Air Emission Testing
and
Relative Accuracy Test Audit
of
EUBOILER1

Lansing Board of Water & Light
601 Island Avenue
Lansing, Michigan

State Registration No. B2647
Renewable Operating Permit MI-ROP-B2647-2012

Prepared for
Lansing Board of Water & Light
Lansing, Michigan

March 21, 2014

Move Forward with Confidence

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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: Lansing Board of Water & Light — County: Ingham

Source Address: 601 Island Avenue — City: Lansing

AQD Source ID (SRN): B2647 — ROP No.: MI-ROP-B2647-2012 — ROP Section No.: NA

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 NA To NA

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

Relative accuracy test audit and PM air emissions report for the EUBOILER1 source.
This form shall certify that the testing was conducted in accordance with the test plan
and that the facility was operated in compliance with permit conditions or
at the maximum 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

Mark Matus	Environmental Manager	517-702-6153
Name of Responsible Official (print or type)	Title	Phone Number

Signature of Responsible Official — Date: 3/18/2014

* Photocopy this form as needed.

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Executive Summary

Lansing Board of Water & Light (BWL) retained Bureau Veritas North America, Inc. to measure emissions of particulate matter (PM) and conduct a Relative Accuracy Test Audits (RATA) for gas flow, carbon dioxide (CO_2), sulfur dioxide (SO_2), and oxides of nitrogen (NO_x) for the EUBOILER1 source located at the BWL facility in Lansing, Michigan. The purpose of the emission test program was to measure PM emissions and to evaluate the accuracy of the continuous emission monitors/continuous emission rate monitoring system (CEMS/CERMS) as required by 40 CFR Part 75, "Continuous Emission Monitoring" and incorporated in Michigan Department of Environmental Quality (MDEQ) Renewable Operating Permit MI-ROP-B2647-2012, effective May 17, 2012.

The testing was conducted February 5 through 7, 2014, and followed United States Environmental Protection Agency (USEPA) Reference Methods outlined in 40 CFR 60, Appendix A: 1, 2, 3, 3A, 4, 5, 6C, and 7E as incorporated in 40 CFR 75. Bureau Veritas measured emissions as summarized in the table below for three load conditions.

Summary of Load Conditions

Parameter	EUBOILER1			USEPA Reference Method
	Low-load Condition	Mid-load Condition	High-load Condition	
Gas flowrate†	•	•	•	1, 2, 3 or 3A, and 4
Carbon dioxide (CO_2)		•		3A
Particulate matter (PM)			•	5
Sulfur dioxide (SO_2)		•		6C
Nitrogen oxides (NO_x)		•		7E

† Gas flowrate procedures include measurement of sampling location, volumetric flowrate, molecular weight, and moisture content.

EUBOILER1 – Low and High-Load Conditions. Testing consisted of twelve ≥5-minute test runs at the outlet of the EUBOILER1 to measure flowrate and CERMS relative accuracy. The results were compared to BWL's CERMS measurements at the outlet of the EUBOILER1 exhaust stack. Four ≥60-minute test runs were also conducted at the outlet of the EUBOILER1 during high-load conditions to measure PM emissions to evaluate compliance with the permit limit. The permit limit for particulate matter is 0.20 pounds per 1,000 pounds of exhaust gases, corrected to 50% excess air.

EUBOILER1 – Mid-Load Condition. Twelve ≥21-minute test runs were performed at the outlet of the EUBOILER1 to measure flowrate, carbon dioxide (CO_2), sulfur dioxide (SO_2), and nitrogen oxide (NO_x) concentrations, emission rates, and CEMS/CERMS relative accuracy. The results were compared to BWL's CEMS/CERMS measurements at the outlet of the EUBOILER1 exhaust stack.

The results of the testing compared to the allowable relative accuracy limits are summarized in the following tables.

EUBOILER1 Flowrate Relative Accuracy Test Audit Results

Date	Emission Unit	Parameter	Average Reference Method Results (scfh)	Average CERMS Results (scfh)	Relative Accuracy (%)	Allowable Relative Accuracy† (%)
February 7, 2014	EUBOILER1 (Low-load condition)	Flowrate	4,551,468	4,788,889	7.0	≤7.5
February 5, 2014	EUBOILER1 (Mid-load condition)	Flowrate	5,405,279	5,405,000	1.3	≤7.5
February 6, 2014	EUBOILER1 (High-load condition)	Flowrate	5,962,998	5,993,556	1.2	≤7.5

† The allowable relative accuracy based on annual RATA frequency in accordance with 40 CFR 75, Appendix B, Section 2.3.1.2
CERMS: continuous emission rate monitoring
scfh: standard cubic feet per hour

EUBOILER1 CO_2, SO_2, and NO_x Relative Accuracy Test Audit Results

Date	Emission Unit	Parameter	Units	Average Reference Method Results	Average CEMS Results	Relative Accuracy (%)	Allowable Relative Accuracy† (%)
February 5, 2014	EUBOILER1 (Mid-load condition)	CO_2	%, wet	13.8	13.4	3.7	≤7.5
February 5, 2014	EUBOILER1 (Mid-load condition)	SO_2	ppmv, wet	248.8	248.4	1.4	≤7.5
February 5, 2014	EUBOILER1 (Mid-load condition)	NO_x	lb/mmBtu	0.214	0.215	0.9	≤7.5

† The allowable relative accuracy based on annual RATA frequency in accordance with 40 CFR 75, Appendix B, Section 2.3.1.2
CEMS: continuous emission monitors
ppmv: part per million by volume
lb/mmBtu: pound per one million British thermal unit
CO_2: carbon dioxide
SO_2: sulfur dioxide
NO_x: nitrogen oxides

The flowrate, CO_2, SO_2, and NO_x measurements demonstrate the CEMS/CERMS are operating within allowable relative accuracy limits.

EUBOILER1 PM Emissions Results

Parameter	Units	Run 1†	Run 2	Run 3	Run 4	Average†	Limit
PM	lb/1000 lb exhaust gas at 50% EA	0.035	0.054	0.069	0.072	0.065	0.20
	lb/hr	17	27	34	36	32	NA

PM: Particulate matter
lb/1000 lb exhaust gas at 50% EA: pound per 1,000 pounds of exhaust gases, corrected to 50% excess air
lb/hr: pound per hour
NA: no lb/hr limit noted in permit
†: Run 1 excluded from the particulate matter run averages

The average results of the particulate matter emission testing indicate that EUBOILER1 complies with the applicable permit limit of 0.20 pound per 1,000 pounds of exhaust gases, corrected to 50% excess air.

1.0 Introduction

Lansing Board of Water & Light (BWL) retained Bureau Veritas North America, Inc. to measure emissions of particulate matter (PM) and conduct a Relative Accuracy Test Audits (RATA) for gas flow, carbon dioxide (CO_2), sulfur dioxide (SO_2), and oxides of nitrogen (NO_x) for the EUBOILER1 source located at the BWL facility in Lansing, Michigan. The purpose of the emission test program was to measure PM emissions and to evaluate the accuracy of the continuous emission monitors/continuous emission rate monitoring system (CEMS/CERMS) as required by 40 CFR Part 75, "Continuous Emission Monitoring" and incorporated in Michigan Department of Environmental Quality (MDEQ) Renewable Operating Permit MI-ROP-B2647-2012, effective May 17, 2012.

Relative Accuracy (RA) means the absolute mean difference between the gas concentration, flow, or emission rate measured by the monitor and the value measured using the reference method (RM), plus the 2.5%-error confidence coefficient of a series of tests, divided by the mean of the RM test runs:

$$RA = 100\frac{\left|\overline{(C_{RM} - C_m)}\right| + t_{\alpha,n-1}\left(\frac{S_d}{\sqrt{n}}\right)}{\overline{C_{RM}}}$$

where:

RA	=	% relative accuracy
C_{RM}	=	parameter measured by reference method
Cm	=	parameter measured by CEMS or CERMS (i.e., the monitor)
$\left\|\overline{C_{RM} - C_m}\right\|$	=	absolute value of mean of the differences between C_{RM} and C_m for the valid test runs
$\overline{C_{RM}}$	=	mean of test run parameter measured by reference method (mean of RM test runs)
$t_{\alpha,n-1}$	=	t value with $\alpha = 0.025$, which is a confidence level of 97.5%
S_d	=	standard deviation of the differences between C_{RM} and C_m
n	=	number of measurements (i.e., test runs)

The confidence coefficient (CC) is:

$$CC = t_{\alpha,n-1}\left(\frac{S_d}{\sqrt{n}}\right)$$

The 2.5%-error confidence coefficient is calculated using a t value corresponding to the 97.5% confidence level.

The testing was conducted February 5 through 7, 2014 and followed United States Environmental Protection Agency (USEPA) Reference Methods outlined in 40 CFR 60, Appendix A: 1, 2, 3, 3A, 4, 5, 6C, and 7E.

1.1 Summary of Test Program

BWL operates six boilers at its Eckert Station in Lansing, Michigan. The boilers are referred to as EUBOILER1, EUBOILER2, EUBOILER3, EUBOILER4, EUBOILER5, and EUBOILER6. The CEMS installed on the EUBOILER1 exhaust stack were evaluated. Air emissions were monitored from the EUBOILER1 source during the following load conditions:

- **EUBOILER1 – Low- and High-Load Conditions.** Testing consisted of twelve ≥5-minute test runs at the outlet of the EUBOILER1 to measure flowrate and CERMS relative accuracy. The results were compared to BWL's CERMS measurements at the outlet of the EUBOILER1 exhaust stack. Four ≥60-minute test runs were also conducted at the outlet of the EUBOILER1 during high-load conditions to measure PM emissions to evaluate compliance with the permit limit. The permit limit for particulate matter is 0.20 pounds per 1,000 pounds of exhaust gases, corrected to 50% excess air.

- **EUBOILER1 – Mid-Load Condition.** Twelve ≥21-minute test runs were performed at the outlet of the EUBOILER1 to measure flowrate, CO_2, SO_2, and NO_x concentrations, emission rates, and CEMS/CERMS relative accuracy. The results were compared to BWL's CEMS/CERMS measurements at the outlet of the EUBOILER1 exhaust stack.

1.2 Purpose of Testing

The testing was performed to evaluate compliance with certain limits of the facility's Renewable Operating Permit and assess the accuracy of the continuous emission monitors as required by 40 CFR 75, "Continuous Emission Monitoring" and incorporated in MDEQ Renewable Operating Permit MI-ROP-B2647-2012, effective May 17, 2012. The specific objectives are:

- Measure PM emissions at high load conditions to evaluate compliance with the permit limit. The permit limit for particulate matter is 0.20 pounds per 1,000 pounds of exhaust gases, corrected to 50% excess air.

- Evaluate the relative accuracy of the installed flow monitor against the reference methods at low-, mid-, and high-load conditions. The allowable relative accuracy based on an annual RATA frequency in accordance with 40 CFR 75, Appendix B, Section 2.3.1.2 is ≤7.5%. The flowrates must be compared in units of standard cubic feet per hour (scfh).

- Evaluate the relative accuracy of the CEMS installed for CO_2 (%), SO_2 [part per million by volume (ppmv)], and NO_x [pound per one million British thermal unit (lb/mmBtu)] against the reference methods at the mid-load condition. The allowable relative accuracy based on an annual RATA frequency in accordance with 40 CFR 75, Appendix B, Section 2.3.1.2 is ≤7.5%.

- Calculate a bias adjustment factor if the mean difference between the CEMS and RM measurements is greater than the confidence coefficient. The bias adjustment factor is applied to the facility's CEMS monitoring data to prevent under-reporting emissions.

1.3 Contact Information

Contact information is listed in Table 1-1. Mr. Thomas Schmelter, Senior Project Manager with Bureau Veritas, led the emission testing program. Ms. Angie Goodman, Environmental Compliance Specialist with BWL, provided process coordination and arranged for facility operating parameters to be recorded. The testing was witnessed by Mr. Tom Gasloli, Environmental Quality Analyst with the MDEQ.

Table 1-1
Contact Persons

Permitee	Emission Testing Company
Lansing Board of Water & Light 1201 South Washington Avenue Lansing, Michigan 48910 Telephone 517.702.6000	Bureau Veritas North America, Inc. 22345 Roethel Drive Novi, Michigan 48375 Telephone 248.344.1770 Facsimile 248.344.2656
Angie Goodman Environmental Compliance Specialist Telephone 517.702.7059 ame1@LBWL.com	Thomas Schmelter, QSTI Senior Project Manager Telephone 248.344.3003 thomas.schmelter@us.bureauveritas.com
Michigan Department of Environmental Quality	
MDEQ – Air Quality Division Technical Programs Unit 525 West Allegan Street Lansing, Michigan 48909-7760 Telephone 517.335.3082 Facsimile 517.241.3571	
Tom Gasloli Environmental Quality Analyst Telephone 517.284.6778 gaslolit@michigan.gov	

2.0 Source and Sampling Locations

2.1 Process Description

BWL operates six boilers at its Eckert Station in Lansing, Michigan. The boilers are referred to as EUBOILER1, EUBOILER2, EUBOILER3, EUBOILER4, EUBOILER5, and EUBOILER6. The CEMS/CERMS installed for flowrate, CO_2, SO_2, and NO_x at the EUBOILER1 exhaust stack were evaluated.

EUBOILER1 is a Babcock and Wilcox pulverized coal-fired boiler with No. 2 fuel oil for startup and flame stabilization. The boiler is rated at 509 MMBtu/hr and equipped with low NO_x burners and overfire air. Particulate matter emissions are controlled by two electrostatic precipitators. The steam generated by the boiler is used for electrical power generation and to provide backup steam for sale to customers for building heating, cooling, and process operations. The basic processing steps for steam and electrical production are presented below:

- Bituminous coal is conveyed from storage to coal bunkers.
- Pulverized coal and air are introduced into the boiler furnace and fired to generate heat.
- The coal combustion heats water wall tubes and the steam drum. The steam drum captures steam and directs it to a header pipe where it is used to rotate a turbine for power generation or distributed to the service area.
- Flue gas from the furnace is exhausted through an electrostatic precipitator (ESP) prior to discharge to atmosphere.

2.2 Control Equipment

As part of the steam and electrical production process, emissions are generated from coal and No. 2 fuel oil combustion. BWL operates pollution control equipment to control the discharge of pollutants to the atmosphere. The EUBOILER1 incorporates the use of low NO_x burners, overfire air, and electrostatic precipitators to control air emissions.

The use of low NO_x burners installed in EUBOILER1 is used to reduce NO_x emissions. Low NO_x burners reduce emissions by staging the combustion process thereby delaying ignition which results in a lower combustion temperature. The lower combustion temperature reduces thermal NO_x formation.

Overfire air works by diverting a portion of the combustion air away from the primary combustion zone. Since, the off-stoichiometric air to fuel ratio results in a lower combustion temperature, thermal NO_x formation is reduced in the primary oxidization zone. Non-combusted fuel from the primary zone is oxidized in the over fire air. The staged combustion provides more complete combustion of the fuel at lower temperatures.

The ESPs are designed to remove particulate matter from the flue gas prior to exhaust to atmosphere. The ESPs are powered by high voltage transformers and solid state rectifiers with spark attenuation. As particles enter an ESP, a negative charge is imparted on them. The negatively charged particles migrate towards grounded collector plates having a positive charge. As the particles collect on the plates they create a dust layer. The accumulated dust layer is removed by rapping the plates. The ESPs have variable intensity controls for the collecting plate rappers and discharge electrode vibrators.

2.3 Flue Gas Sampling Location

A photograph and description of the EUBOILER1 sampling location are presented below.

2.3.1 EUBOILER1 Sampling Location

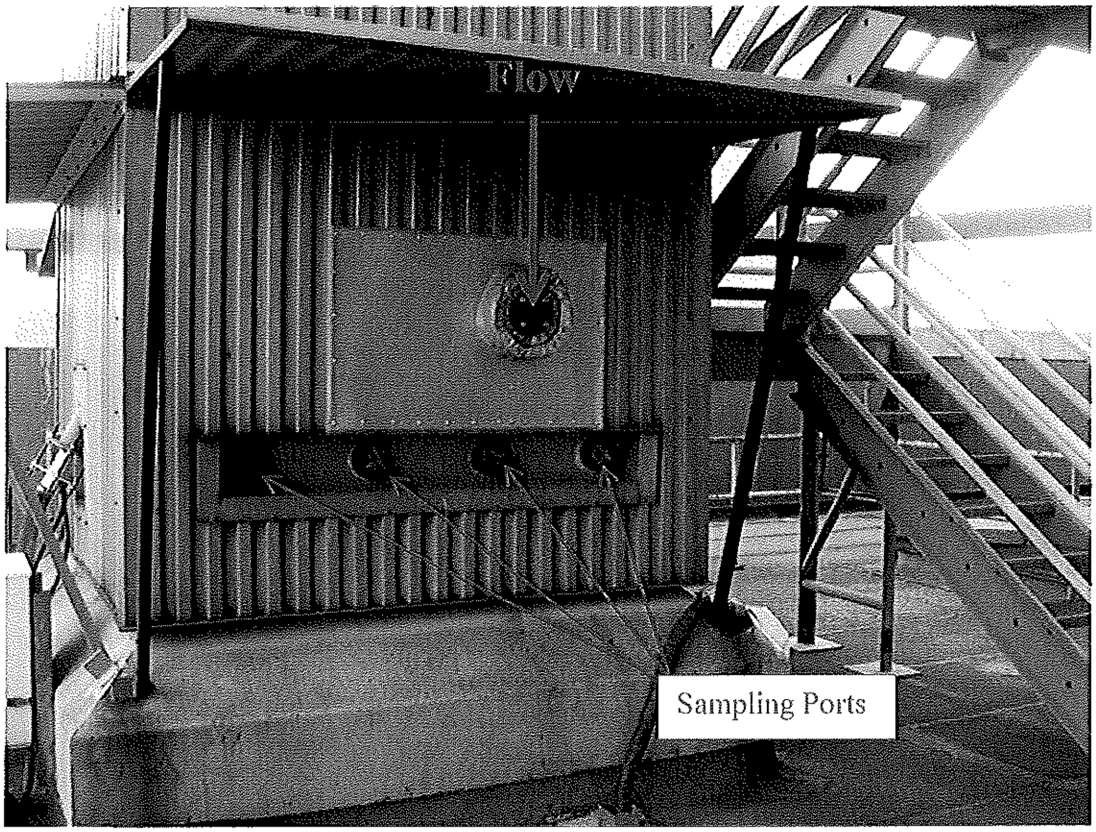
The EUBOILER1 exhausts to atmosphere through stack SVSTACK1. At the sampling location, the ports are positioned within 72-inch-wide by 90-inch-deep rectangular ductwork:

- Approximately 180 inches (2.25 duct diameters) from the nearest upstream disturbance, a bend in the ductwork.
- Approximately 180 inches (2.25 duct diameters) from the nearest downstream disturbance (i.e., duct confluence).

The ports are accessible by elevator to the 10th floor of the building and stairs to the sampling location.

Figure 1 in the Appendix depicts the EUBOILER1 sampling port and traverse point locations. Figure 2-1 is a photograph of the EUBOILER1 sampling location.

Figure 2-1. EUBOILER1 Sampling Location



2.4 Continuous Emission Rate Monitoring Systems

A description and identification of the instrumentation operated by BWL to monitor source emission rates are presented below.

2.4.1 EUBOILER1 Outlet

The airflow monitor is a USI Ultraflow® Model 100 system, Serial No. 9303477. The system measures the transit time of ultrasonic tone bursts between a pair of transducers to measure flue gas velocity. The full-scale range of the CERMS is 174,800 standard cubic feet per minute.

The carbon dioxide CEMS is a Lear Siegler M.L. Model 9820 analyzer, Serial No. 121. The analyzer measures the concentration of carbon dioxide by comparing infrared energy absorbed by the sample gas compared to that of a reference gas using an infrared photometer. The full scale range of the analyzer is 15 percent.

The sulfur dioxide analyzer is a Lear Siegler M.L. Model 9850, Serial No. 349. The analyzer measures the concentration of sulfur dioxide using ultraviolet fluorescent technology. The full scale range of the analyzer is 600 part per million (ppm).

3.0 Summary and Discussion of Results

3.1 Objectives

The testing was performed to evaluate compliance with certain limits of the facility's Renewable Operating Permit and assess the accuracy of the continuous emission monitors as required by 40 CFR 75, "Continuous Emission Monitoring" and incorporated in MDEQ Renewable Operating Permit MI-ROP-B2647-2012, effective May 17, 2012. The specific objectives are:

- Measure PM emissions at high load conditions to evaluate compliance with the permit limit. The permit limit for particulate matter is 0.20 pounds per 1,000 pounds of exhaust gases, corrected to 50% excess air.

- Evaluate the relative accuracy of the installed flow monitor against the reference methods at low-, mid-, and high-load conditions. The allowable relative accuracy based on an annual RATA frequency in accordance with 40 CFR 75, Appendix B, Section 2.3.1.2 is ≤7.5%. The flowrates must be compared in units of scfh.

- Evaluate the relative accuracy of the CEMS installed for CO_2 (%), SO_2 (ppmv), and NO_x (lb/mmBtu) against the reference methods at the mid-load condition. The allowable relative accuracy based on an annual RATA frequency in accordance with 40 CFR 75, Appendix B, Section 2.3.1.2 is ≤7.5%.

- Calculate a bias adjustment factor if the mean difference between the CEMS and RM measurements is greater than the confidence coefficient. The bias adjustment factor is applied to the facility's CEMS monitoring data to prevent under-reporting emissions.

3.2 Test Matrix

The emission testing was conducted to evaluate the objectives in Section 3.1. Table 3-1 presents the sampling and analytical test matrix.

Table 3-1
Test Matrix

Sampling Location	Runs	Sample/Type of Pollutant	USEPA Sampling Method	Analytical Method	Run Time (min)
Outlet of EUBOILER1 **Low-load condition**	12	Gas flowrate	1, 2, 3, and 4	Differential pressure, gravimetric	$\geq$5
Outlet of EUBOILER1 **Mid-load condition**	12	Gas flowrate	1, 2, 3A, and 4	Differential pressure, gravimetric	$\geq$5
		CO_2	3A	Non-dispersive infrared	$\geq$21
		SO_2	6C	Ultraviolet fluorescence	
		NO_x	7E	Chemiluminescence	
Outlet of EUBOILER1 **High-load condition**	12	Gas flowrate	1, 2, 3A, and 4	Differential pressure, gravimetric	$\geq$5
	3	PM	5	Gravimetric	$\geq$60

CO_2: carbon dioxide
SO_2: sulfur dioxide
NO_x: nitrogen oxides
PM: particulate matter

3.3 Field Test Changes and Issues

Based on MDEQ Renewable Operating Permit MI-ROP-B2647-2012, effective May 17, 2012, USEPA Method 5B was referenced in the Intent-to-Test Plan dated January 31, 2014. Following submittal of this Intent-to-Test Plan to MDEQ, Mr. Gasloli, Environmental Quality Analyst with the MDEQ, clarified (via email, dated February 5, 2014) that there is a mistake in the permit and to follow USEPA Method 5 not USEPA Method 5B for PM emission testing.

Field test changes were not required to complete the emission testing.

3.4 Results

The results of each relative accuracy test audit are compared to the allowable relative accuracy limits and the PM results are compared to the permit limit. Detailed results are presented in Tables 1 through 7 after the Tables Tab of this report. Graphs of the O_2, CO_2, SO_2, and NO_x concentrations are presented after the Graphs Tab of this report. Sample calculations are presented in Appendix B.

Table 3-2
EUBOILER1 Flowrate Relative Accuracy Test Audit Results

Date	Emission Unit	Parameter	Average Reference Method Results (scfh)	Average CERMS Results (scfh)	Relative Accuracy (%)	Allowable Relative Accuracy† (%)
February 7, 2014	EUBOILER1 (Low-load condition)	Flowrate	4,551,468	4,788,889	7.0	≤7.5
February 5, 2014	EUBOILER1 (Mid-load condition)	Flowrate	5,405,279	5,405,000	1.3	≤7.5
February 6, 2014	EUBOILER1 (High-load condition)	Flowrate	5,962,998	5,993,556	1.2	≤7.5

† The allowable relative accuracy based on annual RATA frequency in accordance with 40 CFR 75, Appendix B, Section 2.3.1.2
CERMS: continuous emission rate monitoring
scfh: standard cubic feet per hour

Table 3-3
EUBOILER1 CO_2, SO_2, and NO_x Relative Accuracy Test Audit Results

Date	Emission Unit	Parameter	Units	Average Reference Method Results	Average CEMS Results	Relative Accuracy (%)	Allowable Relative Accuracy† (%)
February 5, 2014	EUBOILER1 (Mid-load condition)	CO_2	%, wet	13.8	13.4	3.7	≤7.5
February 5, 2014	EUBOILER1 (Mid-load condition)	SO_2	ppmv, wet	248.8	248.4	1.4	≤7.5
February 5, 2014	EUBOILER1 (Mid-load condition)	NO_x	lb/mmBtu	0.214	0.215	0.9	≤7.5

† The allowable relative accuracy based on annual RATA frequency in accordance with 40 CFR 75, Appendix B, Section 2.3.1.2
CEMS: continuous emission monitors
ppmv: part per million by volume
lb/mmBtu: pound per one million British thermal unit
CO_2: carbon dioxide
SO_2: sulfur dioxide
NO_x: nitrogen oxides

The flowrate, CO_2, SO_2, and NO_x measurements demonstrate the CEMS/CERMS are operating within allowable relative accuracy limits.

Table 3-4
EUBOILER1 PM Emissions Results

Parameter	Units	Run 1†	Run 2	Run 3	Run 4	Average†	Limit
PM	lb/1000 lb exhaust gas at 50% EA	0.035	0.054	0.069	0.072	0.065	0.20
	lb/hr	17	27	34	36	32	NA

PM: Particulate matter
lb/1000 lb exhaust gas at 50% EA: pound per 1,000 pounds of exhaust gases, corrected to 50% excess air
lb/hr: pound per hour
NA: no lb/hr limit noted in permit
†: Run 1 excluded from the particulate matter run averages

The average results of the particulate matter emission testing indicate that EUBOILER1 complies with the applicable permit limit of 0.20 pound per 1,000 pounds of exhaust gases, corrected to 50% excess air.

4.0 Sampling and Analytical Procedures

Bureau Veritas measured emissions in accordance with the procedures specified in USEPA's Standards of Performance for New Stationary Sources. The sampling and analytical methods used during this test program are listed in the following table.

Table 4-1
Sampling and Analytical Test Methods

USEPA Sampling Method	Parameter	Analysis
1 and 2	Gas stream volumetric flowrate	Field measurement, S-type Pitot tube differential pressure
3 and 3A	Oxygen (O_2), carbon dioxide (CO_2), molecular weight	Fyrite® chemical absorption, paramagnetic, and single wavelength infrared technology gas analyzers
4	Moisture content	Gravimetric
5	Particulate matter (PM)	Gravimetric
6C	Sulfur dioxide (SO_2)	Ultraviolet fluorescence absorption
7E	Nitrogen oxides (NO_x)	Chemiluminescence

4.1 Test Methods

4.1.1 Flowrate (USEPA Methods 1 and 2)

Method 1, "Sample and Velocity Traverses for Stationary Sources," from the Code of Federal Regulations, Title 40, Part 60 (40 CFR 60), Appendix A, was used to evaluate the sampling location and the number of traverse points for sampling and the measurement of velocity profiles. Details of the sampling location and number of velocity traverse points are presented in the Table 4-2.

Table 4-2
Sampling Location and Number of Traverse Points

Sampling Locations	Equivalent Duct Diameter (inch)	Distance from Ports to Upstream Flow Disturbance (diameter)	Distance from Ports to Downstream Flow Disturbances (diameter)	Number of Ports	Traverse Points per Port	Total Points
EUBOILER1	80	2.25	2.25	4	4	16

Figure 1 in the Appendix depicts the EUBOILER1 sampling location and traverse points.

Method 2, "Determination of Stack Gas Velocity and Volumetric Flow Rate (Type S Pitot Tube)," was used to measure flue gas velocity and calculate volumetric flowrate. S-type Pitot tubes and thermocouple assemblies, calibrated in accordance with Method 2, Section 10.0, were used during testing. The S-Type Pitot tube coefficient as measured in a wind tunnel was 0.84 (dimensionless). Refer to Appendix A for the calibration and inspection sheets.

Cyclonic Flow Check. Bureau Veritas evaluated whether cyclonic flow was present at the sampling location. Cyclonic flow is defined as a flow condition with an average null angle greater than 20 degrees. The direction of flow can be determined by aligning the Pitot tube to obtain zero (null) velocity head reading—the direction would be parallel to the Pitot tube face openings or perpendicular to the null position. By measuring the angle of the Pitot tube face openings in relation to the stack walls when a null angle is obtained, the direction of flow is measured. If the absolute average of the flow direction angles is greater than 20 degrees, the flue gas is considered to be cyclonic at that sampling location and an alternative location should be found.

The average of the measured traverse point flue gas velocity null angle was 6 degrees at the EUBOILER1 sampling location. The measurement indicates the absence of cyclonic flow at the EUBOILER1 sampling location.

4.1.2 Molecular Weight (USEPA Method 3)

For the low-load and high-load condition testing of EUBOILER1, Molecular weight was evaluated using Method 3, "Gas Analysis for the Determination of Dry Molecular Weight." Flue gas was extracted from the stack through a probe positioned near the centroid of the duct and directed into a Fyrite® gas analyzer. The concentrations of CO_2 and O_2 were then measured by chemical absorption with a Fyrite® gas analyzer to within ±0.5%. The average CO_2 and O_2 result of the grab samples were used to calculate molecular weight.

4.1.3 CO_2, SO_2, and NO_x Concentrations (USEPA Methods 3A, 6C, and 7E)

The following USEPA methods were used to measure gaseous concentrations:

- Method 3A, "Determination of Oxygen and Carbon Dioxide Concentrations in Emissions from Stationary Sources (Instrument Analyzer Procedure)"
- Method 6C, "Determination of Sulfur Dioxide Emissions from Stationary Sources (Instrumental Analyzer Procedure)"
- Method 7E, "Determination of Nitrogen Oxides Emissions from Stationary Sources (Instrument Analyzer Procedure)"

Figure 2 depicts the USEPA Methods 3A, 6C, and 7E sampling train.

Sampling for O_2, CO_2, SO_2, and NO_x consisted of extracting the flue gas from the stack through:

- A heated stainless-steel probe and particulate matter filter.
- Heated (248 ±25°F) Teflon sample line to prevent condensation.
- A chilled Teflon impinger train with peristaltic pump to remove moisture from the sampled gas stream prior to entering the analyzers via separate sampling lines.
- Oxygen, carbon dioxide, sulfur dioxide, and nitrogen oxide gas analyzers.

The flue gas was extracted and continuously introduced into the paramagnetic (O_2), non-dispersive infrared (CO_2), ultraviolet fluorescence (SO_2), and chemiluminescence (NO_x) gas analyzers to measure pollutant concentrations. Data were recorded at 1-second intervals on a computer equipped with data acquisition software. Recorded concentrations are reported in 1-minute averages over the duration of each test run and included in Appendix D Computer-Generated Data Sheets.

Flue gas was withdrawn from three sample points located at 16.7%, 50%, and 83.3% of the depth of the stack. The sampling probe was moved to a new sampling point at seven-minute intervals during the 21-minute RATA tests.

A calibration error check was performed on each analyzer by introducing zero-, mid-, and high-level calibration gases directly into the analyzer. The calibration error check was performed to evaluate if an analyzers respond to within ±2% of the calibration span.

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An NO/NO_2 conversion check was performed prior to testing by introducing an approximate 50 ppm NO_2 calibration gas into the NO_x analyzer. If the analyzer's NO_x concentration response was greater than 90% of the introduced NO_2 calibration gas concentration the analyzers NO/NO_2 conversion met the converter efficiency requirement of Section 13.5 of USEPA Method 7E.

Prior to each test run, a system-bias test was performed where known concentrations of calibration gases were introduced at the probe tip to measure if the response is within ±5% of the analyzer calibration span. At the conclusion of the each test run, an additional system-bias check was performed to evaluate the analyzer drift from pre- and post-test system-bias checks. The acceptable analyzer drift tolerance is ±3% of the calibration span. The results of the pre- and post-test system bias checks were used to correct the measured pollutant concentrations for analyzer drift.

Calibration data, along with the USEPA Protocol 1 certification sheets for the calibration gases used are included in Appendix A.

4.1.4 Moisture Content (USEPA Method 4)

The moisture content of the flue gas was measured gravimetrically following USEPA Method 4, "Determination of Moisture Content in Stack Gases" guidelines. One 35-minute moisture test run collecting a minimum of 21 standard cubic feet of sample was performed for every three RATA test runs. Bureau Veritas' modular USEPA Method 4 stack sampling system consisted of:

- A stainless steel probe.
- Tygon® umbilical vacuum line connecting the probe to the impingers.
- A set of four Greenburg-Smith (GS) impingers with the configuration shown in Table 4-3 situated in a chilled ice bath.
- A length of sample line.
- An Environmental Supply® control case equipped with a pump, dry-gas meter, and calibrated orifice.

Table 4-3
USEPA Method 4 Impinger Configuration

Impinger	Type	Contents	Amount
1	Modified	Water	~100 milliliters
2	Greenburg Smith	Water	~100 milliliters
3	Modified	Empty	0 milliliters
4	Modified	Silica desiccant	~300 grams

Prior to initiating a test run, the sampling train was leak-checked by capping the nozzle tip and applying a vacuum of approximately 15 inches of mercury to the sampling train. The dry-gas meter was then monitored for 1 minute to measure that the sample train leak rate was less than 0.02 cubic feet per minute (cfm). Next, the sampling probe was inserted into the sampling port near the centroid of the stack in preparation of sampling. Flue gas was extracted at a constant rate from the stack and moisture was removed from the sample stream by the chilled impingers.

At the conclusion of a test run, a post-test leak check was conducted and the impinger train was carefully disassembled. The weight of liquid or silica gel in each impinger was measured with a scale capable of measuring ±0.5 grams. The mass of water collected within the impingers and volume of flue gas sampled were used to calculate the moisture content. Figure 3 depicts the USEPA Method 4 sampling train.

4.1.5 Particulate Matter (USEPA Method 5)

USEPA Method 5, "Determination of Particulate Emissions from Stationary Sources," was used to measure the filterable "front-half" particulate matter emissions. The "front half" refers to the filterable particulate mass collected from the nozzle, probe, and filter. Triplicate 60-minute test runs were performed at the outlet of the EUBOILER1. Bureau Veritas' modular isokinetic stack sampling system consists of the following:

- A stainless steel or glass button-hook nozzle.
- A heated (248±25°F) stainless steel or glass-lined probe.
- A desiccated and pre-weighed 110-millimeter-diameter glass fiber filter (manufactured to at least 99.95% efficiency (<0.05 % penetration) for 0.3-micron dioctyl phthalate smoke particles) in a heated (248±25°F) filter box.
- A set of four pre-cleaned GS impingers with the configuration shown in Table 4-4.

- A sample line.
- An Environmental Supply® control case equipped with a pump, dry-gas meter, and calibrated orifice.

Table 4-4
Method 5 Impinger Configuration

Impinger Order (Upstream to Downstream)	Impinger Type	Impinger Contents	Amount of Contents
1	Modified	Water	100 grams
2	Greenburg Smith	Water	100 grams
3	Modified	Empty	0 grams
4	Modified	Silica desiccant	~300 grams

Before testing, a preliminary velocity traverse was performed and a nozzle size was calculated that would allow isokinetic sampling at an average rate of 0.75 cfm. Bureau Veritas selected a pre-cleaned stainless steel nozzle that had an inner diameter that approximates the calculated ideal value. The nozzle was measured with calipers across three cross-sectional chords to evaluate the inside diameter; rinsed and brushed with acetone; and connected to the stainless steel-lined sample probe.

The impact and static pressure openings of the Pitot tube were leak-checked at or above a velocity head of three inches of water for more than 15 seconds. The sampling train was leak-checked by capping the nozzle tip and applying a vacuum of approximately 15 inches of mercury to the sampling train. The dry-gas meter was then monitored for approximately 1 minute to measure that the sample train leak rate was less than 0.02 cfm. The sample probe was inserted into the sampling port to begin sampling.

Ice was placed around the impingers and the probe and filter temperatures were allowed to stabilize at 248±25 °F before each sample run. After the desired operating conditions were coordinated with the facility, testing was initiated.

Stack parameters (e.g., flue velocity, temperature) were monitored to establish the isokinetic sampling rate within ±10 % for the duration of the test. Data were recorded at each of the traverse points.

At the conclusion of a test run and the post-test leak check, the sampling train was disassembled and the impingers and filter were transported to the recovery area. The filter was recovered using tweezers and placed in a Petri dish. The Petri dish was immediately labeled and sealed with Teflon tape. The nozzle, probe, and the front half of the filter holder assembly were brushed and, at a minimum, triple-rinsed with acetone to recover particulate matter. The acetone rinses were collected in pre-cleaned sample containers.

At the end of a test run, the mass of liquid collected in each impinger was measured using a scale to within ±0.5 grams; these masses were used to calculate moisture content of the flue gas. The contents of the impinger train were discarded after the mass is measured.

Bureau Veritas labeled each container with the test number, test location, and test date, and marked the level of liquid on the outside of the container. Immediately after recovery, the sample containers were stored. Bureau Veritas personnel transported the samples to Bureau Veritas' laboratory in Novi, Michigan, for analysis. Figure 4 in the Appendix depicts the USEPA Method 5 sampling train.

4.2 Procedures for Obtaining Process Data

Process data were recorded by BWL personnel. Refer to Section 2.1 and 2.2 for discussions of process and control device data and Appendix E for the operating parameters recorded during testing.

4.3 Sampling Identification and Custody

Sample identification and chain of custody procedures were applicable to the sampling methods used in this test program. Applicable Chain of Custody procedures followed guidelines outlined within ASTM D4840-99 (Reapproved 2010), "Standard Guide for Sample Chain-of-Custody Procedures." Detailed sampling and recovery procedures are described in Section 4.0. For each sample collected (i.e. filter) sample identification and custody procedures were completed as follows:

- Containers were sealed with Teflon tape to prevent contamination.
- Containers were labeled with test number, location, and test date.
- The level of fluid was marked on outside of sample containers to identify if leakage had occurred before delivery of the samples to the laboratory.
- Containers were placed in a cooler for storage.
- Samples were logged using guidelines outlined in ASTM D4840-99 (Reapproved 2010), "Standard Guide for Sample Chain-of-Custody Procedures."
- Samples were delivered to the laboratory.

Chains of custody and laboratory analytical results are included in Appendix F.

5.0 QA/QC Activities

Equipment used in this emissions test program passed quality assurance/quality control (QA/QC) procedures. Refer to Appendix A for equipment calibration and inspection sheets. Field data sheets are presented in Appendix C. Computer-generated Data Sheets are presented within Appendix D.

5.1 Pretest QA/QC Activities

Before testing, the sampling equipment was cleaned, inspected, and calibrated according to procedures outlined in the applicable USEPA sampling methods and USEPA's "Quality Assurance Handbook for Air Pollution Measurement Systems, Volume III, Stationary Source Specific Methods."

5.2 QA/QC Audits

The results of select sampling and equipment QA/QC audits and the acceptable tolerance are presented in the following sections. Calibration and inspection sheets for dry-gas meters (DGM), thermocouples, and Pitot tubes are presented in Appendix A.

5.2.1 Method 5 QA/QC Audits

The sampling trains described in Section 4.1 were audited for measurement accuracy and data reliability. The Table 5-1 summarizes the Method 5 QA/QC audits conducted on each sampling train.

Table 5-1
Method 5 Sampling Train QA/QC Audits

Parameter	Run 1	Run 2	Run 3	Run 4	Method Requirement	Comment
EUBOILER1						
Average velocity pressure head (in H_2O)	0.73	0.74	0.74	0.73	>0.05 in $H_2O^{\dagger}$	Valid
Sampling train leak check Post–test	0.000 ft^3 for 1 min at 5 in Hg	0.012 ft^3 for 1 min at 5 in Hg	0.000 ft^3 for 1 min at 8 in Hg	0.005 ft^3 for 1 min at 10 in Hg	$<$0.020 ft^3 for 1 minute at $\geq$ recorded during test	Valid
Sampling vacuum (in Hg)	3	3 to 4	5 to 8	4 to 9		

† Manometer capable of reading 0 to 10 in H_2O acceptable for measuring differential pressure head above 0.05 in H_2O

5.2.2 Instrument Analyzer QA/QC Audits

The instrument analyzer sampling trains described in Section 4.1 were audited for measurement accuracy and data reliability. The analyzers passed the applicable calibration criteria. Calibration gas selection, error, bias, and drift checks are included in Appendix A. The gas cylinders used to perform the RATA are summarized in the table below.

Table 5-2
Calibration Gas Cylinder Information

Parameter	Gas Vendor	Cylinder Serial Number	Cylinder Value	Expiration Date
N_2	The American Gas Group	EB0019307, EB0029715, XC0298288	99.9995%	N/A
O_2	Pangaea Gases, LLC	EB0049439	11.03 %	6/20/2021
CO_2			10.99 %	
O_2	The American Gas Group	CC19491	20.0%	12/7/2019
CO_2			19.6%	
SO_2	Airgas	SG9151212BAL	224.1 ppm	5/13/2019
SO_2	Airgas	CC259138	499.5 ppm	11/22/2019
NO_x	Airgas	XCO15078B	252.6 ppm	12/2/2021
NO_x	Airgas	XCO33685B	491.7 ppm	12/2/2021

Table 5-2
Calibration Gas Cylinder Information

Parameter	Gas Vendor	Cylinder Serial Number	Cylinder Value	Expiration Date
NO_2	Airgas	LL50974	51.13 ppm	1/25/2015

5.2.3 Dry-Gas Meter QA/QC Audits

Table 5-3 summarizes the DGM calibration checks compared to the acceptable USEPA tolerance. Refer to Appendix A for complete DGM calibrations.

Table 5-3
Dry-Gas Meter Calibration QA/QC Audit

Meter Box	Pre-test DGM Calibration Factor (Y) (dimensionless)	Post-test DGM Calibration Check Value (Y_{qa}) (dimensionless)	Absolute Difference Between Pre- and Post-test DGM Calibrations	Acceptable Tolerance	Calibration Result
2	1.001 Jan. 23, 2014	1.009 Feb. 28, 2014	0.008	$\leq$0.05	Valid

5.2.4 Thermocouple QA/QC Audits

Temperature measurements using thermocouples and digital pyrometers were compared to reference temperatures (i.e., ice water bath, boiling water) to evaluate accuracy of the equipment. The thermocouples and pyrometers measured temperatures within ±1.5% (i.e., the USEPA acceptance criterion) of the reference temperatures. Thermocouple and pyrometer calibration results are presented in the Appendix A.

5.3 QA/QC Blanks

Field blanks were analyzed for the constituent of interest. The results of the blanks are presented in Table 5-4. The blank results do not indicate significant contamination occurred in the field. Blank corrections were not applied.

Table 5-4
QA/QC Blanks

Sample Identification	Result (mg)	Comment
M5 Acetone Blank	<0.5	Reporting limit is 0.5 milligrams. Acetone blank corrections not applied.
M5 Filter Blank	1.8	Reporting limit is 0.5 milligrams. Filter blank corrections not applied

5.4 QA/QC Problems

No QA/QC problems were encountered during this test program.

Limitations

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