Consumers Energy

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Test Report

EUTURBINE2-2

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

November 16, 2022

Test Date: October 6, 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 formaldehyde (CH_2O) testing at the exhaust of one natural gas-fired Solar Taurus 70 combustion turbine-driven compressor unit operating at the Muskegon River Compressor Station (MRCS) in Marion, Michigan. The turbine is identified as EUTURBINE2-2 within Michigan Department of Environment, Great Lakes and Energy (EGLE) Air Quality Division (AQD) Permit to Install (PTI) 16-21A, which incorporates the federal requirements of 40 CFR Part 63, Subpart YYYY, "National Emission Standards for Hazardous Air Pollutants for Stationary Combustion Turbines." EUTURBINE2-2 is a simple cycle turbine used to maintain natural gas pressure for injection and withdrawal from underground storage reservoirs and along the intrastate pipeline and distribution system.

The test program was conducted on October 6, 2022, to evaluate compliance with the ≤91 parts per billion by volume dry (ppbvd) at 15-percent O_2 formaldehyde limit, as required by Table 1 to Subpart YYYY of Part 63 – Emission Limitations. A test protocol was submitted to EGLE on June 28, 2022, and subsequently approved by Ms. Lindsey Wells, Environmental Quality Analyst, in a letter dated August 22, 2022.

Three, minimum 1-hour tests were performed while the turbine was operating within 10 percent of 100-percent load. Flue gas CH_2O, oxygen (O_2), and moisture content concentrations were measured to calculate CH_2O ppmvd @ 15% O_2 following procedures in United States Environmental Protection Agency (USEPA) 40 CFR Part 60, Appendix A, Reference Methods (RM) 1, 3A, and 320.

The results summarized in Table E-1 indicate EUTURBINE2-2 is operating in compliance with 40 CFR Part 63, Subpart YYYY and PTI 16-21 Limits.

Table E-1
Summary of Test Results

Parameter	Unit	Result	Emission Limit
CH_2O	ppbvd @ 15% O_2	39	≤91

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. Formaldehyde testing data is provided in Appendix D. Supporting documentation is provided in Appendix E.

1.0 INTRODUCTION

This report summarizes the results of compliance air emissions testing conducted October 6, 2022, at the exhaust of natural gas-fired Solar Taurus 70 combustion turbine-driven compressor unit 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 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. A test protocol was submitted to EGLE on June 28, 2022, and subsequently approved by Ms. Lindsey Wells, Environmental Quality Analyst, in a letter dated August 22, 2022.

To meet the September 5, 2022, deadline for conducting the Subpart YYYY initial compliance demonstration, Consumers Energy scheduled air emissions testing for August 30, 2022. Consumers Energy attempted to operate the centrifugal compressor supported by EUTURBINE2-2 in an abnormal operating condition using a closed-loop configuration, as natural gas field conditions and demand do not currently support typical operation. Under this operating condition, the turbine can operate for a limited amount of time before risking equipment failure or safety hazard and must be shut down. A representative from Solar (turbine manufacturer) was onsite to assist with the abnormal operating condition and to help troubleshoot, if necessary.

Prior to conducting the August 30, 2022, performance test, formaldehyde and methane concentrations were observed to be higher than expected. To investigate, carbon monoxide (CO), nitrogen oxide (NO_x) and diluent (oxygen, or O_2, and carbon dioxide, or CO_2) concentrations were measured and reviewed. Solar began troubleshooting efforts to determine the cause of the elevated formaldehyde and methane concentrations. This included reviewing operating parameters and adjusting the air/fuel ratio. However, the formaldehyde and methane concentrations remained at high levels. Therefore, the initial compliance demonstration was not commenced as scheduled.

Troubleshooting continued beginning the week of October 3, 2022. Additional turbine operating hours were accrued and the system configuration was modified to allow continuous (i.e., 24-hr) turbine operation. With approval from EGLE-AQD Bay City District office via telephone on October 6, 2022 and follow-up email on October 7, 2022, the 7-day advanced test notification requirement was waived, and the compliance test was conducted on October 6, 2022.

1.2 PURPOSE OF TESTING

The purpose of the test was to evaluate compliance with the ≤91 parts per billion by volume dry (ppbvd) at 15-percent O_2 formaldehyde limit, as required by Table 1 to Subpart YYYY of Part 63 – Emission Limitations. The applicable emission limits are presented in Table 1-1.

Table 1-1
EUTURBINE2-2 Emission Limits

Parameter	Units	Emission Limit
Formaldehyde (CH_2O)	ppbvd @ 15% O_2	≤91

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
EPA Regional Contact	Compliance Tracker, ECA-18J Air Enforcement and Compliance Assurance Branch	U.S. EPA Region 5 77 W. Jackson Blvd. Chicago, Illinois 60604
State Technical Programs Supervisor	Mr. Jeremy Brown Acting TPU Supervisor 517-599-7825 brownj9@michigan.gov	EGLE – 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
State Technical Programs Field Inspector	Ms. Lindsey Wells Technical Programs Unit 517-282-2345 wellsL8@Michigan.gov	EGLE – Technical Programs Unit 525 W. Allegan, Constitution Hall, 2nd Floor S Lansing, Michigan 48933
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
Principal Engineer	Mr. Bradley R. Plummer Principal Engineer 517-206-8006 bradley.plummer@cmsenergy.com	Consumers Energy Company Overisel Compressor Station (ORV-103-5) 4131 138th Ave. Hamilton, Michigan 49419

Table 1-2
Contact Information

Program Role	Contact	Address
Project Manager	Ms. Erin E. Still EPC Project Manager III 616-460-7001 erin.still@cmsenergy.com	Consumers Energy Company Royal Oak Service Center 4600 Coolidge Hwy Royal Oak, Michigan 48073
Field Leader	Ms. Dawn Biering Gas Field Leader III 231-743-4102 dawn.biering@cmsenergy.com	Consumers Energy Company Muskegon River Compressor Station 8613 Pine Road Marion, MI 49665
Sr. Field Leader	Ms. Janet Simon Senior Field Leader II 231-388-2717 janet.simon@cmsenergy.com	Consumers Energy Company Alma Service Center (ALM-109A-REM) 1325 Wright Ave Alma, Michigan 48801
Test Team Representative	Mr. 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

The turbine operating data collected during each test run included:

- Horsepower (BHP)
- Percent power turbine (Npt, %)
- Percent gas producer speed (Ngp, %)
- Fuel gas pressure (psig)
- Lean premixed combustion, SoLoNO$_x$ operation (Active: Yes/No)
- Fuel gas flow (1,000 scfd)
- Fuel gas flow (lb/hr)
- Suction and discharge pressure (psig)
- Ambient temperature (T1, °F)
- Barometric pressure (in Hg)
- Combustion temperature (T5, °F)

Refer to Appendix C for the operating data collected.

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 63, Subpart YYYY, "National Emission Standards for Hazardous Air Pollutants for Stationary Combustion Turbines," for the EU-TURBINE2-2 source under the FGMACTYYYY flexible group conditions.

2.3 Results

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

Table 2-1
Summary of Test Results

Parameter	Unit	Result	Emission Limit
CH_2O	ppbvd @ 15% O_2	39	≤91

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

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 pipeline, 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 pressurizes the pipeline gas using an impeller 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 verified 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

Triplicate, minimum 60-minute test runs to measure formaldehyde and oxygen concentrations were conducted at the exhaust of EUTURBINE2-2 while it was operating within plus or minus 10 percent of 100-percent load. Table 4-1 presents the United States Environmental Protection Agency (USEPA) test methods to be used during this test program. Descriptions of these procedures are presented in the following sections.

Table 4-1
Test Methods

Parameter	Method	Title
Sample traverses	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)
Formaldehyde Water content	320	Measurement of Vapor Phase Organic and Inorganic Emissions by Extractive Fourier Transform Infrared (FTIR) Spectroscopy

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	Run	Sample Type	Start Time (EST)	Stop Time (EST)	Test Duration (min)	EPA Test Method	GPS (%)
Oct. 6, 2022	1	O_2 CH_2O Water content	11:20	12:19	60	1 3A 320	99.91
	2		12:35	13:34	60		99.93
	3		13:48	14:47	60		99.98

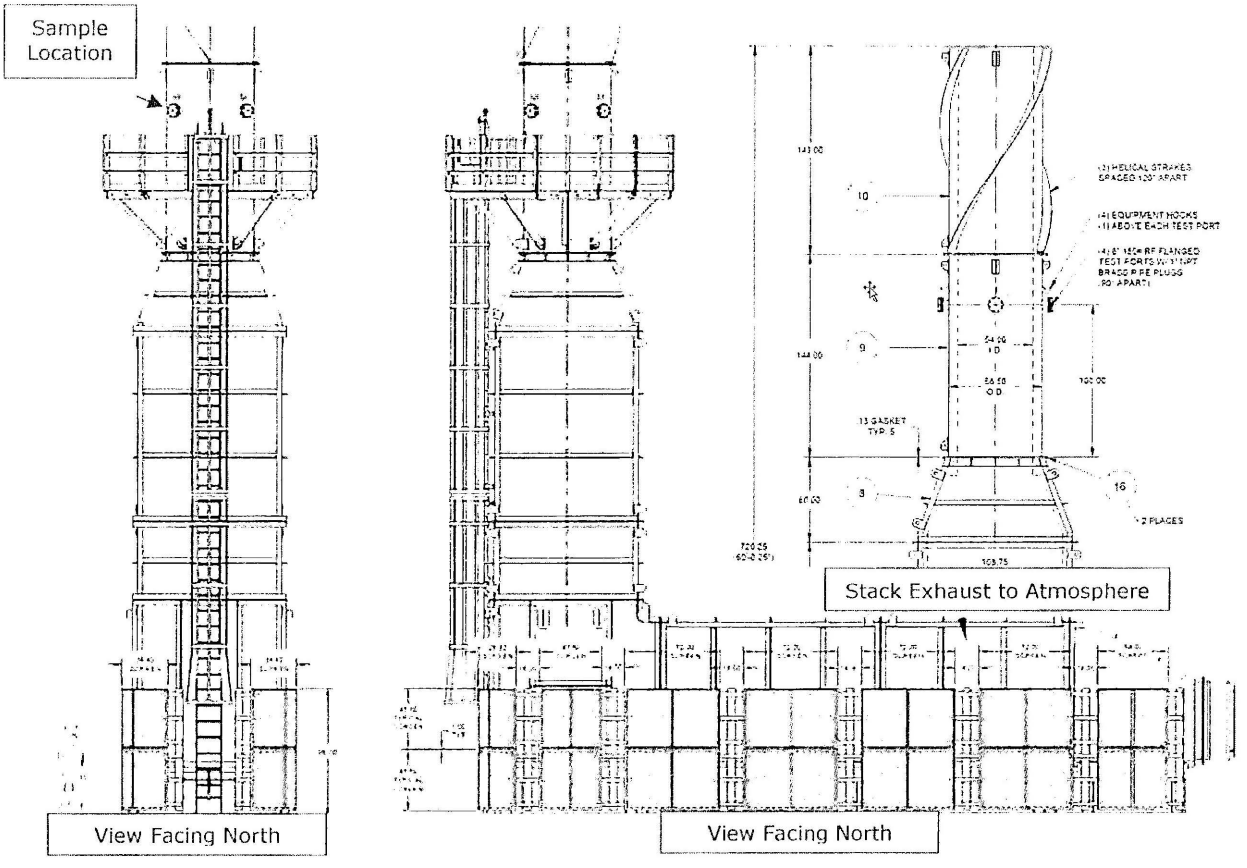
4.2 Sample Location (USEPA Method 1)

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 a rectangular duct to circular stack transition, and
- Approximately 184-inches or 3.4 duct diameters upstream of the stack exit to atmosphere.

The sample ports at the measurement site meet the alternative minimum of 2 stackdiameters downstream and ½ stack diameter upstream of flow disturbances as described in Method 1, § 11.1.1. Refer to Figure 4-1 for a drawing of the EUTURBINE2-2 Exhaust Stack Sample Location.

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



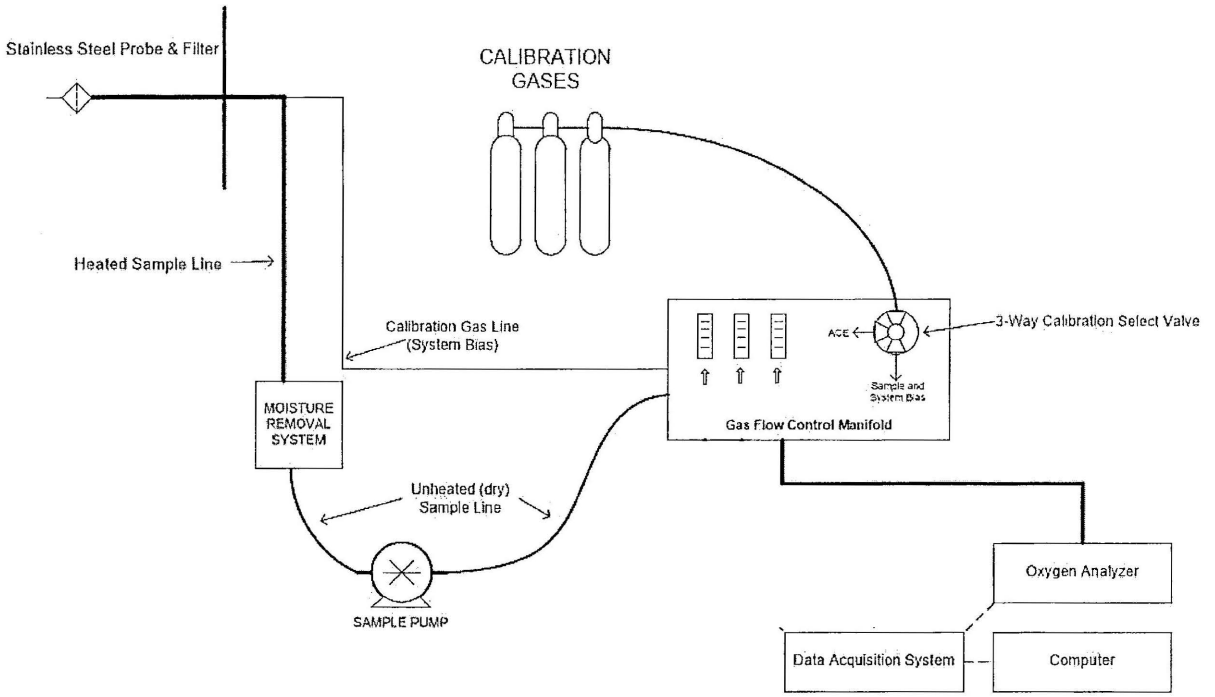
4.3 Oxygen Concentrations (USEPA Method 3A)

Oxygen concentrations were measured following procedures in USEPA Method 3A, Determination of Oxygen and Carbon Dioxide Concentrations in 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. Refer to Figure 4-2 for a drawing of the Method 3A sampling system.

Prior to sampling, the analyzer was calibrated by performing an analyzer calibration error (ACE) test where low-, mid-, and high-level (equivalent to instrument span) calibration gases are introduced directly to the back of the analyzer. The ACE verifies the analyzer responses are within ±2.0% of calibration span or ±0.5% absolute difference.

Following the ACE, an initial measurement system-bias test is performed where the low- and mid- or high- calibration gases are introduced at the sample probe to measure the system response time and verify the system's response is within ±5.0% of span or ±0.5% absolute difference.

Figure 4-2. USEPA Method 3A Sample System



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

Prior to the start of Run 1, a stratification test was performed to determine the appropriate sampling points. Three points on a line passing through the centroidal area of the stack were spaced at 16.7, 50.0, and 83.3 percent of the measurement line. O_2 concentrations were measured for a minimum of twice the system response time at each traverse point. The individual point and mean O_2 concentrations were calculated. Since, the concentrations at each traverse point differed from the mean concentration for all traverse points by no more than ±5.0% of the mean concentration, or ±0.3 percent O_2, samples were collected from a single point that most closely matched the mean.

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 or ±0.5% absolute difference. The analyzer responses are used to correct measured gas concentrations for drift. The average O_2 concentrations for each test run were used to adjust formaldehyde concentrations to 15% O_2.

4.4 Moisture and Formaldehyde (USEPA Method 320)

Formaldehyde and moisture concentrations were measured following the sampling and analytical procedures of USEPA Method 320, *Vapor Phase Organic and Inorganic Emissions by Extractive FTIR.* Exhaust gas was extracted through a heated stainless-steel probe and

heated Teflon® sample line prior to being introduced to a heated-head sampling pump and the FTIR. The stainless-steel probe and Teflon® sample line was maintained at approximately 300°F.

FTIR data was collected using an MKS MultiGas 2030 FTIR spectrometer configured with a StarBoost system. The StarBoost technology consists of a 5-micron infrared detector, optical filtration, and signal amplification. It is designed to optimize signal response and limit instrument noise for low detection limit applications. The FTIR is equipped with a temperature-controlled, 5.11-meter multipass gas cell maintained at 191°C. All data were collected in differential mode with 2 cm-1 resolution sample data and 8 cm-1 resolution background. Each FTIR spectrum was derived from the coaddition of 200 scans, with a new data point generated approximately every 60 seconds. A minimum of 60 minutes of reference spectra data were collected for each run.

Prior to testing, a nitrogen (zero) calibration gas was introduced directly to the FTIR to verify it was free of contaminants. A methane calibration transfer standard (CTS) was introduced used to ensure suitable agreement between the sample and reference spectra. Following the CTS, a calibration gas containing 0.598-ppmv formaldehyde (spike gas) and 250.1 ppmv N_2O (tracer gas) was introduced to the FTIR to verify calibration. The zero and CTS checks were performed through the sampling system and an analyte spike was performed by introducing the formaldehyde and N_2O calibration gas at an approximate 1:10 ratio with the sampled flue gas. The system passed the applicable QA/QC procedures.

An on-site analyte detection limit analysis was performed. The detection limit is calculated as three times the standard deviation of the concentrations from ten representative background spectra taken during the analysis. The detection limit for this test project was 20 ppbv formaldehyde and 0.1% for water.

Following each run, another CTS and zero check were recorded and compared to the pre-test CTS. The pre-test and post-test CTS are required to be within ±5% of the mean value for the run to be valid. Refer to Appendix D for the formaldehyde testing data.

5.0 TEST RESULTS AND DISCUSSION

The test program was conducted on October 6, 2022, to evaluate compliance with the ≤91 parts per billion by volume dry at 15-percent O_2 formaldehyde limit, as required by Table 1 to Subpart YYYY of Part 63 – Emission Limitations.

5.1 Tabulation of Results

The results summarized in Table E-1 indicate EUTURBINE2-2 is operating in compliance with 40 CFR Part 63, Subpart YYYY and PTI 16-21A Limits. The Appendix Table contains detailed results tabulation, process operating conditions, and exhaust gas conditions.

5.2 Significance of Results

The test results indicate compliance with the applicable emissions standard and confirms the turbine operating in enabled SoLoNO$_x$ mode meets Subpart YYYY requirements.

5.3 Variations from Sampling or Operating Conditions

No operating condition variations were observed during the test program.

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. In accordance with 40 CFR 63, Subpart YYYY the EUTURBINE2-2 source is required to demonstrate formaldehyde emissions meet the emission limitations by a performance test on an annual basis.

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 quality 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 and E for additional supporting documentation.

Table 5-1
Summary of 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: Calibration gas standards	Ensure accurate calibration standards	Traceability protocol of calibration gases	Pre-test	Calibration gas uncertainty ≤2.0%
M3A: Calibration Error	Evaluates operation of analyzers	Calibration gases introduces directly into analyzer	Pre-test	±2.0% of the calibration span
M3A: 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
M3A: Stratification Test	Evaluates stratification in duct	Traverse duct and calculate analyte concentration averages	Pre-test	Single Point: each point ±5.0% of the mean or ±0.3% difference
M320: Zero	Verify contaminant free system and detection limit	Calibration gas introduced directly into analyzer	Pre- and Post-test	<detection limit
M320: CTS Direct	Verify analytical stability	Calibration gas directly into analyzer	Pre-test	±5% of calibration value
M320: Analyte Direct	Verify FTIR calibration	Calibration gas directly into analyzer	Pre-test	Verify calibration value

Table 5-1
Summary of QA/QC Procedures

QA/QC Activity	Purpose	Procedure	Frequency	Acceptance Criteria
M320: CTS Response	Verify sample recovery	Calibration gas through sample system	Pre- and Post-test	±5% of direct measurement
M320: Zero Response Spike	Verify leak free analytical system	Calibration gas through sample system	Pre- and Post-test	Bias correct data
M320: Analyte Spike	Evaluates operation of analyzer	Calibration gas into sampling system at ≤10.0% of sampling rate	Pre-test Post-test	average spiked concentration 0.7 to 1.3 times the expected concentration

5.8 Calibration Sheets

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

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.