DEQ

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: Wolverine Power, Gaylord Generating Station County: Otsego

Source Address: 2700 Millbocker Road City: Ggaylord

AQD Source ID (SRN): N6833 ROP No.: N6833-2010 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 8/26/2014 To 8/28/2014

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

Enclosed compliance 5-year test report for turbine NOx emission verification. Testing was performed in accordance with the test protocol dated July 27, 2014.

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

Brian L. Warner, CHMM	VP of Environmental Strategy	231-775-5700
Name of Responsible Official (print or type)	Title	Phone Number

Signature of Responsible Official Date: 10/2/14

* Photocopy this form as needed.

EQP 5736 (Rev 11-04)

EMISSION TEST REPORT

Title	COMPLIANCE TEST REPORT FOR THE VERIFICATION OF NITROGEN OXIDE EMISSIONS FROM THREE NATURAL GAS FIRED TURBINES
Report Date	October 8, 2014
Test Date(s)	August 26 - 28, 2014

Facility Information	
Name	Wolverine Power Supply Cooperative, Inc.
Street Address	2700 Millbocker Road
City, County	Gaylord, Otsego

Facility Permit Information			
State Registration No.:	N6833	MI-ROP No.:	N6833-2010

Testing Contractor	
Company	Derenzo and Associates, Inc.
Mailing Address	39395 Schoolcraft Rd Livonia MI 48150
Phone	(734) 464-3880
Project No.	1406012

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ROP COMPLIANCE TEST REPORT
FOR THE
VERIFICATION OF
NITROGEN OXIDES EMISSIONS FROM
NATURAL GAS FIRED TURBINES

WOLVERINE POWER SUPPLY COOPERATIVE

1.0 INTRODUCTION

Wolverine Power Supply Cooperative, Inc. (Wolverine Power) State Registration Number (SRN) N6833 retained Derenzo and Associates, Inc. to perform testing for the determination of nitrogen oxides (NOx) emissions from the exhaust of three (3) natural gas fired turbines at the facility located at 2700 Millbocker Road in Gaylord, Otsego County, Michigan.

The Michigan Department of Environmental Quality, Air Quality Division (MDEQ-AQD) Renewable Operating Permit issued to Wolverine Power (MI-ROP-N6833-2010) requires the verification of NO_x emission rates for each of the 3 turbines; EUTURBINE01, EUTURBINE02, and EUTURBINE03 (flexible group FGTURBINE includes).

The compliance testing was performed by Derenzo and Associates, Inc. (Derenzo and Associates) representatives Jason Logan and Daniel Wilson on August 26-28, 2014. Mr. Jeremy Howe from the MDEQ-AQD was on-site to observe portions of the compliance testing. Process coordination was provided by Mr. Jim Tucker of Wolverine Power.

The emissions sampling was performed using procedures specified in the Test Plan dated July 17, 2014. A test plan approval letter was sent by the MDEQ dated August 6, 2014.

Questions regarding this emission test report should be directed to:

Mr. Jason Logan
Environmental Consultant
Derenzo and Associates, Inc.
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(734) 464-3880

Mr. Brian Warner
Wolverine Power Supply Cooperative
10125 West Watergate Road
PO Box 229
Cadillac, Michigan 49601
(231) 775-5700

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 Wolverine Power employees or representatives.

I certify that the testing was conducted in accordance with the approved 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.

This test report has been reviewed by Wolverine Power representatives and approved for submittal to the Michigan Department of Environmental Quality. I certify that the facility operating conditions were in compliance with permit requirements and were at the maximum routine operating conditions for the facility. Based on information and belief formed after reasonable inquiry, the statements and information in this report are true, accurate and complete.

Brian Warner
Vice President, Environmental Affairs
Wolverine Power Cooperative

2.0 SUMMARY OF TEST RESULTS

The exhaust gas from each of the three turbine engines was analyzed for NO_x, oxygen (O_2) and carbon dioxide (CO_2) content using instrumental analyzers. Mass emission rates for NO_X were calculated using USEPA Reference Method 19 based on analysis of the natural gas fuel.

During the testing, the turbines were operated at full load (100%), 75% load, and 50% load. Three (3) sampling periods were performed at each operating condition (i.e., a total of 9 test periods per turbine).

The results of the emissions testing project are summarized in Table 2.1 below. Data and results for each test period are presented in Section 5.0 of this document and Tables 5.1 through 5.9. These test results verify that Turbine Nos. 1, 2, and 3 operate in compliance with the emission limits specified in MI-ROP-N6833-2010 at each tested load.

Table 2.1 Summary of measured turbine engine NOx emissions

Emission Unit	Operating Load	NOx Emissions (lb/MMBtu)	NOx Emissions (lb/hr)
EUTURBINE01	100%	0.30	87.1
EUTURBINE01	75%	0.27	65.2
EUTURBINE01	50%	0.25	47.4
EUTURBINE02	100%	0.37	110.1
EUTURBINE02	75%	0.31	74.1
EUTURBINE02	50%	0.28	51.3
EUTURBINE03	100%	0.34	101.7
EUTURBINE03	75%	0.29	71.8
EUTURBINE03	50%	0.27	50.3
Permit Limits	--	0.48	168.5

3.0 SOURCE DESCRIPTION

3.1 General Process Description

Wolverine Power is an electrical co-op that operates three natural gas fired turbines to generate electricity for export to the local electricity distribution grid. The turbines are General Electric Frame 5N simple cycle combustion turbines.

3.2 Rated Capacities, Type and Quantity of Raw Materials Used

The natural gas turbines have a rated heat input rate of 351 million British thermal units per hour (MMBtu/hr) and a rated electricity generation capacity of 23.4 megawatts (MW) each. The turbines are fueled exclusively with pipeline quality natural gas.

3.3 Emission Control System Description

The turbines are not equipped with add-on emission control equipment. Combustion emissions are minimized through proper operation and maintenance of the combustion system. Turbine exhaust gas is released directly to atmosphere through individual exhaust stacks.

Appendix A provides process data for Turbine Nos. 1, 2, and 3.

4.0 SAMPLING AND ANALYTICAL PROCEDURES

A test plan for the compliance testing was prepared by Wolverine Power and Derenzo and Associates and reviewed by the MDEQ-AQD. This section provides a summary of the sampling and analytical procedures that were used during the test and presented in the test plan.

4.1 Sampling Locations (USEPA Method 1)

The configuration of the turbine exhaust stack sample locations satisfied the USEPA Method 1 criteria for a representative sample location. Four (4) equally-spaced sample ports were installed in the rectangular stack and a cross-sectional grid was developed for sampling the turbine exhaust gas. The grid consisted of three (3) equally-spaced sample points for each sample port (total of 12 sample points). Each rectangular stack measures 147 inches by 122 inches, resulting in a calculated equivalent diameter (De) of 132 inches (11.1 feet).

$De = (2 \times L \times W) / (L+W) = 133$ inches

The sampling point locations were determined in accordance with USEPA Method 1.

Appendix B provides diagrams of the performance test sampling location.

4.2 Exhaust Gas Molecular Weight Determination (USEPA Methods 3A)

CO_2 and O_2 content in the exhaust gas stream was measured continuously throughout each test period in accordance with USEPA Method 3A. The CO_2 content of the exhaust was monitored using a non-dispersive infrared (NDIR) gas analyzer. The O_2 content of the exhaust was monitored using a gas analyzer that utilizes a paramagnetic sensor.

During each pollutant sampling period, a continuous sample of the exhaust gas stream was extracted from the stack using a stainless steel probe connected to a Teflon® heated sample line. The sample probe was placed in the stack upstream from the sample port openings (to avoid any infiltration of ambient air into the sampling system). The sampled gas was filtered and conditioned by removing moisture prior to being introduced to the analyzer. Therefore, measurement of O_2 and CO_2 content correspond to standard dry gas conditions. Instrument response for each analyzer was recorded on an ESC Model 8816 data logging 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 appropriate upscale calibration and zero gas to determine analyzer calibration error and system bias (described in Section 4.5.1 of this document).

Appendix C presents gas sampling procedures and diagrams for the USEPA Method 3A sampling train.

4.3 NO_X Concentration Measurements (USEPA Method 7E)

NO_X pollutant concentration in the turbine exhaust gas was 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 engine exhaust gas was extracted from the stack using the Teflon® heated sample line and gas conditioning system described in Section 4.3 and Appendix C of this document, and delivered to the instrumental analyzer. Prior to, and at the conclusion of each test, the instrument was calibrated using appropriate upscale calibration and zero gas to determine analyzer calibration error and system bias (described in Section 4.5.1 of this document).

4.4 NO_X Emission Rate Determination (USEPA Method 19)

The NO_X mass emission rate for each turbine was calculated based on analysis of the fuel gas and the equations provided in USEPA Method 19 for the Oxygen-Based F Factor, Dry Basis. The F factor is a ratio of the volume of combustion components per unit of heat input. A third-party analysis of the fuel used on each test day provided sulfur, fixed gas (oxygen, nitrogen, and carbon dioxide) and hydrocarbon (methane, ethane, propane, etc.) contents in weight percent. The fuel analytical results were used to calculate the weight percent of individual elemental components of the fuel (C, H, O, N and S), which were used to calculate the fuel F-factor (F_d) using Method 19 equation 19-13.

The heat input rate for each test period was calculated based on the recorded fuel use rate and the natural gas heating value reported by the laboratory.

Appendix F provides the laboratory analytical report for the three fuel samples.

4.5 Instrumental Analyzer Quality Assurance Verification

4.5.1 Instrument Calibration and System Bias Checks

At the beginning of each day, initial three-point instrument calibrations were performed 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 appropriate 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 verifying the instrument response against the initial instrument calibration readings.

The Method 3A and 7E instruments were calibrated with USEPA Protocol 1 certified concentrations of CO_2, O_2, and NO_x in nitrogen and zeroed using nitrogen.

A STEC Model SGD-710C ten-step gas divider was used to obtain intermediate calibration gas concentrations as needed.

4.5.2 Sampling System Response Time Determination

The response time of the sampling system was determined prior to the compliance test program by introducing upscale gas and zero gas, in series, into the sampling system using a tee connection at the base of the sample probe. The elapsed time for the analyzer to display a reading of 95% of the expected concentration was determined using a stopwatch.

The individual test periods commenced once the sampling probe had been in place for at least twice the maximum system response time.

4.5.3 Determination of Exhaust Gas Stratification

A stratification test for each turbine exhaust stack was performed during the first performance test for each turbine. The stainless steel sample probe was positioned at sample points in each port correlating to 16.7, 50.0 (centroid) and 83.3% of the stack diameter (30.1 inches, 70.75 inches and 111.4 inches from the stack wall along the 122" dimension of each exhaust stack). Therefore a total of 12 points were sampled during the stratification test. Pollutant concentration data were recorded at each sample point for a minimum of twice the maximum system response time.

The recorded data for the EUTURBINE01 exhaust stack indicates that the measured O_2, CO_2 and NO_X concentrations varied by more than 5%, but less than 10%, of the mean ppm or percent value for each analyte. Therefore EUTURBINE01 was minimally stratified and three points were used in the sampling port which closely resembled the average. These three points were sampled for 7 minutes each, which accounts for a 21 minute test. For EUTURBINE02, the O_2, CO_2 and NO_X concentrations varied by more than 10%. Each of the 12 points were sampled for three minutes for each test period. Recorded data for EUTURBINE03 indicates the measured concentrations did not vary at each point by more than 5% of the mean value. Therefore EUTURBINE03 pollutant concentrations were not considered stratified and a single point which closely represented the mean was used for the test sample location.

Stratification calculation worksheets are provided in Appendix E.

4.5.4 NO_X Converter Test

The NO_2 – NO conversion efficiency of the TEI Model 42C instrumental analyzer was verified on-site prior to the commencement of the performance tests. The instrument analyzer NO_2 – NO converter uses a catalyst at high temperatures to convert the NO_2 to NO for measurement. A USEPA Protocol 1 certified NO_2 calibration gas was used to verify the efficiency of the NO_2 – NO converter.

The NO_2 – NO conversion efficiency test satisfied the USEPA Method 7E criteria (the calculated NO_2 – NO conversion efficiency is greater than or equal to 90%).

4.5.5 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 previous 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 introduced into the system. The field evaluation procedures presented in Section 3.2 of Method 205 were followed prior to use of gas divider.

4.5.6 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 the 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.

Appendix D presents test equipment quality assurance data (NO_2 – NO conversion efficiency test data, stratification test data, instrument calibration and system bias check records, calibration gas and gas divider certifications, and interference test results).

5.0 TEST RESULTS AND DISCUSSION

5.1 Operating Conditions During the Compliance Test

During the compliance test program, each turbine was operated at approximately 100% of maximum load, 75% of maximum load, and 50% of maximum load. The actual operating loads and percent capacities are presented in the table below.

	100% Load		75% Load		50% Load	
Emission Unit	Generation Rate (MW)	Percent of Capacity	Generation Rate (MW)	Percent of Capacity	Generation Rate (MW)	Percent of Capacity
Turbine 1	22.1	94.6%	16.2	69.3%	10.9	46.5%
Turbine 2	22.1	94.6%	16.7	71.3%	10.9	46.5%
Turbine 3	21.7	92.6%	16.6	70.8%	10.9	46.5%

The natural gas fuel used in each turbine was sampled and analyzed by a third-party laboratory for heating value (Btu/dscf). Fuel use rate for each test period was measured by Wolverine Power using permanently-installed fuel use meters (Mcf/hr or 1,000 cubic feet of fuel per hour).

Emission Unit	Fuel Heating Value (Btu/dscf)	Avg. Fuel Use 100% Load (Mcf/hr)	Avg. Fuel Use 75% Load (Mcf/hr)	Avg. Fuel Use 50% Load (Mcf/hr)
Turbine 1	991	294	241	190
Turbine 2	972	305	243	187
Turbine 3	990	306	248	190

Operating data are provided in Appendix A; natural gas analytical results are provided in Appendix F.

A site-specific fuel F-factor (F_d) was calculated based on an analysis of the fuel and equation 19-13 in USEPA Method 19. The calculated F-factor for the three gas samples ranged between

8,490 and 8,493 dscf/MMBtu; the default natural gas F-factor specified in USEPA Method 19 is 8,710 dscf/MMBtu.

Fuel F-factor calculations are provided in Appendix E.

5.2 NO_x Emission Rate Measurement Results

The turbine engine exhaust gas streams were sampled at three operating loads. Instrumental analyzers were used to measure concentrations of NO_X, O_2, and CO_2 in the exhaust gas.

The NOx mass emission rate in pounds per million Btu (lb/MMBtu) was calculated for each test period using the measured NOx and O_2 concentrations (dry basis) and the Oxygen-Based F Factor, Dry Basis equation presented in USEPA Method 19:

$$E_{NOx} = C_{NOx} * 1.19E\text{-}07 * F_d * (20.9 / (20.9 - \%O_2))$$

Where:	E_{NOx}	= NO_x emission rate (lb/MMBtu)
	C_{NOx}	= measured NO_x concentration, dry basis (ppmvd)
	1.19E-07	= USEPA Method 19 conversion factor, ppmv to lb/scf
	F_d	= Calculated F factor, dry basis, dscf/MMBtu
	$\%O_2$	= measured exhaust gas O_2 concentration (% vol. dry basis)

The NOx mass emission rate in pounds per hour (lb/hr) was calculated based on the measured natural gas heat content (laboratory analytical data), fuel use rate and NOx emission rate (lb/MMBtu):

$$E'_{NOx} = E_{NOx} * HV * U / 1{,}000$$

Where:	E'_{NOx}	= NO_x mass emission rate (lb/hr)
	E_{NOx}	= NO_x emission rate, heat input basis (lb/MMBtu)
	HV	= Fuel heating value (Btu/dscf)
	U	= Fuel use rate (Mcf/hr)

The NO_X emission rate for the three gas-fired turbine engines (27 individual test periods) ranged between 0.25 and 0.38 lb/MMBtu. The calculated mass emission rate (lb/hr) is generally in proportion to the operating load.

Tables 5.1 through 5.3 present measured exhaust gas conditions and pollutant emission rates for EUTURBINE01.

Tables 5.4 through 5.6 present measured exhaust gas conditions and pollutant emission rates for EUTURBINE02.

Tables 5.7 through 5.9 present measured exhaust gas conditions and pollutant emission rates for EUTURBINE03.

Appendix E provides field data and emission calculations for each turbine.

Appendix G provides raw instrumental analyzer response data for the compliance test program.

5.3 Emission Compliance Determination

MI-ROP-N6833-2010 issued to Wolverine Power specifies maximum allowable NO_X emission rates for each GE Frame 5 turbine in the flexible emission group FGTURBINE (containing EUTURBINE01, EUTURBINE02, and EUTURBINE03). The allowable NOx emission rates for each turbine are 0.48 lb/MMBtu and 168.5 lb/hr. The measured NOx emission rates for each turbine (Turbine Nos. 1, 2 and 3) were less than the permitted NOx emission limits at each operating condition.

5.4 Variations from Normal Sampling Procedures or Operating Conditions

The testing was performed in accordance with the Test Plan dated July 17, 2014 and the specified USEPA test methods. All instrument calibrations and sampling period results for Turbine Nos. 1, 2, and 3 satisfied the quality assurance verifications required by USEPA Methods 3A, 7E, 19, and 205.

Table 5.1 Measured exhaust gas conditions and air pollutant emission rates for Wolverine Power Turbine No. 1 at 100% load

Test No.	1	2	3	
Test date	08/26/14	08/26/14	08/26/14	Test
Test period (24-hr clock)	08:35-09:43	10:11-10:31	10:50-11:10	Avg.
Turbine Generation (MW)	22.3	22.2	22.0	22.1
Fuel Heat Content (Btu/dscf)	991.3	991.3	991.3	991.3
Fuel Flow Rate (Mcfh)	292.0	290.0	301.0	294.3
Heat Input (MMBtu/hr)	289	287	298	292
Exhaust gas composition				
CO_2 content (% vol)	2.36	2.48	2.49	2.44
O_2 content (% vol)	16.94	16.91	16.83	16.89
Nitrogen oxides emission rates				
NO_X conc. (ppmvd)*	54.8	57.3	57.9	56.7
NO_X emissions (lb/hr)	84.6	87.2	89.6	87.1
NO_X permit limit (lb/hr)				*168.5*
NO_X emissions (lb/mmBTU)	0.29	0.30	0.30	0.30
NO_X permit limit (lb/mmBTU)				*0.48*

* Corrected for calibration bias.
MW - Megawatt
Btu/dscf - heat content in British themal units per dry standard cubic feet
lb/MMBtu - pound of pollutant per million British thermal units
MMBtu/hr – Million British thermal units per hour
% Volume - % of gas in measured air stream
ppmvd – parts per million by volume, dry basis
lb/hr – mass emission rate in pounds per hour

Table 5.2 Measured exhaust gas conditions and air pollutant emission rates for Wolverine Power Turbine No. 1 at 75% load

Test No.	1	2	3	
Test date	08/26/14	08/26/14	08/26/14	Test
Test period (24-hr clock)	11:28-11:48	12:05-12:25	12:41-13:01	Avg.
Turbine Generation (MW)	16.2	16.2	16.3	16.2
Fuel Heat Content (Btu/dscf)	991.3	991.3	991.3	991.3
Fuel Flow Rate (Mcfh)	240.5	240.5	242.5	241.2
Heat Input (MMBtu/hr)	238	238	240	239
Exhaust gas composition				
CO_2 content (% vol)	1.95	1.95	1.95	1.9
O_2 content (% vol)	17.76	17.77	17.76	17.76
Nitrogen oxides emission rates				
NO_X conc. (ppmvd)*	39.9	40.7	41.0	40.6
NO_X emissions (lb/hr)	64.0	65.4	66.3	65.2
NO_X permit limit (lb/hr)				*168.5*
NO_X emissions (lb/mmBTU)	0.27	0.27	0.28	0.27
NO_X permit limit (lb/mmBTU)				*0.48*

* Corrected for calibration bias.
MW - Megawatt
Btu/dscf - heat content in British themal units per dry standard cubic feet
lb/MMBtu - pound of pollutant per million British thermal units
MMBtu/hr – Million British thermal units per hour
% Volume - % of gas in measured air stream
ppmvd – parts per million by volume, dry basis
lb/hr – mass emission rate in pounds per hour

Table 5.3 Measured exhaust gas conditions and air pollutant emission rates for Wolverine Power Turbine No. 1 at 50% load

Test No.	1	2	3	
Test date	08/26/14	08/26/14	08/26/14	Test
Test period (24-hr clock)	13:17-13:37	13:55-14:15	14:34-14:54	Avg.
Turbine Generation (MW)	10.9	10.9	10.9	10.9
Fuel Heat Content (Btu/dscf)	991.3	991.3	991.3	991.3
Fuel Flow Rate (Mcfh)	195.0	185.5	190.5	190.3
Heat Input (MMBtu/hr)	193	184	189	189
Exhaust gas composition				
CO_2 content (% vol)	1.49	1.44	1.46	1.46
O_2 content (% vol)	18.54	18.62	18.58	18.58
Nitrogen oxides emission rates				
NO_X conc. (ppmvd)*	28.0	27.5	27.4	27.6
NO_X emissions (lb/hr)	48.4	46.9	47.0	47.4
NO_X permit limit (lb/hr)				*168.5*
NO_X emissions (lb/mmBTU)	0.25	0.25	0.25	0.25
NO_X permit limit (lb/mmBTU)				*0.48*

* Corrected for calibration bias.
MW - Megawatt
Btu/dscf - heat content in British themal units per dry standard cubic feet
lb/MMBtu - pound of pollutant per million British thermal units
MMBtu/hr – Million British thermal units per hour
% Volume - % of gas in measured air stream
ppmvd – parts per million by volume, dry basis
lb/hr – mass emission rate in pounds per hour

Table 5.4 Measured exhaust gas conditions and air pollutant emission rates for Wolverine Power Turbine No. 2 at 100% load

Test No.	1	2	3	
Test date	08/27/14	08/27/14	08/27/14	Test
Test period (24-hr clock)	08:38-09:44	10:09-11:16	11:38-12:45	Avg.
Turbine Generation (MW)	22.3	22.2	22.0	22.1
Fuel Heat Content (Btu/dscf)	971.6	971.6	971.6	971.6
Fuel Flow Rate (Mcfh)	308.0	304.0	301.7	304.6
Heat Input (MMBtu/hr)	299	295	293	296
Exhaust gas composition				
CO_2 content (% vol)	2.25	2.19	2.27	2.24
O_2 content (% vol)	17.30	17.31	17.19	17.27
Nitrogen oxides emission rates				
NO_X conc. (ppmvd)*	63.5	62.6	65.9	64.0
NO_X emissions (lb/hr)	111.4	108.8	110.0	110.1
NO_X permit limit (lb/hr)				*168.5*
NO_X emissions (lb/mmBTU)	0.37	0.37	0.38	0.37
NO_X permit limit (lb/mmBTU)				*0.48*

* Corrected for calibration bias.
MW - Megawatt
Btu/dscf - heat content in British themal units per dry standard cubic feet
lb/MMBtu - pound of pollutant per million British thermal units
MMBtu/hr – Million British thermal units per hour
% Volume - % of gas in measured air stream
ppmvd – parts per million by volume, dry basis
lb/hr – mass emission rate in pounds per hour

Table 5.5 Measured exhaust gas conditions and air pollutant emission rates for Wolverine Power Turbine No. 2 at 75% load

Test No.	1	2	3	
Test date	08/27/14	08/27/14	08/27/14	Test
Test period (24-hr clock)	13:02-14:09	14:27-15:37	15:55-17:04	Avg.
Turbine Generation (MW)	16.6	16.7	16.7	16.7
Fuel Heat Content (Btu/dscf)	971.6	971.6	971.6	971.6
Fuel Flow Rate (Mcfh)	240.2	242.7	245.8	242.9
Heat Input (MMBtu/hr)	233	236	239	236
Exhaust gas composition				
CO_2 content (% vol)	1.92	1.94	1.97	1.94
O_2 content (% vol)	17.70	17.72	17.67	17.70
Nitrogen oxides emission rates				
NO_X conc. (ppmvd)*	46.9	47.8	48.1	47.6
NO_X emissions (lb/hr)	72.3	74.9	75.2	74.1
NO_X permit limit (lb/hr)				*168.5*
NO_X emissions (lb/mmBTU)	0.31	0.32	0.31	0.31
NO_X permit limit (lb/mmBTU)				*0.48*

* Corrected for calibration bias.
MW - Megawatt
Btu/dscf - heat content in British themal units per dry standard cubic feet
lb/MMBtu - pound of pollutant per million British thermal units
MMBtu/hr – Million British thermal units per hour
% Volume - % of gas in measured air stream
ppmvd – parts per million by volume, dry basis
lb/hr – mass emission rate in pounds per hour

Table 5.6 Measured exhaust gas conditions and air pollutant emission rates for Wolverine Power Turbine No. 2 at 50% load

Test No.	1	2	3	
Test date	08/27/14	08/27/14	08/27/14	Test
Test period (24-hr clock)	17:20-18:28	18:45-19:53	20:11-21:18	Avg.
Turbine Generation (MW)	11.0	10.9	11.0	10.9
Fuel Heat Content (Btu/dscf)	971.6	971.6	971.6	971.6
Fuel Flow Rate (Mcfh)	188.5	185.8	187.5	187.3
Heat Input (MMBtu/hr)	183	181	182	182
Exhaust gas composition				
CO_2 content (% vol)	1.47	1.45	1.46	1.46
O_2 content (% vol)	18.52	18.47	18.65	18.55
Nitrogen oxides emission rates				
NO_X conc. (ppmvd)*	32.3	31.5	30.3	31.4
NO_X emissions (lb/hr)	52.6	49.4	51.9	51.3
NO_X permit limit (lb/hr)				*168.5*
NO_X emissions (lb/mmBTU)	0.29	0.27	0.28	0.28
NO_X permit limit (lb/mmBTU)				*0.48*

* Corrected for calibration bias.
MW - Megawatt
Btu/dscf - heat content in British themal units per dry standard cubic feet
lb/MMBtu - pound of pollutant per million British thermal units
MMBtu/hr – Million British thermal units per hour
% Volume - % of gas in measured air stream
ppmvd – parts per million by volume, dry basis
lb/hr – mass emission rate in pounds per hour

Table 5.7 Measured exhaust gas conditions and air pollutant emission rates for Wolverine Power Turbine No. 3 at 100% load

Test No.	1	2	3	
Test date	08/28/14	08/28/14	08/28/14	Test
Test period (24-hr clock)	08:45-09:55	10:16-10:36	10:56-11:16	Avg.
Turbine Generation (MW)	21.8	21.6	21.6	21.7
Fuel Heat Content (Btu/dscf)	989.6	989.6	989.6	989.6
Fuel Flow Rate (Mcfh)	305.8	305.5	306.0	305.8
Heat Input (MMBtu/hr)	303	302	303	303
Exhaust gas composition				
CO_2 content (% vol)	2.57	2.57	2.57	2.57
O_2 content (% vol)	16.77	16.77	16.76	16.77
Nitrogen oxides emission rates				
NO_X conc. (ppmvd)*	64.3	66.3	66.7	65.7
NO_X emissions (lb/hr)	99.5	102.4	103.1	101.7
NO_X permit limit (lb/hr)				*168.5*
NO_X emissions (lb/mmBTU)	0.33	0.34	0.34	0.34
NO_X permit limit (lb/mmBTU)				*0.48*

* Corrected for calibration bias.
MW - Megawatt
Btu/dscf - heat content in British themal units per dry standard cubic feet
lb/MMBtu - pound of pollutant per million British thermal units
MMBtu/hr – Million British thermal units per hour
% Volume - % of gas in measured air stream
ppmvd – parts per million by volume, dry basis
lb/hr – mass emission rate in pounds per hour

Table 5.8 Measured exhaust gas conditions and air pollutant emission rates for Wolverine Power Turbine No. 3 at 75% load

Test No.	1	2	3	
Test date	08/27/14	08/28/14	08/28/14	
Test period (24-hr clock)	11:36-11:56	12:14-12:34	12:53-13:13	Avg.
Turbine Generation (MW)	16.7	16.5	16.6	16.6
Fuel Heat Content (Btu/dscf)	989.6	989.6	989.6	989.6
Fuel Flow Rate (Mcfh)	249.0	247.5	248.5	248.3
Heat Input (MMBtu/hr)	246	245	246	246
Exhaust gas composition				
CO_2 content (% vol)	2.08	2.09	2.08	2.1
O_2 content (% vol)	17.58	17.55	17.59	17.58
Nitrogen oxides emission rates				
NO_X conc. (ppmvd)*	45.9	46.4	45.7	46.0
NO_X emissions (lb/hr)	72.0	71.6	71.7	71.8
NO_X permit limit (lb/hr)				*168.5*
NO_X emissions (lb/mmBTU)	0.29	0.29	0.29	0.29
NO_X permit limit (lb/mmBTU)				*0.48*

* Corrected for calibration bias.
MW - Megawatt
Btu/dscf - heat content in British themal units per dry standard cubic feet
lb/MMBtu - pound of pollutant per million British thermal units
MMBtu/hr – Million British thermal units per hour
% Volume - % of gas in measured air stream
ppmvd – parts per million by volume, dry basis
lb/hr – mass emission rate in pounds per hour

Table 5.9 Measured exhaust gas conditions and air pollutant emission rates for Wolverine Power Turbine No. 3 at 50% load

Test No.	1	2	3	
Test date	08/28/14	08/28/14	08/28/14	Test
Test period (24-hr clock)	13:31-13:51	14:09-14:29	14:49-15:09	Avg.
Turbine Generation (MW)	11.0	10.9	10.9	10.9
Fuel Heat Content (Btu/dscf)	989.6	989.6	989.6	989.6
Fuel Flow Rate (Mcfh)	189.5	189.0	190.5	189.7
Heat Input (MMBtu/hr)	188	187	189	188
Exhaust gas composition				
CO_2 content (% vol)	1.59	1.60	1.59	1.59
O_2 content (% vol)	18.38	18.36	18.37	18.37
Nitrogen oxides emission rates				
NO_X conc. (ppmvd)*	32.1	32.1	32.1	32.1
NO_X emissions (lb/hr)	50.5	50.0	50.5	50.3
NO_X permit limit (lb/hr)				*168.5*
NO_X emissions (lb/mmBTU)	0.27	0.27	0.27	0.27
NO_X permit limit (lb/mmBTU)				*0.48*

* Corrected for calibration bias.
MW - Megawatt
Btu/dscf - heat content in British themal units per dry standard cubic feet
lb/MMBtu - pound of pollutant per million British thermal units
MMBtu/hr – Million British thermal units per hour
% Volume - % of gas in measured air stream
ppmvd – parts per million by volume, dry basis
lb/hr – mass emission rate in pounds per hour