

## 1.0 PROJECT OVERVIEW

### 1.1 GENERAL

Montrose Air Quality Services, LLC (Montrose) located at 1371 Brummel Avenue, Elk Grove Village, Illinois was contracted by Bluewater Gas Storage, LLC to perform an air emission test program at the Bluewater Gas Storage Station located in Columbus, Michigan. Testing was performed to satisfy the requirements of the Michigan Department of Environmental -Quality (MDEQ) PTI, the United States Environmental Protection Agency (U.S. EPA), 40 CFR 63.6640 (c), Subpart ZZZZ, as applicable.

The specific objective of the test program is as follows:

- Determine the nitrogen oxides (NO<sub>x</sub>) and carbon monoxide (CO) emissions from three natural gas fired, compressor engines at the Bluewater Gas Storage

Testing was performed on EU-COMP NORTH (UPC1), EU-COMP WEST (UPC3), and EU-COMP EAST (UPC4) on September 15, 2020. Coordinating the field aspects of the test program were:

Shelly Heston – WEC Energy Group - (920) 433-1294

Frank Rasmussen – Bluewater Gas Storage - (810) 305-3912

Brandon Check – Montrose Air Quality Services, LLC – (630) 860-4740

State observer:

Regina Angellotti – EGLE - Air Quality Division – (313) 418-0895

## 1.2 EXECUTIVE SUMMARY

The results of the test program are summarized in the following table.

**TABLE 1-1  
 EXECUTIVE SUMMARY**

| Location      | NO <sub>x</sub><br>(lb/hr) |        | CO<br>(ppmdv@15%O <sub>2</sub> ) |        | CO<br>(lb/hr) |         |
|---------------|----------------------------|--------|----------------------------------|--------|---------------|---------|
|               | Limit                      | Result | Limit                            | Result | Limit         | Result  |
| EU-COMP NORTH | 4.5                        | 3.05   | 47                               | 0.160  | 0.4           | 0.00273 |
| EU-COMP WEST  | 7.4                        | 3.86   | 47                               | 8.05   | 1.85          | 0.511   |
| EU-COMP EAST  | 7.4                        | 4.35   | 47                               | 10.2   | 1.85          | 0.637   |

## 1.3 ASTM D7036-04(2011)

All applicable Montrose field personnel used on-site for this test program were compliant with ASTM D7036-04(2011) "Standard Practice for Competence of Air Emissions Testing Bodies" for all tests performed. This includes having the appropriate QSTI directly supervise the testing.

The following table summarizes the key personnel that were involved with this project:

**TABLE 1-2  
 PROJECT PERSONNEL**

| Personnel               | Position on Project    | Date of QSTI Exam |
|-------------------------|------------------------|-------------------|
| Brandon Check, Q.S.T.I. | Client Project Manager | 03/31/2016        |

## 1.4 METHODOLOGY

The concentrations of oxygen (O<sub>2</sub>), NO<sub>x</sub>, and CO at the exhaust of each engine was determined using EPA Methods 3A, 7E and 10. The sample gas was withdrawn from the outlet at a constant rate through a stainless steel probe, a glass fiber filter and a Teflon sample line. The probe, filter and sample line were operated at a minimum temperature of 250 °F to prevent the condensation of moisture. The sample gas passed through a gas cooler system. The gas cooler consists of two separate stages designed to lower the dew point of the sample gas to 35 °F, thus removing the moisture. Each stage of the gas cooler is designed to minimize contact of condensed moisture with the dry sample gas. The dry gas is then delivered to the O<sub>2</sub>, NO<sub>x</sub> and CO analyzers.

Three 15 minute test runs were performed at the outlet of each engine. Results from the analyzers were determined on a “dry” basis. Results are in parts per million dry volume (ppmdv), ppmdv at 15 percent (%) O<sub>2</sub> (ppmdv@15%) (CO only) and in pound per hour (lb/hr).

## 1.5 PARAMETERS

The following specific parameters were determined at each engine at the Bluewater Gas Storage Station test locations during each test run:

- oxygen concentration
- nitrogen oxides concentration
- carbon monoxide concentration

## 1.6 QUALITY STATEMENT

Montrose is qualified to conduct this test program and has established a quality management system that led to accreditation with ASTM Standard D7036-04 (Standard Practice for Competence of Air Emission Testing Bodies). Montrose participates in annual functional assessments for conformance with D7036-04 which are conducted by the American Association for Laboratory Accreditation (A2LA). All testing performed by Montrose is supervised on site by at least one Qualified Individual (QI) as defined in D7036-04 Section 8.3.2. Data quality objectives for estimating measurement uncertainty within the documented limits in the test methods are met by using approved test protocols for each project as defined in D7036-04 Sections 7.2.1 and 12.10. Additional quality assurance information is presented in the report appendices.

## 1.7 RESULTS

A complete summary of test results is presented in Tables 2-1 through 2-6.

Testing was performed according to Test Plan No. 023AS-698905-PP-182. The procedures outlined in that document were followed except where noted.

Sample measurements were conducted at three points on the line passing through the centroidal area at 16.7, 50.0, and 83.3 percent (%) of the measurement line. Each point was sampled for five minutes for each fifteen minute test run.

After Run 1 of EU-COMP NORTH the post run low and upscale bias checks passed, but the upscale drift for CO exceeded the specifications in section 13.3, the run data was valid, but a 3 point calibration error test and a system bias check was completed and passed before any more test runs were performed.

## 2.0 SUMMARY OF RESULTS

**TABLE 2-1  
 SUMMARY OF EU-COMP NORTH RESULTS**

| Test Parameters                 | Run 1     | Run 2     | Run 3     | Average         |
|---------------------------------|-----------|-----------|-----------|-----------------|
| Date                            | 9/15/2020 | 9/15/2020 | 9/15/2020 |                 |
| Start Time                      | 12:50     | 13:41     | 14:11     |                 |
| Stop Time                       | 13:05     | 13:56     | 14:26     |                 |
| <b>Gas Conditions</b>           |           |           |           |                 |
| Oxygen (% dry)                  | 8.17      | 8.23      | 8.23      | <b>8.21</b>     |
| Fuel Factor, Fd                 | 8612      | 8612      | 8612      | <b>8612</b>     |
| Fuel Flow (MSCH)                | 7.259     | 7.202     | 7.261     | <b>7.241</b>    |
| Heating Value (BTU)             | 1064      | 1066      | 1066      | <b>1065</b>     |
| Heat Input (MMBTU/hr)           | 7.72      | 7.67      | 7.74      | <b>7.71</b>     |
| <b>Nitrogen Oxides Results</b>  |           |           |           |                 |
| Concentration (ppmdv)           | 249       | 232       | 219       | <b>233</b>      |
| Emission rate, E (lb/mmBTU)     | 0.420     | 0.394     | 0.372     | <b>0.395</b>    |
| Emission rate (lb/hr)           | 3.24      | 3.02      | 2.88      | <b>3.05</b>     |
| <b>Carbon Monoxide Results</b>  |           |           |           |                 |
| Concentration (ppmdv)           | 0.448     | 0.248     | 0.335     | <b>0.344</b>    |
| Concentration, C (ppmdv@15% O2) | 0.208     | 0.115     | 0.156     | <b>0.160</b>    |
| Emission rate, E (lb/mmBTU)     | 0.000460  | 0.000256  | 0.000346  | <b>0.000354</b> |
| Emission Rate (lb/hr)           | 0.00356   | 0.00196   | 0.00268   | <b>0.00273</b>  |

**TABLE 2-2  
 EU-COMP NORTH PROCESS DATA**

| Run | RMP/BHP  | % Load | Catalyst Pressure drop | Catalyst inlet temperature | Fuel Flow (MSCFH) | Fuel Consumed (MSCF) |
|-----|----------|--------|------------------------|----------------------------|-------------------|----------------------|
| 1   | 1118/785 | 76     | 5.8                    | 792                        | 7.3               | 1.8                  |
| 2   | 1118/787 | 76     | 5.8                    | 794                        | 7.2               | 1.8                  |
| 3   | 1118/788 | 77     | 5.8                    | 794                        | 7.3               | 1.8                  |

**TABLE 2-3  
 SUMMARY OF EU-COMPWEST RESULTS**

| <b>Test Parameters</b>          | <b>Run 1</b> | <b>Run 2</b> | <b>Run 3</b> | <b>Average</b> |
|---------------------------------|--------------|--------------|--------------|----------------|
| Date                            | 9/15/2020    | 9/15/2020    | 9/15/2020    |                |
| Start Time                      | 15:08        | 15:36        | 16:03        |                |
| Stop Time                       | 15:23        | 15:51        | 16:18        |                |
| <b>Gas Conditions</b>           |              |              |              |                |
| Oxygen (% dry)                  | 11.4         | 11.5         | 11.5         | <b>11.4</b>    |
| Fuel Factor, Fd                 | 8612         | 8612         | 8612         | <b>8612</b>    |
| Fuel Flow (MSCFH)               | 26.9         | 26.9         | 26.9         | <b>26.9</b>    |
| Heating Value (BTU)             | 1066         | 1067         | 1067         | <b>1066</b>    |
| Heat Input (MMBTU/hr)           | 28.6         | 28.6         | 28.6         | <b>28.6</b>    |
| <b>Nitrogen Oxides Results</b>  |              |              |              |                |
| Concentration (ppmdv)           | 60.6         | 58.6         | 58.6         | <b>59.3</b>    |
| Emission rate, E (lb/mmBTU)     | 0.137        | 0.134        | 0.134        | <b>0.135</b>   |
| Emission rate (lb/hr)           | 3.93         | 3.83         | 3.82         | <b>3.86</b>    |
| <b>Carbon Monoxide Results</b>  |              |              |              |                |
| Concentration (ppmdv)           | 14.3         | 12.3         | 12.1         | <b>12.9</b>    |
| Concentration, C (ppmdv@15% O2) | 8.88         | 7.70         | 7.58         | <b>8.05</b>    |
| Emission rate, E (lb/mmBTU)     | 0.0197       | 0.0171       | 0.0168       | <b>0.0179</b>  |
| Emission Rate (lb/hr)           | 0.564        | 0.489        | 0.481        | <b>0.511</b>   |

**TABLE 2-4  
 EU-COMPWEST PROCESS DATA**

| <b>Run</b> | <b>RPM/BHP</b> | <b>% Load</b> | <b>Catalyst Pressure drop (in)</b> | <b>Catalyst inlet temperature (F)</b> | <b>Fuel Flow (MSCFH)</b> | <b>Fuel Consumed (MSCF)</b> |
|------------|----------------|---------------|------------------------------------|---------------------------------------|--------------------------|-----------------------------|
| 1          | 945/3710       | 89            | 2.5                                | 904.1                                 | 26.8                     | 6.7                         |
| 2          | 944/3703       | 88            | 2.5                                | 903.3                                 | 26.9                     | 6.7                         |
| 3          | 943/3700       | 89            | 2.5                                | 903.4                                 | 26.9                     | 6.7                         |

**TABLE 2-5  
 SUMMARY OF EU-COMPEAST RESULTS**

| Test Parameters                 | Run 1     | Run 2     | Run 3     | Average |
|---------------------------------|-----------|-----------|-----------|---------|
| Date                            | 9/15/2020 | 9/15/2020 | 9/15/2020 |         |
| Start Time                      | 8:20      | 8:51      | 9:22      |         |
| Stop Time                       | 8:35      | 9:06      | 9:37      |         |
| <b>Gas Conditions</b>           |           |           |           |         |
| Oxygen (% dry)                  | 11.5      | 11.5      | 11.4      | 11.5    |
| Fuel Factor, Fd                 | 8612      | 8612      | 8612      | 8612    |
| Fuel Flow (MSCFH)               | 26.28     | 26.46     | 26.6      | 26.4    |
| Heating Value (BTU)             | 1072      | 1070      | 1063      | 1069    |
| Heat Input (MMBTU/hr)           | 28.2      | 28.3      | 28.3      | 28.3    |
| <b>Nitrogen Oxides Results</b>  |           |           |           |         |
| Concentration (ppmdv)           | 66.8      | 66.8      | 69.5      | 67.7    |
| Emission rate, E (lb/mmBTU)     | 0.152     | 0.152     | 0.158     | 0.154   |
| Emission rate (lb/hr)           | 4.29      | 4.31      | 4.46      | 4.35    |
| <b>Carbon Monoxide Results</b>  |           |           |           |         |
| Concentration (ppmdv)           | 16.2      | 16.4      | 16.2      | 16.3    |
| Concentration, C (ppmdv@15% O2) | 10.1      | 10.3      | 10.1      | 10.2    |
| Emission rate, E (lb/mmBTU)     | 0.0225    | 0.0228    | 0.0224    | 0.0225  |
| Emission Rate (lb/hr)           | 0.633     | 0.645     | 0.632     | 0.637   |

**TABLE 2-6  
 EU-COMPEAST PROCESS DATA**

| Run | RPM/BHP  | % Load | Catalyst Pressure drop (in) | Catalyst inlet temperature (F) | Fuel Flow (MSCFH) | Fuel Consumed (MSCF) |
|-----|----------|--------|-----------------------------|--------------------------------|-------------------|----------------------|
| 1   | 950/3688 | 90     | 0.1                         | 897.2                          | 26.3              | 6.6                  |
| 2   | 950/3693 | 90     | 0.1                         | 901.1                          | 26.5              | 6.6                  |
| 3   | 950/3699 | 90     | 0.1                         | 904.0                          | 26.6              | 6.6                  |

### 3.0 TEST PROCEDURES

#### 3.1 METHOD LISTING

The following EPA test methods were referenced for the test program. These methods can be found in 40 CFR Part 60 Appendix A and 40 CFR Part 63, Appendix A.

- Method 3A Determination of Oxygen and Carbon Dioxide Concentrations in Emissions from Stationary Sources (Instrumental Analyzer Procedure)
- Method 7E Determination of nitrogen oxides 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 oxides emission rates

#### 3.2 METHOD DESCRIPTIONS

##### 3.2.1 Methods 3A, 7E and 10

The oxygen, nitrogen oxides and carbon monoxide concentrations at the test location were determined using EPA Methods 3A, 7E and 10. A schematic of the sample system is shown in Figure 1 in the Appendix.

The sample gas was withdrawn from the test location at a constant rate through an in-situ 0.3 micron stainless steel cindered frit, a stainless steel probe and Teflon sample line. The sample line was operated at a temperature of 250 °F to prevent the condensation of moisture. The sample gas passed through an M & C Type EC gas cooler system. The gas cooler is designed to unobtrusively lower the dewpoint of the sample gas to 35 °F, thus removing the moisture. The dry gas was then vented to the oxygen analyzer. Results from this analyzer were determined on a dry basis.

The analyzers that were used for this project are listed in the table below.

**TABLE 3-1  
 ANALYZERS USED FOR PROJECT**

| Parameter       | Manufacturer | Model Number | Operating Principle              | Units Reported | Ranges used        |
|-----------------|--------------|--------------|----------------------------------|----------------|--------------------|
| Oxygen          | Servo        | 1440         | Paramagnetic                     | (%)            | 0-20.95            |
| Nitrogen Oxides | Thermo       | 42i          | Chemiluminescence                | ppmd           | 0-503.7<br>0-89.48 |
| Carbon Monoxide | Thermo       | 48i-tie      | Infrared, Gas Filter Correlation | ppmd           | 0-48.54            |

Prior to sampling, a calibration error test was performed on the analyzer using EPA Protocol 1 gases. The zero and high-range calibration gases for each constituent was introduced directly into each analyzer. Each analyzer was then adjusted to the appropriate values. The mid-range

and low-range gases were introduced to each analyzer and the measured values were then recorded. The measured values for each calibration gas were compared to the calibration gas values and the differences were less than the method requirement of two percent of the span value.

A sample system bias check was performed, by introducing the zero and mid-range calibration gases into the sampling system at the base of the probe. The gas was drawn through the entire sampling system. The measured responses were compared to the calibration error test values to determine the bias in response due to the sampling system. In all cases, the sampling system bias was less than the method requirement of five percent of the span value. In addition, the system response time was determined by measuring the time required for each analyzer to reach 95 percent of its' high-range calibration gas value.

After each test run the instrument drift for the analyzer was determined by introducing the zero and mid-range calibration gases into the sampling system at the base of the probe. The gas was drawn through the entire sampling system. The measured responses were compared to the values from the previous test run to determine the analyzer drift. For all test runs, the analyzer drift was less than the method requirement of three percent of the span value.

### **3.2.2 Method 19**

EPA Method 19 was used to calculate pollutant emission rates in terms of pounds per million Btu (lb/mmBtu). The calculation was based on the oxygen content of the sample gas and an appropriate F factor, which is the ratio of combustion gas volumes to heat inputs. For this project the F factor used was 8,614 dscf/mmBtu for natural gas.

#### **4.0 DESCRIPTION OF INSTALLATION**

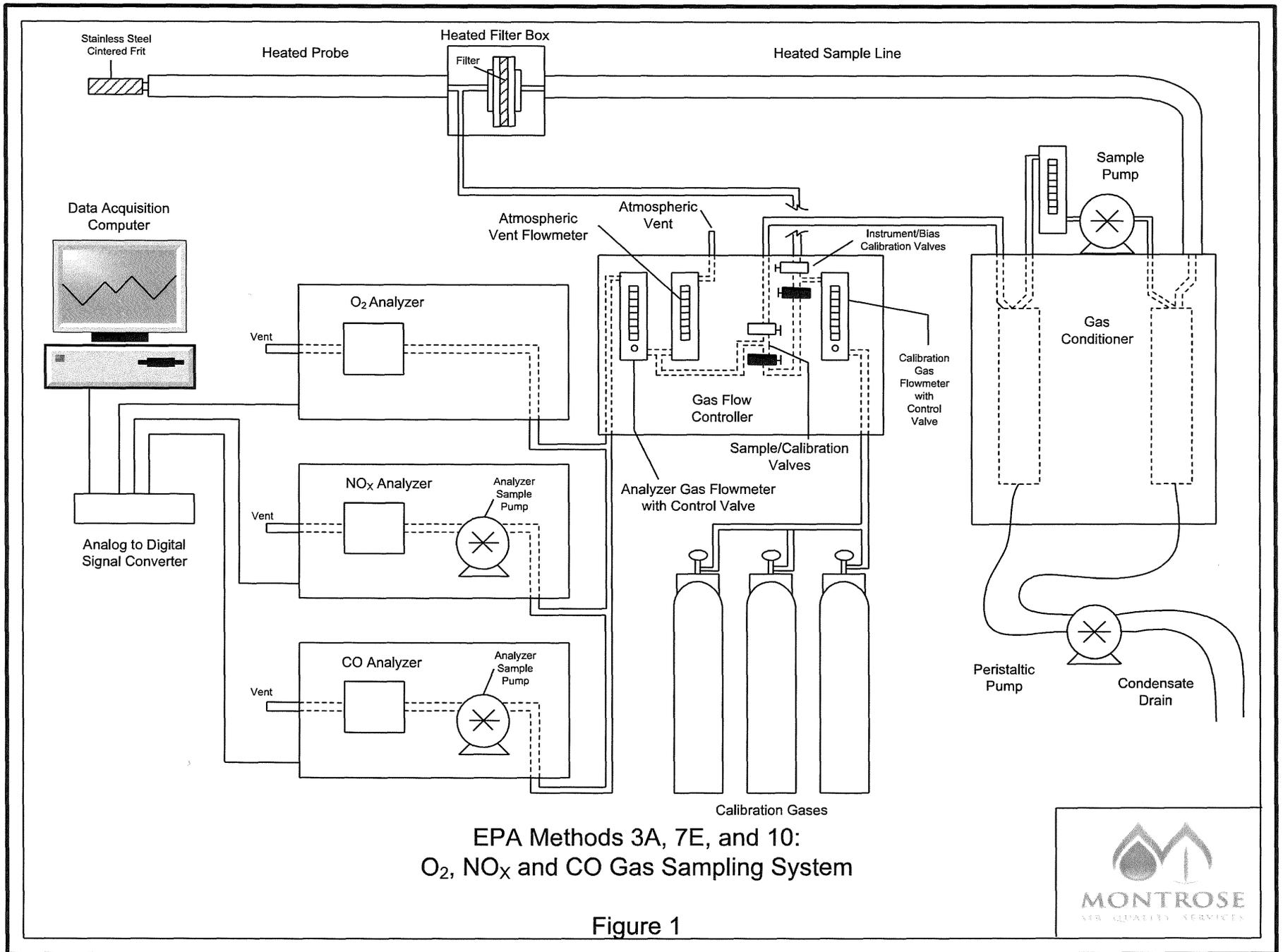
EU-COMP NORTH is a 10.1 MMBtu/hr heat input Caterpillar G3516 natural gas fired 4-stroke lean burn reciprocating internal combustion engine driving a compressor. It is controlled with a catalytic oxidation system.

EU-COMPEAST is a 31.9 MMBtu/hr heat input Caterpillar G3616 natural gas fired 4-stroke lean burn reciprocating internal combustion engine driving a compressor. It is controlled with a catalytic oxidation system.

EU-COMP WEST is a 31.9 MMBtu/hr heat input Caterpillar G3616 natural gas fired 4-stroke lean burn reciprocating internal combustion engine driving a compressor. It is controlled with a catalytic oxidation system.

The CAT control system calculates load % using fuel flow, manifold pressure, combustion air flow and rpms.

## **APPENDIX A FIGURES**



EPA Methods 3A, 7E, and 10:  
O<sub>2</sub>, NO<sub>x</sub> and CO Gas Sampling System

Figure 1

