Derenzo Environmental Services
Consulting and Testing

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AIR EMISSION TEST REPORT

Title	AIR EMISSION TEST REPORT FOR THE VERIFICATION OF NITROGEN OXIDES EMISSIONS FROM A NATURAL GAS FUELED BOILER
Report Date	December 7, 2016
Test Dates	November 30, 2016

Facility Information	
Name	Central Michigan University
Street Address	1720 South East Campus Drive
City, County	Mount Pleasant, Isabella County

Facility Permit Information			
ROP No.:	MI-ROP-K2460-2015	Facility SRN :	K2460
PTI No.:	PTI 218-15	Emission Unit :	EU-BLR4

Testing Contractor	
Company	Derenzo Environmental Services
Mailing Address	39395 Schoolcraft Road Livonia, MI 48150
Phone	(734) 464-3880
Project No.	1608002

DEQ

MICHIGAN DEPARTMENT OF ENVIRONMENTAL QUALITY
AIR QUALITY DIVISION

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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: Central Michigan University — County: Isabella

Source Address: 1720 South East Campus Drive — City: Mt Pleasant

AQD Source ID (SRN): K2460 — ROP No.: K2460-2015 — 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 _____ To _____

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

Test report associated with compliance testing for PTI No. 218-15 for EU-BLR4.
The testing was conducted in accordance with the approved test plan
and the facility was operated in compliance with the permit, at or near
maximum routine 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

Jonathan Webb	Associate Vice President	(989) 774-7473
Name of Responsible Official (print or type)	Title	Phone Number

Signature of Responsible Official — Date: 12-12-2016

* Photocopy this form as needed.

EQP 5736 (Rev 11-04)

AIR EMISSION TEST REPORT
FOR THE
VERIFICATION OF NITROGEN OXIDES EMISSIONS
FROM A
NATURAL GAS FUELED BOILER

CENTRAL MICHIGAN
UNIVERSITY

1.0 INTRODUCTION

Central Michigan University (CMU) operates a power plant to provide steam and electricity for its campus located in Mount Pleasant, Isabella County (Facility State Registration No., SRN K2460). A Renewable Operating Permit (MI-ROP-K2460-2015) has been issued to the stationary source for the powerhouse processes and other emission sources on campus. CMU has modified Boiler No. 4 (emission unit EU-BLR4) such that it has the capability to be fueled with natural gas (the boiler was previously fueled with wood biomass). The modified boiler was issued Permit to Install No. 218-15, which has not, as of yet, been incorporated into the Renewable Operating Permit.

Permit to Install (PTI) No. 218-15 specifies that:

Within 180 days after commencement of initial startup of the natural gas fired burners in EU-BLR4, the permittee shall verify NOx emission rates from EU-BLR4 by testing at owner's expense, in accordance with Department requirements. No less than 60 days prior to testing, the permittee shall submit a complete test plan to the AQD Technical Programs Unit and District Office. The AQD must approve the final plan prior to testing. Verification of emission rates includes the submittal of a complete report of the test results to the AQD Technical Programs Unit and District Office within 60 days following the last date of the test.

The compliance testing was performed by Derenzo Environmental Services, a Michigan-based environmental consulting and testing company. Derenzo Environmental Services representatives Clay Gaffey and Andy Rusnak performed the field sampling November 30, 2016.

The exhaust gas sampling and analysis was performed using procedures specified in the Test Plan dated August 30, 2016 that was reviewed and approved by the Michigan Department of Environmental Quality (MDEQ). MDEQ representatives Mr. David Patterson and Mr. Ben Witkopp observed portions of the testing project.

Appendix 1 contains the test plan approval letter.

Questions regarding this emission test report should be directed to:

Andy Rusnak, QSTI
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Stan Mandziuk
Project Manager
Central Michigan University
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Report Certification

This test report was prepared by Derenzo Environmental Services based on field sampling data collected by Derenzo Environmental Services. Facility process data were collected and provided by CMU employees or representatives. This test report has been reviewed by CMU representatives and approved for submittal to the MDEQ.

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:

Andy Rusnak, QSTI
Technical Manager
Derenzo Environmental Services

I certify that the facility and emission units were operated at maximum routine operating conditions for the test event. Based on information and belief formed after reasonable inquiry, the statements and information in this report are true, accurate and complete.

Responsible Official Certification:

Jonathan Webb
Associate Vice President / Facilities Management
Central Michigan University

2.0 SOURCE AND SAMPLING LOCATION DESCRIPTION

2.1 General Process Description

Boiler No. 4 generates high-pressure steam for an electricity generation turbine. Low pressure steam exiting the turbine is piped throughout the campus for heating.

CMU has modified Boiler No. 4 (emission unit EU-BLR4) such that it has the capability to be fueled with natural gas. A modified Permit to Install was issued in March 2016 to allow for the installation of low-NOx natural gas burners.

2.2 Rated Capacities and Air Emission Controls

PTI No. 218-15 allowed the facility to install natural gas burners that have a total maximum heat input rating of 68 MMBtu/hr. The actual natural gas burners that were installed have a total rated heat input capacity of 60.2 MMBtu/hr based on the fuel higher heating value (HHV).

When burning natural gas, NOx emissions are controlled by low NOx burners. Emissions are exhausted through stack SV-1.

2.3 Sampling Locations

The boiler exhaust gas is released to the atmosphere through a dedicated vertical exhaust stack with a vertical release point.

The boiler exhaust sampling ports are located in the exhaust stack. The exhaust stack has an inner diameter of 60.0 inches. The stack is equipped with two (2) sample ports, opposed 90°, that provide a sampling location greater than 120.0 inches (>2.0 duct diameters, A dimension) upstream of a stack size reduction and greater than 168.0 inches (>2.8 duct diameters, B dimension) downstream of a duct tie-in and satisfy the USEPA Method 1 criteria for a representative sample location.

Individual traverse points were determined in accordance with USEPA Method 1.

Appendix 2 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 for EU-BLR4 in PTI No. 218-15 state:

> *... the permittee shall verify NOx emission rates from EU-BLR4 by testing at owner's expense, in accordance with Department requirements.*

Testing was performed to demonstrate compliance with the NOx emission limit specified in PTI No. 218-15 for EU-BLR4.

3.2 Operating Conditions During the Compliance Tests

The testing was performed while Boiler No. 4 was operated at maximum routine operating conditions (average heat input during testing periods was 54.0 MMBtu/hr). CMU representatives provided total fuel use readings for the boiler in 15-minute increments during each test period.

Fuel flowrate, boiler master (i.e., steam header pressure controller, %) and the steam flow (1,000 lbs/hr, kph) were also recorded by CMU representatives in 15-minute increments for each test period.

CMU representatives also provided a gas analysis report from DTE Energy which documents the heat content (HHV) of the natural gas supplied to the facility.

Appendix 3 provides the gas analysis and operating records provided by CMU representatives for the test periods.

Table 3.1 presents a summary of the average boiler operating conditions during the test periods.

3.3 Summary of Air Pollutant Sampling Results

The gases exhausted from the sampled natural gas fueled boiler (Boiler No. 4) were sampled for three (3) one-hour test periods during the compliance testing performed November 30, 2016.

Table 3.2 presents the average measured NOx emission rate for the boiler (average of the three test periods).

Test results for each one hour sampling period and comparison to the permitted emission rates is presented in Section 6.0 of this report.

Table 3.1 Average Boiler No. 4 operating conditions during the test periods

Emission Unit	Master (%)	Fuel Use (scfh)	Heat Input (MMBtu/hr)	Steam Flow (lb/hr)
Boiler No. 4	85	52,200	54.0	44,900

Table 3.2 Average measured NOx emission rate for Boiler No. 4 (three-test average)

Emission Unit	NO_x Emission Rate (lb/hr)
Boiler No. 4	4.81
Permit Limit	*8.20*

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 CMU 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 and infrared instrumental analyzer.
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 analyzers.

4.2 Exhaust Gas Velocity Determination (USEPA Method 2)

The boiler exhaust stack gas velocities and volumetric flow rates were determined using USEPA Method 2 prior to and after each test. An S-type or standard 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 prior to each traverse 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 4 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 boiler 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 California Analytical, Inc. Model ZRF nondispersive infrared gas analyzer. The O_2 content of the exhaust was monitored using a California Analytical, Inc. Model ZFK3 gas analyzer that uses a zirconia ion sensor.

During each sampling period, a continuous sample of the boiler 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 concentrations 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 5 provides O_2 and CO_2 calculation sheets. Raw instrument response data are provided in Appendix 6.

4.4 Exhaust Gas Moisture Content (USEPA Method 4)

Moisture content of the boiler 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 concentration in the boiler exhaust gas stream 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 boiler exhaust gas was extracted from the stack using the Teflon® heated sample line and gas conditioning system and delivered to the instrumental analyzer. 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 5 provides NO_X calculation sheets. Raw instrument response data are provided in Appendix 6.

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 90.2% of the expected value, i.e., greater than 90% 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 delivered 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 preformed prior to their use in the field (July 26, 2006), 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 2.5% 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 boiler 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 boiler exhaust stack indicated that the measured O_2 and CO_2 concentrations did not vary by more than 5% of the mean across the stack diameter. Therefore, the boiler exhaust gas was considered to be unstratified and the compliance test sampling was performed at a single sampling location within the exhaust stack.

5.6 Meter Box Calibrations

The dry gas meter sampling 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 Nutech metering consoles were calibrated using a NIST traceable Omega® Model CL 23A temperature calibrator.

Appendix 7 presents test equipment quality assurance data (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 and stratification checks).

6.0 RESULTS

6.1 Test Results and Allowable Emission Limits

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

The measured NOx emission rate for Boiler No. 4 is less than the allowable limit specified in PTI No. 218-15 for EU-BLR4:

- 8.20 lb/hr.

6.2 Variations from Normal Sampling Procedures or Operating Conditions

The testing was performed in accordance with USEPA methods and the approved test protocol. The boiler was operated at maximum routine operating conditions and no variations from normal operating conditions occurred during the boiler test periods.

Table 6.1 Measured exhaust gas conditions and NOx air pollutant emission rate for Boiler No. 4 (EU-BLR4)

Test No.	1	2	3	
Test date	11/30/16	11/30/16	11/30/16	Three Test
Test period (24-hr clock)	800-900	930-1030	1100-1200	Average
Master Control Setting (%)	85	85	85	85
Fuel flowrate (scfh)	52,300	52,100	52,100	52,200
Heat Input Rate (MMBtu/hr)	54.1	53.9	53.9	54.0
Steam flowrate (lb/hr)	45,000	44,500	45,200	44,900
Exhaust Gas Composition				
CO_2 content (% vol)	10.2	10.2	10.2	10.2
O_2 content (% vol)	3.37	3.37	3.40	3.38
Moisture (% vol)	11.8	17.8	17.1	15.6
Exhaust gas temperature (°F)	311	318	338	322
Exhaust gas flowrate (dscfm)	9,943	9,716	9,979	9,879
Nitrogen Oxides				
NO_X conc. (ppmvd)	68.4	67.3	68.2	68.0
NO_X emissions (lb/hr)	4.88	4.69	4.88	4.81
Permitted emissions (lb/hr)	-	-	-	8.20