Derenzo and Associates, Inc.
Environmental Consultants

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AIR QUALITY DIV.

AIR EMISSION TEST REPORT

Title AIR EMISSION TEST REPORT FOR THE VERIFICATION OF NITROGEN OXIDE EMISSIONS FROM A NATURAL GAS FUELED TURBINE

Report Date June 1, 2015

Test Dates May 12, 2015

Facility Information	
Name	Merit Energy Company – Kalkaska Gas Plant
Street Address	1080 Prough Road SW
City, County	Kalkaska, Kalkaska

Facility Permit Information			
Permit No.:	MI-ROP-B4292-2014	Facility SRN :	B4292

Testing Contractor	
Company	Derenzo and Associates, Inc.
Mailing Address	39395 Schoolcraft Road Livonia, MI 48150
Phone	(734) 464-3880
Project No.	1502018

MICHIGAN DEPARTMENT OF ENVIRONMENTAL QUALITY
AIR QUALITY DIVISION

RENEWABLE OPERATING PERMIT
REPORT CERTIFICATION

Authorized by 1994 P.A. 451, as amended. Failure to provide this information may result in civil and/or criminal penalties.

Reports submitted pursuant to R 336.1213 (Rule 213), subrules (3)(c) and/or (4)(c), of Michigan's Renewable Operating Permit (ROP) program must be certified by a responsible official. Additional information regarding the reports and documentation listed below must be kept on file for at least 5 years, as specified in Rule 213(3)(b)(ii), and be made available to the Department of Environmental Quality, Air Quality Division upon request.

Source Name Merit Energy Company - Kalkaska Gas Plant County Kalkaska

Source Address 1080 Prough Road SW City Kalkaska

AQD Source ID (SRN) B4292 ROP No. MI-ROP-B4292-2014 ROP Section No. _____

Please check the appropriate box(es):

☐ **Annual Compliance Certification (Pursuant to Rule 213(4)(c))**

Reporting period (provide inclusive dates): From _____ To _____

☐ 1. During the entire reporting period, this source was in compliance with **ALL** terms and conditions contained in the ROP, each term and condition of which is identified and included by this reference. The method(s) used to determine compliance is/are the method(s) specified in the ROP.

☐ 2. During the entire reporting period this source was in compliance with all terms and conditions contained in the ROP, each term and condition of which is identified and included by this reference, **EXCEPT** for the deviations identified on the enclosed deviation report(s). The method used to determine compliance for each term and condition is the method specified in the ROP, unless otherwise indicated and described on the enclosed deviation report(s).

☐ **Semi-Annual (or More Frequent) Report Certification (Pursuant to Rule 213(3)(c))**

Reporting period (provide inclusive dates): From _____ To _____

☐ 1. During the entire reporting period, **ALL** monitoring and associated recordkeeping requirements in the ROP were met and no deviations from these requirements or any other terms or conditions occurred.

☐ 2. During the entire reporting period, all monitoring and associated recordkeeping requirements in the ROP were met and no deviations from these requirements or any other terms or conditions occurred, **EXCEPT** for the deviations identified on the enclosed deviation report(s).

☒ **Other Report Certification**

Reporting period (provide inclusive dates): From 5/12/15 To 5/12/15

Additional monitoring reports or other applicable documents required by the ROP are attached as described:

Emission verification test report for a natural gas fired turbine and associated waste heat recovery unit (EU-KGPN-TURB-C)

Testing was conducted in accordance with the approved test plan and the facility was operated in compliance with the permit conditions and maximum normal operating conditions for the facility.

I certify that, based on information and belief formed after reasonable inquiry, the statements and information in this report and the supporting enclosures are true, accurate and complete

Kurt Jagoda	Operations Manager	(231) 258-6309
Name of Responsible Official (print or type)	Title	Phone Number

Signature of Responsible Official — Date: 5/28/15

* Photocopy this form as needed.

EQP 5736 (Rev 11-04)

AIR EMISSION TEST REPORT
FOR THE
VERIFICATION OF NITROGEN OXIDE EMISSIONS
FROM A
NATURAL GAS FUELED TURBINE

MERIT ENERGY – KALKASKA GAS PLANT

1.0 INTRODUCTION

Merit Energy (Merit) owns and operates a natural gas fired turbine engine and waste heat recovery unit (WHRU) at the Kalkaska Gas Plant in Kalkaska, Kalkaska County, Michigan (Facility SRN: B4292). The natural gas fired turbine and associated WHRU are identified as emission unit EU-KGPN-TURB-C in Renewable Operating Permit (ROP) No. MI-ROP-B4292-2014 issued by the Michigan Department of Environmental Quality (MDEQ). The turbine is also regulated under 40 CFR Part 60, Subpart KKKK – New Source Performance Standards (NSPS) for Stationary Combustion Turbines.

The conditions of MI-ROP-B4292-2014 indicate that:

1. Annual performance tests shall be conducted to demonstrate compliance with nitrogen oxides (NOx) emissions of 1.2 lb/MW-hr.

2. The NOx testing frequency can be reduced to once every two years if the emission test results are less than or equal to 0.9 lb/MW-hr.

The conditions of 40 CFR Subpart KKKK specify that:

1. For new turbines fired by natural gas with peak heat input rate > 55 million British Thermal Units per hour (MMBtu/hr) and < 850 MMbtu/hr, NOx emission standards are 15 ppm at 15% O_2 or 1.2 lb/MW-hr

2. The testing must be performed at any load condition within plus or minus 25 percent of 100 percent of peak load. The testing may be performed at the highest achievable load point, if at least 75 percent of peak load cannot be achieved in practice.

The annual emission test event was performed by Derenzo and Associates, Inc. (Derenzo and Associates) on May 12, 2015. Derenzo and Associates representatives Jason Logan, Jeff Schlaf, and Blake Beddow performed the field sampling and measurements. MDEQ representatives Mr. Robert Dickman and Mr. Shane Nixon observed portions of the testing project.

Questions regarding this emission test report should be directed to:

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Derenzo and Associates, Inc.
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Mr. Sean Craven
Project Manager
Merit Energy Company
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Kalkaska, MI 49646
Ph: (231) 258-6369

Report Certification

This test report was prepared by Derenzo, Associates, Inc. based on field sampling data collected by Derenzo and Associates, Inc. Facility process data were collected and provided by Merit Energy employees or representatives. This test report has been reviewed by Merit Energy representatives and approved for submittal to the MDEQ. A signed ROP report certification (EQP 5736) accompanies this report.

I certify that the testing was conducted in accordance with the specified test methods and submitted test plan unless otherwise specified in this report. I believe the information provided in this report and its attachments are true, accurate, and complete.

Report Prepared By:

Jason Logan
Environmental Consultant
Derenzo and Associates, Inc.

Reviewed by:

Robert L. Harvey, P.E.
General Manager
Derenzo and Associates, Inc.

2.0 SOURCE AND SAMPLING LOCATION DESCRIPTION

2.1 General Process Description

Merit operates a gas-fired turbine (EU-KGPN-TURB-C) at the Kalkaska Gas Plant in Kalkaska, Michigan that is fueled exclusively with natural gas. The turbine is used for plant electrical production. In addition, a natural gas-fired duct burner that has a rated heat input of 28.0 MMbtu/hr, is used with the WHRU to heat thermal oil for other processes at the facility.

The operating parameters (i.e., turbine load and natural gas use rate) are synchronized with the Great Lakes Power Grid. The turbine control system automatically adjusts power output depending on the needs of the power grid. The WHRU operates as necessary when there is a demand for heated oil in the facility.

2.2 Rated Capacities and Air Emission Controls

The natural gas fueled turbine has a rated heat input of 60.2 MMBtu/hr and the duct burner associated with the WHRU has a rated heat input rate of 28.0 MMBtu/hr. The turbine is equipped with dry low NOx burners that are designed to pre-mix the fuel and combustion air at ratio that minimizes burners temperatures and NO_X formation. The exhaust gas is used to heat oil in the WHRU and is released to atmosphere without additional add-on emission controls.

2.3 Sampling Locations

The turbine exhaust gas is released to the atmosphere through a dedicated vertical exhaust stack.

The exhaust stack has an inner diameter of 45 inches, and is equipped with two (2) sample ports, opposed 90°, that provide a sampling location 48 inches (~1 duct diameters) upstream and 180 inches (4 duct diameters) downstream from any flow disturbance. This satisfies the USEPA Method 1 criteria for a representative sample location.

Appendix A provides diagrams of the emission test sampling locations.

3.0 SUMMARY OF TEST RESULTS AND OPERATING CONDITIONS

3.1 Purpose and Objective of the Tests

The conditions of Renewable Operating Permit (ROP) No. MI-ROP-B4292-2014 and 40 CFR Part 60 Subpart KKKK require Merit to test nitrogen oxides (NOx) emissions from EU-KGPN-TURB-C annually, or bi-annually, depending on the result of the previous stack test.

3.2 Operating Conditions During the Compliance Tests

The testing was performed while the turbine was operated at maximum achievable operating conditions (100% load +/- 25%). Merit representatives provided MW output data in 15-minute intervals for each test period. The turbine generator output ranged between 4.60 and 4.64 MW for each test period.

Fuel feed rate (cubic feet per minute) was recorded by Merit representatives in 15-minute intervals for each test period. The average fuel consumption rate of the turbine ranged between 1,366 and 1,375 scfm. The average fuel consumption rate of the WHRU ranged between 536 and 557 scfm.

Appendix B provides operating records provided by Merit representatives for the test periods.

Table 3.1 presents a summary of the average turbine emissions and operating conditions during the test periods.

3.3 Summary of Air Pollutant Sampling Results

The gas exhausted from the natural gas fueled turbine (EU-KGPN-TURB-C) was sampled for three (3) one-hour test periods during the compliance testing performed May 12, 2015.

Test results for each one hour sampling period are presented in Table 6.1 of this report.

Table 3.1 Average turbine emissions and operating conditions during the test periods

Turbine Parameter	EU-KBPN-TURB-C
Generator output (MW)	4.62
Turbine fuel use (scfm)	1,372
WHRU fuel use (scfm)	547
Exhaust Flowrate (scfm)	30,701
NOx Emission Rate (lb/MW-hr)	0.45
NOx Concentration (ppmvd at 15% O_2	7.1

4.0 SAMPLING AND ANALYTICAL PROCEDURES

A test protocol for the air emission testing was reviewed and approved by the MDEQ. This section provides a summary of the sampling and analytical procedures that were used during the testing periods.

4.1 Summary of Sampling Methods

USEPA Method 1	Exhaust gas velocity measurement locations were determined based on the physical stack arrangement and requirements in USEPA Method 1
USEPA Method 2	Exhaust gas velocity pressure was determined using a Type-S Pitot tube connected to a red oil incline manometer; temperature was measured using a K-type thermocouple connected to the Pitot tube.
USEPA Method 3A	Exhaust gas O_2 and CO_2 content was determined using zirconia ion/paramagnetic and infrared instrumental analyzers, respectively.
USEPA Method 4	Exhaust gas moisture was determined based on the water weight gain in chilled impingers.
USEPA Method 7E	Exhaust gas NOx concentration was determined using chemiluminescence instrumental analyzer.
USEPA Method 205	Verification of Dilution Systems for Field Instrument Calibrations

4.2 Exhaust Gas Velocity Determination (USEPA Method 2)

The turbine exhaust stack gas velocity and volumetric flowrate was determined using USEPA Method 2 prior to and after each test. An S-type Pitot tube connected to a red-oil manometer was used to determine velocity pressure at each traverse point across the stack cross section. Gas temperature was measured using a K-type thermocouple mounted to the Pitot tube. The Pitot tube and connective tubing were leak-checked periodically to verify the integrity of the measurement system.

The absence of significant cyclonic flow for the exhaust configuration was verified using an S-type Pitot tube and oil manometer. The Pitot tube was positioned at each velocity traverse point with the planes of the face openings of the Pitot tube perpendicular to the stack cross-sectional plane. The Pitot tube was then rotated to determine the null angle (rotational angle as measured from the perpendicular, or reference, position at which the differential pressure is equal to zero).

Appendix C provides exhaust gas flowrate calculations and field data sheets.

4.3 Exhaust Gas Molecular Weight Determination (USEPA Method 3A)

CO_2 and O_2 content in the turbine exhaust gas was measured continuously throughout each test period in accordance with USEPA Method 3A. The CO_2 content of the exhaust was monitored using a Servomex 4900 single beam single wavelength (SBSW) infrared gas analyzer. The O_2 content of the exhaust was monitored using a Servomex 4900 gas analyzer that uses a paramagnetic sensor.

During each sampling period, a continuous sample of the turbine exhaust gas stream was extracted from the stack using a stainless steel probe connected to a Teflon® heated sample line. The sampled gas was conditioned by removing moisture prior to being introduced to the analyzers; therefore, measurement of O_2 and CO_2 content correspond to standard dry gas conditions. Instrument response data were recorded using an ESC Model 8816 data acquisition system that monitored the analog output of the instrumental analyzers continuously and logged data as one-minute averages.

Prior to, and at the conclusion of each test, the instruments were calibrated using upscale calibration and zero gas to determine analyzer calibration error and system bias (described in Section 5.0 of this document). Sampling times were recorded on field data sheets.

Appendix D provides O_2 and CO_2 calculation sheets. Raw instrument response data are provided in Appendix E.

4.4 Exhaust Gas Moisture Content (USEPA Method 4)

Moisture content of the turbine exhaust gas was determined in accordance with USEPA Method 4 using a chilled impinger sampling train. The moisture sampling was performed concurrently with the instrumental analyzer sampling. During each sampling period a gas sample was extracted at a constant rate from the source where moisture was removed from the sampled gas stream using impingers that were submersed in an ice bath. At the conclusion of each sampling period, the moisture gain in the impingers was determined gravimetrically by weighing each impinger to determine net weight gain.

4.5 NO_x Concentration Measurements (USEPA Method 7E)

NO_X pollutant concentrations in the turbine exhaust gas streams were determined using a Thermo Environmental Instruments, Inc. (TEI) Model 42c High Level chemiluminescence NO_X analyzer.

Throughout each test period, a continuous sample of the turbine exhaust gas was extracted from the stack using the Teflon® heated sample line and gas conditioning system and delivered to the instrumental analyzers. Instrument response for each analyzer was recorded on an ESC Model 8816 data acquisition system that logged data as one-minute averages. Prior to, and at the conclusion of

each test, the instruments were calibrated using upscale calibration and zero gas to determine analyzer calibration error and system bias.

Appendix D provides NO_X calculation sheets. Raw instrument response data are provided in Appendix E.

5.0 QA/QC ACTIVITIES

5.1 NO_x Converter Efficiency Test

The NO_2 – NO conversion efficiency of the Model 42c analyzer was verified prior to the testing program. A USEPA Protocol 1 certified concentration of NO_2 was injected directly into the analyzer, following the initial three-point calibration, to verify the analyzer's conversion efficiency. The analyzer's NO_2 – NO converter uses a catalyst at high temperatures to convert the NO_2 to NO for measurement. The conversion efficiency of the analyzer is deemed acceptable if the measured NO_2 concentration is within 90% of the expected value.

The NO_2 – NO conversion efficiency test satisfied the USEPA Method 7E criteria (measured NO_2 concentration was -6.64% of the expected value, i.e., within 10% of the expected value as required by Method 7E).

5.2 Gas Divider Certification (USEPA Method 205)

A STEC Model SGD-710C 10-step gas divider was used to obtain appropriate calibration span gases. The ten-step STEC gas divider was NIST certified (within the last 12 months) with a primary flow standard in accordance with Method 205. When cut with an appropriate zero gas, the ten-step STEC gas divider delivers calibration gas values ranging from 0% to 100% (in 10% step increments) of the USEPA Protocol 1 calibration gas that was introduced into the system. The field evaluation procedures presented in Section 3.2 of Method 205 were followed prior to use of gas divider. The field evaluation yielded no errors greater than 2% of the triplicate measured average and no errors greater than 2% from the expected values.

5.3 Instrumental Analyzer Interference Check

The instrumental analyzers used to measure NO_X, O_2 and CO_2 have had an interference response test performed prior to their use in the field, pursuant to the interference response test procedures specified in USEPA Method 7E. The appropriate interference test gases (i.e., gases that would be encountered in the exhaust gas stream) were introduced into each analyzer, separately and as a mixture with the analyte that each analyzer is designed to measure. All of analyzers exhibited a composite deviation of less than 3.0% of the span for all measured interferent gases. No major analytical components of the analyzers have been replaced since performing the original interference tests.

5.4 Instrument Calibration and System Bias Checks

At the beginning of each day of the testing program, initial three-point instrument calibrations were performed for the NO_x, CO_2 and O_2 analyzers by injecting calibration gas directly into the inlet sample port for each instrument. System bias checks were performed prior to and at the conclusion of each sampling period by introducing the upscale calibration gas and zero gas into the sampling system (at the base of the stainless steel sampling probe prior to the particulate filter and Teflon® heated sample line) and determining the instrument response against the initial instrument calibration readings.

The instruments were calibrated with USEPA Protocol 1 certified concentrations of CO_2, O_2, and NO_x in nitrogen and zeroed using hydrocarbon free nitrogen. A STEC Model SGD-710C ten-step gas divider was used to obtain intermediate calibration gas concentrations as needed.

5.5 Determination of Exhaust Gas Stratification

A stratification test was performed for the turbine exhaust stack. The stainless steel sample probe was positioned at sample points correlating to 16.7, 50.0 (centroid) and 83.3% of the stack diameter. Pollutant concentration data were recorded at each sample point for a minimum of twice the maximum system response time.

The recorded concentration data for the turbine exhaust stack indicated that the measured NOx concentrations were minimally stratified (i.e. varied by more than 5% of the three-point mean, but not more than 10%). Therefore, the sampling probe was placed at three points during each one hour test, and each point was sampled for an equal amount of time (i.e. 20 minutes per point).

5.6 Meter Box Calibrations

The isokinetic metering console, which was used for exhaust gas moisture content sampling, was calibrated prior to and after the testing program. This calibration uses the critical orifice calibration technique presented in USEPA Method 5. The metering console calibration exhibited no data outside the acceptable ranges presented in USEPA Method 5.

The digital pyrometer in the metering console was calibrated using a NIST traceable Omega® Model CL 23A temperature calibrator.

Appendix F presents test equipment quality assurance data for the emission test equipment (NO_2 – NO conversion efficiency test data, instrument calibration and system bias check records, calibration gas and gas divider certifications, interference test results, meter box calibration records, Pitot tube calibration records).

6.0 RESULTS

6.1 Test Results and Allowable Emission Limits

Turbine operating data and air pollutant emission measurement results for each one-hour test period are presented in Table 6.1.

The measured NO_X concentration was approximately 10 ppmvd with an exhaust gas oxygen content of 13%. The adjusted NOx concentration was 7.1 ppmvd at 15% oxygen.

The calculated NO_X mass emission rate is 2.07 lb/hr. Based on a turbine generator output of 4.62 MW, this is equivalent to an emission rate of 0.45 lb/MW-hr. Only the turbine generator output (MW) was used to determine total gross power output in the NOx emission factor calculation. Duct burner fuel use (or useful recovered thermal output) was not added to the gross power output term; the lb/MW-hr emission rate was less than the applicable limit without including the additional combined cycle thermal contribution from the duct burner.

The measured air pollutant concentrations and emission rates for EU-KGPN-TURB-C are less than the allowable limits specified in Renewable Operating Permit (ROP) No. MI-ROP-B4292-2014:

- 1.2 lb/MW-hr or
- 15ppm at 15% oxygen for NO_X;

6.2 Variations from Normal Sampling Procedures or Operating Conditions

The testing for all pollutants was performed in accordance with the approved test protocol. The turbine was operated maximum achievable operating conditions and no variations from the normal operating conditions occurred during the test periods.

Table 6.1 Summary of EU-KGPN-TURB-C Test Results
Merit Energy – Kalkaska Gas Plant, Kalkaska, Kalkaska County, Michigan

Test No.	1	2	3	
Test Date	05/12/15	05/12/15	05/12/15	Test
Test Period (24-hr clock)	8:50-9:50	10:25-11:25	11:45-12:45	Avg.
Turbine Output (MW)	4.63	4.60	4.64	4.62
Load Percentage (%)	86.7%	86.4%	86.2%	86.4%
Turbine Fuel Consumption (scfm)	1,375	1,366	1,375	1,372
WHRU Fuel Consumption (scfm)	557	536	548	547
Exhaust gas composition				
CO_2 content (% vol)	4.2	4.2	4.1	4.2
O_2 content (% vol)	13.0	13.0	13.2	13.1
Moisture (% vol)	8.2	7.6	7.8	7.9
Exhaust gas flowrate				
Standard conditions (scfm)	32,842	32,983	34,065	33,297
Dry basis (dscfm)	30,250	30,447	31,405	30,701
Nitrogen oxides emission rates				
NO_X conc. (ppmvd)*	10.2	8.7	9.3	9.4
NO_X conc. (ppmvd at 15% O_2)*	7.6	6.6	7.1	7.1
*NO_X conc. permit limit(ppmvd at 15% O_2)**				*15*
NO_X emissions (lb/hr NO_2)	2.22	1.91	2.09	2.07
NO_X emissions (lb/MW-hr NO_2)	0.48	0.42	0.45	0.45
NO_X permit limit (lb/MW-hr)				*1.20*

*Corrected for calibration bias.