



# Oxides of Nitrogen Emissions Test Report

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*Prepared for:*

**State of Michigan**

Lansing, Michigan

Source Address:

State of Michigan  
Department of Technology, Management and Budget  
7432 Parsons Road  
Lansing, Michigan

Project No. 14-4602.00  
October 22, 2014

BT Environmental Consulting, Inc.  
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Royal Oak, Michigan 48073  
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**EXECUTIVE SUMMARY**

BT Environmental Consulting, Inc. (BTEC) was retained by the State of Michigan to evaluate nitrogen oxides (NOx) emission rates from two gas turbines operating at a single load condition at the State of Michigan, Department of Technology, Management and Budget (DTMB) facility located in Lansing, Michigan. Testing for this project was completed on October 2, 2014. The water-to-fuel ratio was set at 0.5 for both turbines during testing.

Testing consisted of triplicate 20-minute test runs for NOx at both sampling locations. Sampling was performed utilizing United States Environmental Protection Agency (USEPA) reference test methods. The average results of the testing are highlighted in the following table:

**Table I  
Overall Emission Summary**

Source	Pollutant	Average Emission Rates	Emission Limit
		ppm dry, corrected to 15% O <sub>2</sub>	ppm dry, corrected to 15% O <sub>2</sub>
FGTURB/HRSG1	NOx <sup>1</sup>	27 ppm	42 ppm
FGTURB/HRSG2	NOx <sup>1</sup>	30 ppm	42 ppm

<sup>1</sup>: Corrected as per USEPA 7E

## **1. Introduction**

BT Environmental Consulting, Inc. (BTEC) was retained by the State of Michigan to evaluate nitrogen oxides (NO<sub>x</sub>) emission rates from two gas turbines operating at a single load condition at the State of Michigan, Department of Technology, Management and Budget (DTMB) facility located in Lansing, Michigan. Testing for this project was completed on October 2, 2014. The purpose of this report is to document the results of the emissions compliance test program.

The Air Quality Division (AQD) of Michigan's Department of Environmental Quality has published a guidance document entitled "Format for Submittal of Source Emission Test Plans and Reports" (December 2013, see Appendix A). The following is a summary of the emissions test program and results in the format outlined by the AQD document.

### **1.a Identification, Location, and Dates of Test**

Field sampling for the emissions compliance test program was conducted on October 2, 2014 at the DTMB facility in Lansing, Michigan. The emission test program included the evaluation of exhaust gas oxides of nitrogen (NO<sub>x</sub>) and oxygen (O<sub>2</sub>) concentrations in the exhaust from two gas turbine cogeneration systems.

### **1.b Purpose of Testing**

The purpose of the testing was to demonstrate continuous compliance with the emission limitations of Title 40, Part 60, Subpart KKKK of the Code of Federal Regulations as specified by 40 CFR 60, Subpart KKKK.

### **1.c Source Description**

Two nominally rated 19.0 MMBtu/hr natural gas-fired turbines (EUTURBINE1 and EUTURBINE2) with electrical generators. The exhaust from the turbines is routed through heat recovery steam generators (EUHRSG1 and EUHRSG2), each with a nominally rated 20.0 MMBtu/hr natural gas-fired duct burner. EUTURBINE1 and EUHRSG1 are included in flexible group FGTURB/HRSG1. EUTURBINE2 and EUHRSG2 are included in flexible group FGTURB/HRSG1.



#### **1.d Test Program Contact**

The contact for information regarding the test program as well as the test report is:

Mr. David Sproul, P.E.  
Project Director  
DTMB, Design & Construction Division  
2<sup>nd</sup> Floor, Stevens T. Mason Building  
P.O. Box 30026  
Lansing, Michigan 48909  
(517) 373-8322

#### **1.e Testing Personnel**

Names and affiliations for personnel who were present during the testing program are summarized by Table 1.

### **2. Summary of Results**

Sections 2.a through 2.d summarize the results of the emissions compliance test program.

#### **2.a Operating Data**

Operating data recorded during the emissions test program includes steam load (lb/hr), kW produced, natural gas flowrate (MSCFH) and water to fuel ratio. Process data is included as Appendix B.

#### **2.b Applicable Permit**

The applicable permit for this emissions test program is Permit No. 156-10A.

#### **2.c Results**

The overall results of the emissions compliance test program are summarized by Table 2. (see Section 5.a).

#### **2.d Emission Regulation Comparison**

The turbines are limited to not greater than 42 ppmv NO<sub>x</sub> @ 15% O<sub>2</sub>.

### **3. Source Description**

Sections 3.a through 3.d provide a detailed description of the process.

### **3.a Process Description**

Two nominally rated 19.0 MMBtu/hr natural gas-fired turbines (EUTURBINE1 and EUTURBINE2) with electrical generators. The exhaust from the turbines is routed through heat recovery steam generators (EUHRSG1 and EUHRSG2), each with a nominally rated 20.0 MMBtu/hr natural gas-fired duct burner. EUTURBINE1 and EUHRSG1 are included in flexible group FGTURB/HRSG1. EUTURBINE2 and EUHRSG2 are included in flexible group FGTURB/HRSG1.

### **3.b Raw and Finished Materials**

The raw material used is natural gas.

### **3.c Process Capacity**

Each turbine is rated at 19.0 MMBtu/hr and each HRSG is rated at 20.0 MMBtu/hr.

### **3.d Process Instrumentation**

The process operating parameters relevant to the emissions test program include steam load (lb/hr), energy produced (KW), fuel flowrate (MSCFH), and the water to fuel ratio.

## **4. Sampling and Analytical Procedures**

Sections 4.a through 4.d provide a summary of the sampling and analytical procedures used to verify emission rates from the Turbines.

### **4.a Sampling Train and Field Procedures**

Sampling and analytical procedures followed the following reference test methods codified at Title 40, Part 60, Appendix A of the Code of Federal Regulations (40 CFR 60, Appendix A):

- Method 3A - "*Gas Analysis for Determination of Dry Molecular Weight (Analyzer Method)*" was used to evaluate the O<sub>2</sub> content of the exhaust gas.
- Method 7E - "*Determination of Nitrogen Oxides Emissions from Stationary Sources*" was used to measure the NO<sub>x</sub> concentration of the exhaust gas.

The NO<sub>x</sub> content of the gas stream was measured using a TECO Model 42i NO<sub>x</sub> gas analyzer (or equivalent) and the O<sub>2</sub> content was measured using a M&C Products PMA 100-L O<sub>2</sub> gas analyzer (or equivalent). A sample of the gas stream was drawn through an insulated stainless-steel probe with an in-line glass fiber filter to remove any particulate, a heated Teflon<sup>®</sup> sample line, and through an electronic sample conditioner to remove the



moisture from the sample before it enters the analyzer. Data was recorded at 4-second intervals on a PC equipped with data acquisition software. A schematic of the sampling train is provided as Figure 1.

#### **4.b Recovery and Analytical Procedures**

There were no samples collected as part of this emissions test program.

#### **4.c Sampling Ports**

Sample ports are located downstream of the heat recovery steam generators. An exhaust gas stratification check was performed during the first test run on both exhaust stacks.

#### **4.d Traverse Points**

The exhaust gas stratification check included traverse points as specified by Method 1.

### **5. Test Results and Discussion**

Sections 5.a through 5.k provide a summary of the test results.

#### **5.a Results Tabulation**

The results of the emissions test program are summarized by Table 2. Detailed emission test results for each exhaust stack are summarized in Tables 3 and 4. Field data sheets and computer-generated raw data are provided in Appendix C.

#### **5.b Discussion of Results**

Emission rates were less than 75% of the emission limitations.

#### **5.c Sampling Procedure Variations**

There were no sampling procedure variations used during the emission compliance test program.

#### **5.d Process or Control Device Upsets**

No upset conditions occurred during testing.

#### **5.e Control Device Maintenance**

No control device maintenance was performed during the testing.



#### **5.f Audit Sample Analyses**

No samples were collected as part of the test program.

#### **5.g Calibration Sheets**

All relevant equipment calibration documents are provided as Appendix D.

#### **5.h Sample Calculations**

Sample calculations are provided in Appendix E.

#### **5.i Field Data Sheets**

Field documents relevant to the emissions test program are presented in Appendix C.

#### **5.j Laboratory Data**

No laboratory analysis was included in this test program.

## **TABLES**

**Table 1  
Test Personnel**

Name and Title	Affiliation	Telephone
Mr. David Sproul Project Director	DTMB, Design & Construction Div. 2 <sup>nd</sup> Floor, Stevens T. Mason Building P.O. Box 30026 Lansing, Michigan 48909	(517) 373-8322
Mr. Randal Tysar Senior Environmental Engineer	BTEC 4949 Fernlee Avenue Royal Oak, Michigan 48073	(248) 548-8070
Mr. Matthew Young Senior Project Manager	BTEC 4949 Fernlee Avenue Royal Oak, Michigan 48073	(248) 548-8070
Mr. Paul Draper Environmental Technician	BTEC 4949 Fernlee Avenue Royal Oak, Michigan 48073	(248) 548-8070
Mr. Ken Felder Environmental Technician	BTEC 4949 Fernlee Avenue Royal Oak, Michigan 48073	(248) 548-8070
Mr. David Patterson Laboratory Scientist	MDEQ – AQD P.O. Box 30260 Lansing, Michigan 48909	(517) 373-7084

**Table 2  
Overall Emission Summary**

Source	Pollutant	Average Emission Rates	Emission Limit
		ppm dry, corrected to 15% O <sub>2</sub>	ppm dry, corrected to 15% O <sub>2</sub>
FGTURB/HRSG1	NO <sub>x</sub> <sup>1</sup>	27 ppm	42 ppm
FGTURB/HRSG2	NO <sub>x</sub> <sup>1</sup>	30 ppm	42 ppm

<sup>1</sup>: Corrected as per USEPA 7E

**Table 3**  
**Turbine 1 NOx Emission Rates**  
**State of Michigan DTMB**  
**Lansing, MI**  
**BTEC Project No. 14-4602.00**  
**Sampling Date: 10/2/14**

Parameter	Run 1	Run 2	Run 3	Average
Test Run Date	10/2/2014	10/2/2014	10/2/2014	
Test Run Time	8:05 - 8:33	8:42 - 9:02	9:09 - 9:29	
Oxygen Concentration (%)	11.7	11.9	12.1	<b>11.9</b>
Oxygen Concentration (% , drift corrected as per USEPA 7E)	11.8	11.9	12.2	<b>12.0</b>
Outlet Oxides of Nitrogen Concentration (ppmv)	40.2	40.0	39.0	<b>39.8</b>
Outlet NOx Concentration (ppmv, corrected as per USEPA 7E)	41.8	41.5	40.4	<b>41.2</b>
Outlet NOx Concentration (ppmv, corrected to 15% O <sub>2</sub> )	<b>27.1</b>	<b>27.2</b>	<b>27.4</b>	<b>27.2</b>

ppmv = parts per million on a volume-to-volume basis

$$\text{Conc}_{@15\%O_2} = \text{Conc} * (20.9 - 15)/(20.9 - \%O_2)$$

**Table 4**  
**Turbine 2 NOx Emission Rates**  
**State of Michigan DTMB**  
**Lansing, MI**  
**BTEC Project No. 14-4602.00**  
**Sampling Date: 10/2/14**

Parameter	Run 1	Run 2	Run 3	Average
Test Run Date	10/2/2014	10/2/2014	10/2/2014	
Test Run Time	12:47 - 13:13	13:22 - 13:42	13:50 - 14:10	
Oxygen Concentration (%)	13.5	13.7	13.2	13.5
Oxygen Concentration (% , drift corrected as per USEPA 7E)	13.6	13.7	13.3	13.5
Outlet Oxides of Nitrogen Concentration (ppmv)	36.4	35.2	36.9	36.2
Outlet NOx Concentration (ppmv, corrected as per USEPA 7E)	37.8	36.7	38.5	37.6
Outlet NOx Concentration (ppmv, corrected to 15% O <sub>2</sub> )	30.3	30.2	29.8	30.1

ppmv = parts per million on a volume-to-volume basis

$$\text{Conc}_{@15\%O_2} = \text{Conc} * (20.9 - 15) / (20.9 - \%O_2)$$

**FIGURE**

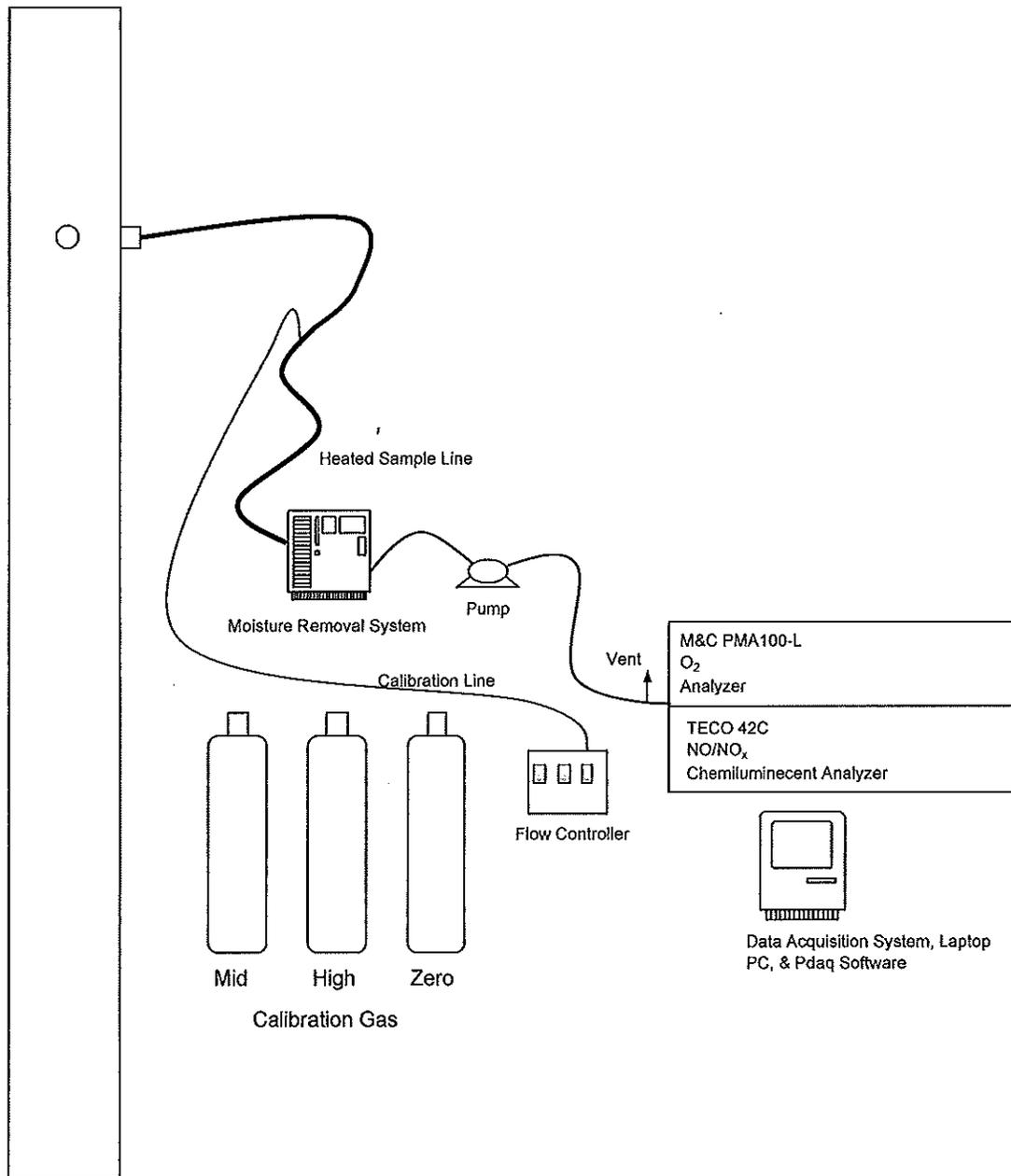


Figure 1

Site:  
USEPA Methods 3A and 7E  
State of Michigan, DTMB  
Lansing, Michigan

Sampling Date:  
October 2, 2014

**BT Environmental Consulting Inc.**  
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