 to 09:19 and 09:20 to 09:39.

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 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 NO_2 to NO	Introduce NO_2 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.

Appendix Table

Table 1
Muskegon River Compressor Station
EUTURBINE2-2 Emission Rates and Process Data

Parameter	Average Result
Diluent Concentrations and Emissions	
O_2 Concentration, %, dry	15.2
Nitrogen Oxides (NO_x) Concentrations and Emissions	
NOx Concentration, ppmvd	7.0
NO_x Concentration, ppmvd @ 15% O_2	**7.2**
NO_x Emission Rate, lb/MMBtu	0.0260
NO_x Emission Rate, lb/hr	**2.1**
NO_x Emission Rate, tpy	**9.0**
NO_x Emission Rate, g/HP-hr	0.13
Process Data	
Natural Gas Fuel Factor, Fc, scf/MMBtu	1,012.5
Natural Gas Fuel Factor, Fd, dscf/MMBtu	8,501.6
Natural Gas Gross Heating Value, Btu/ft^3	1,042.8
Turbine Fuel Flow Rate, ft^3/min	1,299
Stack gas flow rate, dscfm	42,345
Gas Producer Speed, %	99.2
Turbine Power, BHP	7,542

Appendix A
Sample Calculations