



# Gas Turbine Emissions Test Report

*Prepared for:*

**Wayne County Airport Authority**

**RECEIVED**  
JUN 12 2014  
AIR QUALITY DIV.

Source Address:

Detroit Metropolitan Wayne County Airport  
Building 611 (Powerhouse)  
Detroit, Michigan 48232

Project No. 05-3464.00  
May 19, 2014

BT Environmental Consulting, Inc.  
4949 Fernlee Avenue  
Royal Oak, Michigan 48073  
(248) 548-8070

**EXECUTIVE SUMMARY**

BT Environmental Consulting, Inc. (BTEC) was retained by the Wayne County Airport Authority to evaluate nitrogen oxides (NO<sub>x</sub>) and carbon monoxide (CO) emission rates from a single gas turbine operating at two different load conditions. Triplicate 21-minute tests were conducted at a load of 11.0 MW. The turbine load was then changed to 8.3 MW and an additional three 21-minute test runs conducted. The emissions test program was conducted on April 11, 2014. The results of the emission test program are summarized by Table I.

**Table I**  
**Emission Test Program Results Summary**

<b>Emission Unit Identification</b>	<b>Pollutant</b>	<b>Test Result (11.0 MW)</b>	<b>Test Result (8.3 MW)</b>	<b>Limit</b>
EUTURBINE	NO <sub>x</sub> @ 15% O <sub>2</sub> (ppm)	7.8	8.6	25
	NO <sub>x</sub> (lb/MMBtu)	0.03	0.03	0.06
	NO <sub>x</sub> (lb/hr)	3.7	3.4	8.7
	CO (lb/MMBtu)	0.022	0.023	0.061
	CO (lb/hr)	2.8	2.5	8.8

## **1. Introduction**

BT Environmental Consulting, Inc. (BTEC) was retained by the Wayne County Airport Authority to evaluate nitrogen oxides (NO<sub>x</sub>) and carbon monoxide (CO) emission rates from a single gas turbine operating at two different load conditions. Triplicate 21-minute tests were conducted at a load of 11.0 MW. The turbine load was then changed to 8.3 MW and an additional three 21-minute test runs conducted. The emissions test program was conducted on April 11, 2014.

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). This document is provided as Appendix A. The following is a summary of the emissions test program and results in the format suggested by the aforementioned document.

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

Field sampling for the emissions compliance test program was conducted on April 11, 2014 at the Building 611 Powerhouse located at Detroit Metropolitan Wayne County Airport (DTW). The emission test program included the evaluation of NO<sub>x</sub> and CO emission rates from one natural gas-fired turbine.

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

Michigan Permit to Install No. 175-10 limits the turbine to (1) 25 ppm NO<sub>x</sub> corrected to 15% O<sub>2</sub>, (2) 0.06 lbs NO<sub>x</sub> per MMBtu, (3) 8.7 lbs NO<sub>x</sub> per hour; (4) 0.061 lbs CO per MMBtu, and (5) 8.8 lbs CO per hour.

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

The emission unit is a Titan 130-20501S Axial gas turbine manufactured by Solar Turbines. The turbine is equipped to fire natural gas only. Additional information regarding the Titan 130-20501S Axial gas turbine as well as the associated SoLoNO<sub>x</sub> dry emissions control technology are provided in Appendix B.

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

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

Mr. Bryan C. Wagoner  
Airport Environmental Administrator  
Detroit Metropolitan Wayne County Airport  
L.C. Smith Terminal, 2<sup>nd</sup> Floor  
Detroit, Michigan 48232  
(734) 247-3686

## 1.e Testing Personnel

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

**Table 1**  
**Testing Personnel**

<b>Name</b>	<b>Affiliation</b>
John Philbrook	DTW
Matthew Young	BTEC
Randal Tysar	BTEC
Mark Dziadosz	MDEQ
Steve Weis	MDEQ

## 2. Summary of Results

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

### 2.a Operating Data

Turbine operating load (kW) and natural gas flowrate (lb/hr) were monitored throughout the emissions test program and are summarized in Appendix E.

### 2.b Applicable Permit

Michigan Permit to Install No. 175-10 was issued for the turbine.

### 2.c Results

The results of the emissions test program are summarized by Table 2. Detailed results for each test run are summarized by Tables 3 and 4.

### 2.d Emission Regulation Comparison

Emission limitations for the turbine are summarized in Section 1.b.

## 3. Source Description

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

### 3.a Process Description

The Titan 130-20501S Axial turbine is a single shaft gas turbine that is regulated by electrical load only. Air to fuel mix ratios are controlled automatically with slightly higher turbine loads possible during periods of higher ambient air density.

The turbine is nominally rated for a maximum of 145 MMBtu/hr heat input and the generator is rated for a maximum power load of 15 MW.

### **3.b Process Flow Diagram**

Due to the simplicity of the turbine process, a process flow diagram is not provided.

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

The raw material used is natural gas.

### **3.d Process Capacity**

The turbine is nominally rated for a maximum of 145 MMBtu/hr heat input and the generated is rated for a maximum power load of 15 MW.

### **3.e Process Instrumentation**

Process instrumentation relevant to the emissions test program includes natural gas flowrate (lbs/hr) and electrical load (MW). Relevant data is summarized in Appendix E.

## **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 turbine.

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

The NO<sub>x</sub> content of the gas stream was measured using a TECO Model 42i NO<sub>x</sub> gas analyzer, the CO content of the gas stream was measured using a TECO Model 48i CO gas analyzer, and the O<sub>2</sub> content was measured using a M&C Products PMA 100-L O<sub>2</sub> gas analyzer. A sample of the gas stream will be drawn through an insulated stainless-steel probe with an in-line glass fiber filter to remove any particulate, a heated Teflon® sample line, and through a Universal Analyzers 3080PV electronic sample conditioner to remove the moisture from the sample before it enters the analyzer. Data will be recorded at 4-second intervals on a PC equipped with data acquisition software.

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

- Method 3A, “*Determination of Oxygen and Carbon Dioxide Concentrations in Emissions from Stationary Sources*”
- Method 7E, “*Determination of Nitrogen Oxide Emissions from Stationary Sources*”
- Method 10, “*Determination of Carbon Monoxide Emissions from Stationary Sources*”,
- Method 19, “*Determination of Sulfur Dioxide Removal Efficiency and Particulate*”

*Matter, Sulfur Dioxide, and Nitrogen Oxide Emission Rates*

Exhaust gas flowrates were calculated using turbine natural gas flowrate data (provided by DTW), the gross heating value and density of the natural gas (as provided by the natural gas utility from a recent sampling and analysis, see Appendix E), and the equations included in Method 19.

**4.b Recovery and Analytical Procedures**

Recovery procedures are described in section 4.a.

**4.c Sampling Ports**

Exhaust gas sampling was conducted in the turbine exhaust stack. The stack is round and 72 inches in diameter, and is equipped with two test ports positioned at 90 degrees.

**4.d Traverse Points**

The absence of stratification was verified by traversing the stack at Method 1 locations with the probe moved at two-minute intervals during the first test run. During the test run, each individual O<sub>2</sub> reading was within 0.3 percent of the overall mean.

**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.

**Table 2  
Emission Test Program Results Summary**

<b>Emission Unit Identification</b>	<b>Pollutant</b>	<b>Test Result (11.0 MW)</b>	<b>Test Result (8.3 MW)</b>	<b>Limit</b>
EUTURBINE	NOx @ 15% O <sub>2</sub> (ppm)	7.8	8.6	25
	NOx (lb/MMBtu)	0.03	0.03	0.06
	NOx (lb/hr)	3.7	3.4	8.7
	CO (lb/MMBtu)	0.022	0.023	0.061
	CO (lb/hr)	2.8	2.5	8.8

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

Emission limitations and the results of the emissions test program are summarized by Table 2 (see section 5.a).

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

No sampling procedure variations were used during the emissions test program.

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

The emissions test program commenced on April 10, 2014, however, the turbine stopped operating approximately seven minutes into the first test run at 11.0 MW. After the turbine was again functional, the emissions test program was started from the beginning on April 11, 2014. Available test results for the aborted test run are available electronically in Appendix F.

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

The Solar turbine is not equipped with an add-on emissions control device.

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

Audit samples are not applicable to this emissions test program.

## **5.g Calibration Sheets**

Certificates of analysis for the calibration gases used during testing are provided as Appendix C.

## **5.h Sample Calculations**

Sample calculations are provided as Appendix D.

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

Copies of field data sheets and relevant field notes are provided as Appendix F.

## **5.j Laboratory Data**

There are no laboratory results for this test program.

# **TABLES**



**Table 3**  
**EU-Turbine Detailed Emission Test Results Summary**  
**Detroit Metropolitan Wayne County Airport**  
**BTEC Project No. 05-3464**  
**11.0 MW Load Condition**  
**Sampling Date: April 11, 2014**

Parameter		Run 1	Run 2	Run 3	Average
11.0 MW Load	Test Run Date	4/11/2014	4/11/2014	4/11/2014	
	Test Run Time	9:31 - 9:52	10:06-10:27	10:33-10:54	
	Oxides of Nitrogen Concentration (ppmv)	7.80	7.79	8.14	7.91
	Oxygen concentration (%)	15.03	14.88	14.79	14.90
	Oxygen concentration (%) (corrected as per USEPA 7E)	15.06	15.02	15.02	15.03
	Natural Gas Flowrate (kscf/hr)	128.8	128.8	128.8	128.8
	Natural Gas Heating Value (Btu/scf)	984	984	984	984
	NOx Concentration (ppmv, corrected as per USEPA 7E)	7.79	7.60	7.98	7.79
	NOx Concentration (lb/dscf, corrected as per USEPA 7E)	9.3E-07	9.1E-07	9.5E-07	9.3E-07
	NOx Emission Factor (lb/MMBtu, corrected as per USEPA 7E)	0.029	0.028	0.029	0.029
<b>NOx Emission Rate (lb/hr) (corrected as per USEPA 7E)</b>	<b>3.7</b>	<b>3.6</b>	<b>3.7</b>	<b>3.7</b>	
<b>NOx Concentration (ppmv@15% O2)</b>	<b>7.9</b>	<b>7.6</b>	<b>8.0</b>	<b>7.8</b>	
11.0 MW Load	Carbon Monoxide Concentration (ppmv)	10.12	9.71	10.00	9.94
	Oxygen concentration (%)	15.03	14.88	14.79	14.90
	Oxygen concentration (%) (corrected as per USEPA 7E)	15.06	15.02	15.02	15.03
	Natural Gas Flowrate (kscf/hr)	128.8	128.8	128.8	128.8
	Natural Gas Heating Value (Btu/scf)	984.0	984.0	984.0	984
	CO Concentration (ppmv, corrected as per USEPA 7E)	9.78	9.67	10.02	9.82
	CO Concentration (lb/dscf, corrected as per USEPA 7E)	7.1E-07	7.0E-07	7.3E-07	7.1E-07
	CO Emission Factor (lb/MMBtu, corrected as per USEPA 7E)	0.022	0.022	0.023	0.022
	<b>CO Emission Rate (lb/hr) (corrected as per USEPA 7E)</b>	<b>2.8</b>	<b>2.8</b>	<b>2.9</b>	<b>2.8</b>

Calculated using USEPA Method 19 equation 19-1

dscf = dry standard cubic feet

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

lb/hr = pounds per hour

MW = molecular weight (NOx = 46.01, CO = 28.01)

24.14 = molar volume of air at standard conditions (70°F, 29.92" Hg)

35.31 = ft<sup>3</sup> per m<sup>3</sup>

453600 = mg per lb

10<sup>6</sup> = Btu per MMBtu

3785.4 = mL per gallon

**Equations**

lb/dscf = ppmv \* MW/24.14 \* 1/35.31 \* 1/453,600

eq 19-1:  $E = C_d F_d * 20.9 / (20.9 - \%O_{2d})$

NOx @ 15% O2 = NOx measured (ppm) X (5.9/(20.9-O2% measured))

**Table 4**  
**EU-Turbine Detailed Emission Test Results Summary**  
**Detroit Metropolitan Wayne County Airport**  
**BTEC Project No. 05-3464**  
**8.3 MW Load Condition**  
**Sampling Date: April 11, 2014**

Parameter		Run 4	Run 5	Run 6	Average
	Test Run Date	4/11/2014	4/11/2014	4/11/2014	
	Test Run Time	11:01 - 11:22	11:28 - 11:49	11:55 - 12:16	
8.3 MW Load	Oxides of Nitrogen Concentration (ppmv)	9.00	9.04	8.98	9.01
	Oxygen concentration (%)	14.56	14.58	14.44	14.53
	Oxygen concentration (%) (corrected as per USEPA 7E)	14.92	14.95	14.86	14.91
	Natural Gas Flowrate (kscf/hr)	109.2	109.2	109.2	109.2
	Natural Gas Heating Value (Btu/scf)	984	984	984	984
	NOx Concentration (ppmv, corrected as per USEPA 7E)	8.78	8.78	8.76	8.77
	NOx Concentration (lb/dscf, corrected as per USEPA 7E)	1.0E-06	1.0E-06	1.0E-06	1.0E-06
	NOx Emission Factor (lb/MMBtu, corrected as per USEPA 7E)	0.032	0.032	0.032	0.032
	<b>NOx Emission Rate (lb/hr) (corrected as per USEPA 7E)</b>	<b>3.4</b>	<b>3.4</b>	<b>3.4</b>	<b>3.4</b>
<b>NOx Concentration (ppmv@15% O2)</b>	<b>8.7</b>	<b>8.7</b>	<b>8.6</b>	<b>8.6</b>	
8.3 MW Load	Carbon Monoxide Concentration (ppmv)	10.64	10.62	10.19	10.48
	Oxygen concentration (%)	14.56	14.58	14.44	14.53
	Oxygen concentration (%) (corrected as per USEPA 7E)	14.92	14.95	14.86	14.91
	Natural Gas Flowrate (kscf/hr)	109.2	109.2	109.2	109.2
	Natural Gas Heating Value (Btu/scf)	984.0	984.0	984.0	984
	CO Concentration (ppmv, corrected as per USEPA 7E)	10.58	10.45	10.03	10.35
	CO Concentration (lb/dscf, corrected as per USEPA 7E)	7.7E-07	7.6E-07	7.3E-07	7.5E-07
	CO Emission Factor (lb/MMBtu, corrected as per USEPA 7E)	0.023	0.023	0.022	0.023
	<b>CO Emission Rate (lb/hr) (corrected as per USEPA 7E)</b>	<b>2.5</b>	<b>2.5</b>	<b>2.4</b>	<b>2.5</b>

Calculated using USEPA Method 19 equation 19-1

dscf = dry standard cubic feet

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

lb/hr = pounds per hour

MW = molecular weight (NOx = 46.01, CO = 28.01)

24.14 = molar volume of air at standard conditions (70°F, 29.92" Hg)

35.31 = ft<sup>3</sup> per m<sup>3</sup>

453600 = mg per lb

10<sup>6</sup> = Btu per MMBtu

3785.4 = mL per gallon

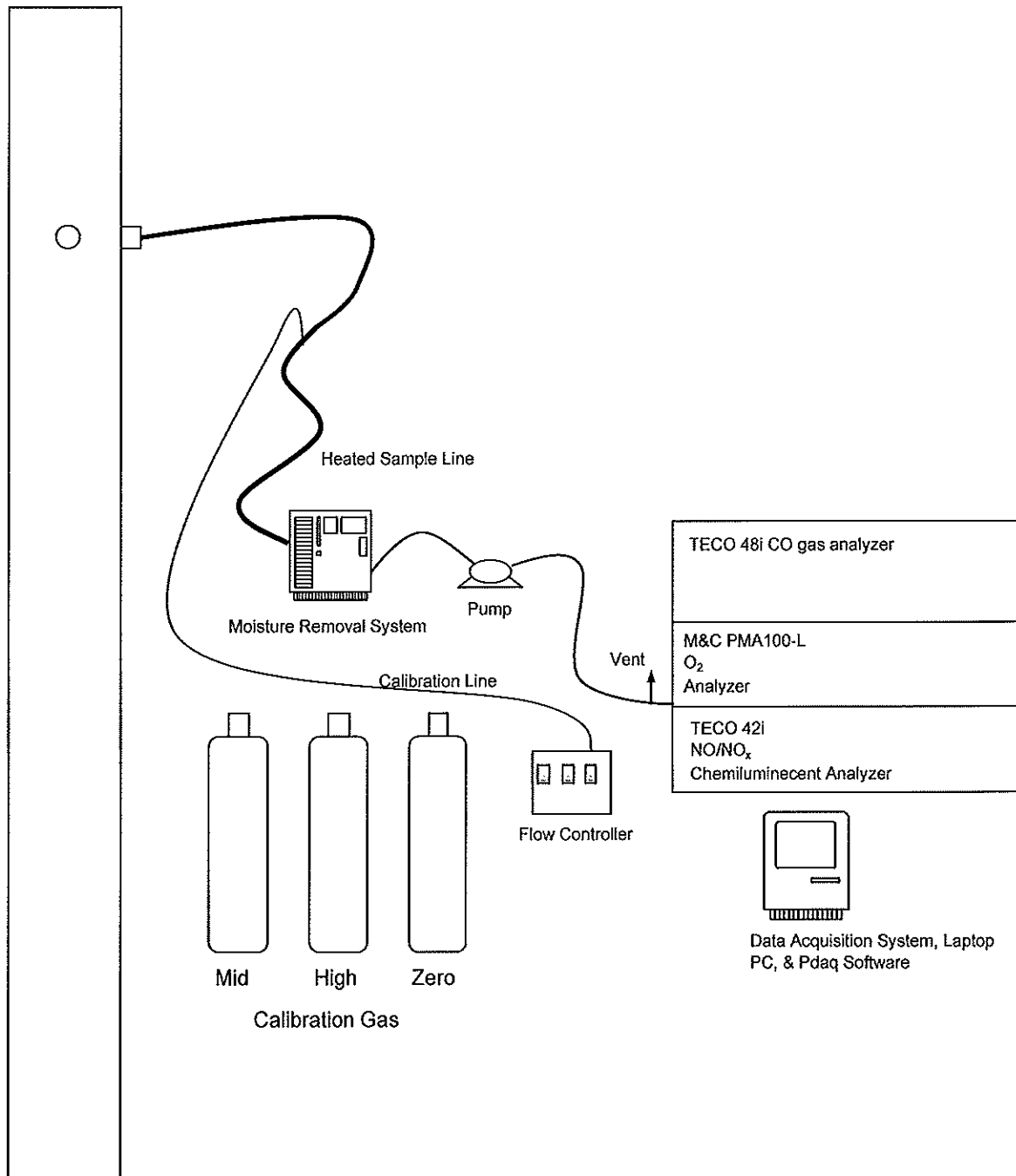
**Equations**

$$\text{lb/dscf} = \text{ppmv} * \text{MW} / 24.14 * 1/35.31 * 1/453,600$$

$$\text{eq 19-1: } E = C_d F_d * 20.9 / (20.9 - \%O_{2d})$$

$$\text{NOx @ 15\% O}_2 = \text{NOx measured (ppm)} * (5.9 / (20.9 - \%O_2 \text{ measured}))$$

**FIGURE**



**Figure 1**

Site:  
 USEPA Methods 3A, 7E, and 10  
 Detroit Metropolitan Wayne County Airport  
 Detroit, Michigan

Test Date: April 11, 2014

**BT Environmental Consulting Inc.**  
 4949 Fernlee Avenue  
 Royal Oak MI 48073