

**TEST REPORT
ANNUAL COMPLIANCE DEMONSTRATION
BLUEWATER GAS STORAGE, LLC.
BLUEWATER GAS STORAGE STATION
UCP1, UCP3 & UCP4
COLUMBUS, MICHIGAN**

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AIR QUALITY DIVISION

Prepared For:

Bluewater Gas Storage
333 S. Wales Center
Columbus, MI 48063

Prepared By:

Montrose Air Quality Services, LLC
1371 Brummel Avenue
Elk Grove Village, Illinois

Document Number: 023AS-459221-RT-231
Test Date: September 18, 19 & 20, 2018
Document Date: November 2, 2018



REVIEW AND CERTIFICATION

All work, calculations, and other activities and tasks performed and presented in this document were carried out by me or under my direction and supervision. I hereby certify that, to the best of my knowledge, Montrose operated in conformance with the requirements of the Montrose Quality Management System and ASTM D7036-04 during this test project.

Signature:  Date: 10/19/18

Name: Brandon Check Title: Client Project Manager

I have reviewed, technically and editorially, details, calculations, results, conclusions, and other appropriate written materials contained herein. I hereby certify that, to the best of my knowledge, the presented material is authentic, accurate, and conforms to the requirements of the Montrose Quality Management System and ASTM D7036-04.

Signature:  Date: 10/19/18

Name: Roy Slick Title: QA/QC Manager

PROJECT OVERVIEW

1.1 GENERAL

Montrose Air Quality Services, LLC (Montrose) formerly known as Airtech Environmental Services Inc. (Airtech) 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_x), carbon monoxide (CO) and formaldehyde (HCHO) emissions from three (3) natural gas fired, compressor engines at the Bluewater Gas Storage

Testing was performed on EU-COMP NORTH (UPC1) on September 19, 2018. Testing was performed on EU-COMP WEST (UPC3) on September 18, 2018. Testing was performed on EU-COMP EAST (UPC4) on September 20, 2018. 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
Sean Cronin – Montrose Air Quality Services, LLC – (630) 860-4740

Observing on behalf of the Michigan Department of Environmental Quality were:

Tom Gasloli – Michigan Department of Environmental Quality (9/18/18)
Sebastian Kallumkal – Michigan Department of Environmental Quality (9/18/18)
Regina Hines – Michigan Department of Environmental Quality (9/20/18)

1.2 EXECUTIVE SUMMARY

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

**TABLE 1-1
EXECUTIVE SUMMARY**

Location	NOX (lb/hr)		CO (ppmdv@15%O ₂)		CO (lb/hr)		HCHO (lb/hr)	
	Limit	Result	Limit	Result	Limit	Result	Limit	Result
EU-COMP NORTH	4.5	4.17	47	0.217	0.40	0.00373	0.017	0.000659
EU-COMP WEST	7.4	7.33	47	14.5	1.85	1.05	0.248	0.182
EU-COMPEAST	7.4	6.90	47	3.85	1.85	0.280	0.248	0.0520

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
Sean Cronin, Q.S.T.I.	Field Project Manager	11/22/2017

1.4 METHODOLOGY

The concentration of NO_x, CO and HCHO and the moisture content of the gas steam at the exhaust of each engine was determined using EPA Method 320. The constituents were measured on a "wet" basis using a temporary Continuous Emission Monitoring System (CEMS) which utilizes Fourier Transform Infrared (FTIR) spectroscopy.

The concentration of oxygen (O₂), at the exhaust of each engine were determined using EPA Methods 3A. 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 O₂ analyzer.

Three sixty (60) minute runs were performed at the outlet of each engine. Results from are reported in units of parts per million (ppmwv) on a wet basis, ppm on a dry basis, (ppmdv), ppmdv corrected to 15% oxygen (ppmdv@15%O₂), pounds per million British thermal unit (lb/mmBtu) and pounds per hour (lb/hr).

The quality assurance requirements of Method 320 are summarized in the following table. The average spiked concentration of all samples met the method requirements of within 70% to 130% of the expected concentration.

**TABLE 1-3
 METHOD 320 QUALITY ASSURANCE REQUIREMENTS**

Constituent/ Sample #	Spike Gas Standard Value	Native Concentration	Expected Concentration (ppm)	Spike Concentration (ppm)	Recovery (%)
UCP1	10.6	0.0663	0.884	0.812	91.9
UCP3	10.6	4.34	4.70	4.34	92.5
UCP4	10.6	1.52	2.15	1.98	92.0

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
- moisture content
- nitrogen oxides
- carbon monoxide
- formaldehyde concentration

1.6 RESULTS

A complete summary of test results is presented in Tables 1 through 3¹.

Performance data is available upon request.

At the EU-COMPWEST test location, Run 2 failed its post test QA. After making connections to the sampling system the subsequent concentrations varied from the original Run 1 and Run 2 concentrations by an amount significant enough that it was decided to discard the results of those runs and conduct three new test runs. At the EU-COMPEAST test location, the unit did not meet the HCHO limit. The MDEQ was informed, the catalyst was changed, and three new test runs were performed.

In both cases, the data from the runs not used may be found in the Analyzer section of the Appendix.

At the EU-COMPWEST test location during Run 3, the probe came out of the stack before the run was complete. The run was extended to encompass a full hour.

At the EU-COMPEAST test location the analyzer times are one hour different than the Process Data times due to an incorrect time on the data acquisition computer.

¹ MEASUREMENT UNCERTAINTY STATEMENT

Both qualitative and quantitative factors contribute to field measurement uncertainty and should be taken into consideration when interpreting the results contained within this report. Whenever possible, Montrose personnel reduce the impact of these uncertainty factors through the use of approved and validated test methods. In addition, Montrose personnel perform routine instrument and equipment calibrations and ensure that the calibration standards, instruments, and equipment used during test events meet, at a minimum, test method specifications as well as the specifications of the Montrose Quality Manual and ASTM D7036-04. The limitations of the various methods, instruments, equipment, and materials utilized during this test have been reasonably considered, but the ultimate impact of the cumulative uncertainty of this project is not fully identified within the results of this report.

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2.0 SUMMARY OF RESULTS

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

Test Parameters	Run 1	Run 2	Run 3	Average
Date	9/19/2018	9/19/2018	9/19/2018	
Start Time	12:28	14:22	15:39	
Stop Time	13:59	15:23	16:40	
Fuel Factor, Fd	8616	8616	8616	
Heat Input (MMBTU/hr)	7.76	7.76	7.71	
Fuel BTU	1057	1057	1058	
Gas Conditions				
Oxygen (% dry)	7.46	7.27	7.25	7.33
Moisture (%)	13.1	13.2	13.2	13.1
Pollutant Results				
Nitrogen Oxides Concentration (ppmwv)	287	298	302	295
Nitrogen Oxides Concentration (ppmdv)	330	343	348	340
Nitrogen Oxides Concentration, C (ppmdv@15% O2)	145	148	150	148
Nitrogen Oxides Emission rate, E (lb/mmBTU)	0.528	0.541	0.548	0.539
Nitrogen Oxides Emission rate (lb/hr)	4.10	4.19	4.22	4.17
Carbon Monoxide Concentration (ppmwv)	0.499	0.407	0.396	0.434
Carbon Monoxide Concentration (ppmdv)	0.574	0.468	0.456	0.499
Carbon Monoxide Concentration, C (ppmdv@15% O2)	0.252	0.203	0.197	0.217
Carbon Monoxide Emission rate, E (lb/mmBTU)	0.000560	0.000450	0.000437	0.000482
Carbon Monoxide Emission Rate (lb/hr)	0.00434	0.00349	0.00337	0.00373
Formaldehyde Concentration, C (ppmwv)	0.0435	0.0984	0.0732	0.0717
Formaldehyde Concentration, C (ppmdv)	0.0500	0.113	0.0843	0.0825
Formaldehyde Concentration, C (ppmdv@15% O2)	0.114	0.262	0.195	0.190
Formaldehyde Emission rate, E (lb/mmBTU)	0.0000522	0.000117	0.0000867	0.0000852
Formaldehyde Emission Rate, E (lb/hr)	0.000405	0.000905	0.000668	0.000659

**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	1142/747	71	5.7	801	7.33	7.33
2	1140/749	71	5.7	800	7.33	7.33
3	1140/744	71	5.7	800	7.28	7.28

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

Test Parameters	Run 1	Run 2	Run 3	Average
Date	9/18/2018	9/18/2018	9/18/2018	
Start Time	14:45	16:02	17:19	
Stop Time	15:45	17:01	18:27	
Fuel Factor, Fd	8613	8614	8615	
Heat Input (MMBTU/hr)	32.5	32.7	32.6	
Fuel BTU	1052	1053	1055	
Gas Conditions				
Oxygen (% dry)	9.58	9.64	9.64	9.62
Moisture (%)	11.2	11.1	11.1	11.2
Pollutant Results				
Nitrogen Oxides Concentration (ppmwv)	107	104	103	105
Nitrogen Oxides Concentration (ppmdv)	121	117	116	118
Nitrogen Oxides Concentration, C (ppmdv@15% O2)	62.8	61.4	60.8	61.7
Nitrogen Oxides Emission rate, E (lb/mmBTU)	0.229	0.224	0.222	0.225
Nitrogen Oxides Emission rate (lb/hr)	7.45	7.31	7.24	7.33
Carbon Monoxide Concentration (ppmwv)	25.0	24.6	24.4	24.7
Carbon Monoxide Concentration (ppmdv)	28.2	27.6	27.4	27.8
Carbon Monoxide Concentration, C (ppmdv@15% O2)	14.7	14.5	14.4	14.5
Carbon Monoxide Emission rate, E (lb/mmBTU)	0.0325	0.0321	0.0319	0.0322
Carbon Monoxide Emission Rate (lb/hr)	1.06	1.05	1.04	1.05
Formaldehyde Concentration, C (ppmwv)	3.96	3.92	4.07	3.98
Formaldehyde Concentration, C (ppmdv)	4.46	4.41	4.57	4.48
Formaldehyde Concentration, C (ppmdv@15% O2)	8.56	8.41	8.73	8.57
Formaldehyde Emission rate, E (lb/mmBTU)	0.00553	0.00550	0.00570	0.00558
Formaldehyde Emission Rate, E (lb/hr)	0.180	0.180	0.186	0.182

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

Run	RPM/BHP	% Load	Catalyst Pressure drop (in)	Catalyst inlet temperature (F)	Fuel Flow (MSCFH)	Fuel Consumed (MSCF)
1	987/4315	94	3.0	964	30.93	30.93
2	988/4320	95	3.1	964	31.05	31.05
3	988/4318	95	3.0	964	30.93	30.93

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

Test Parameters	Run 1	Run 2	Run 3	Average
Date	9/20/2018	9/20/2018	9/20/2018	
Start Time	6:35	8:12	9:09	
Stop Time	7:36	8:53	10:09	
Fuel Factor, Fd	8616	8615	8614	
Heat Input (lb/mmBTU)	32.9	32.7	32.8	
Fuel BTU	1051	1049	1049	
Gas Conditions				
Oxygen (% dry)	9.76	9.74	9.71	9.74
Moisture (%)	11.0	11.1	11.3	11.1
Pollutant Results				
Nitrogen Oxides Concentration (ppmwv)	97.0	97.0	97.1	97.0
Nitrogen Oxides Concentration (ppmdv)	109	109	109	109
Nitrogen Oxides Concentration, C (ppmdv@15% O2)	57.8	57.7	57.7	57.7
Nitrogen Oxides Emission rate, E (lb/mmBTU)	0.211	0.210	0.210	0.210
Nitrogen Oxides Emission rate (lb/hr)	6.92	6.88	6.89	6.90
Carbon Monoxide Concentration (ppmwv)	6.41	6.45	6.56	6.48
Carbon Monoxide Concentration (ppmdv)	7.21	7.26	7.40	7.29
Carbon Monoxide Concentration, C (ppmdv@15% O2)	3.82	3.84	3.90	3.85
Carbon Monoxide Emission rate, E (lb/mmBTU)	0.00847	0.00851	0.00865	0.00854
Carbon Monoxide Emission Rate (lb/hr)	0.278	0.278	0.284	0.280
Formaldehyde Concentration, C (ppmwv)	1.19	1.11	1.06	1.12
Formaldehyde Concentration, C (ppmdv)	1.34	1.25	1.20	1.26
Formaldehyde Concentration, C (ppmdv@15% O2)	2.53	2.36	2.27	2.39
Formaldehyde Emission rate, E (lb/mmBTU)	0.00169	0.00157	0.00150	0.00159
Formaldehyde Emission Rate, E (lb/hr)	0.0555	0.0513	0.0492	0.0520

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

Run	RPM/BHP	% Load	Catalyst Pressure drop (in)	Catalyst inlet temperature (F)	Fuel Flow (MSCFH)	Fuel Consumed (MSCF)
1	986/4295	92	3.2	875	31.23	31.23
2	984/4279	92	3.1	877	31.13	31.13
3	984/4287	92	3.1	878	31.24	31.24

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
- Method 320 Measurement of Vapor Phase Organic and Inorganic Emissions by Extractive Fourier Transform Infrared (FTIR) Spectroscopy

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 cintered 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 stream was split into two parts, one part went directly into an FTIR, the other part went to the gas conditioner. 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. Results from the FTIR were determined on a wet 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	Range to be used
Oxygen	Teledyne	T803	Paramagnetic	(%)	0-21.21
Nitrogen Oxides	MKS	2030	FTIR	ppmw	89.84
Carbon Monoxide	MKS	2030	FTIR	ppmw	90.18

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 8,860 dscf/mmBtu for natural gas.

3.2.3 Method 320

The NO_x, CO and HCHO concentrations and the moisture content of the gas stream at each test location were determined using EPA Method 320. A sample of the gas stream was continuously withdrawn from the test location and analyzed using a continuous FTIR gas analysis system.

The sample gas was withdrawn from each test location 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 temperature of 370 °F to prevent the condensation of moisture. The sample gas then passed through the FTIR spectrometer gas cell.

The FTIR gas analyzers that were used for this project are MKS MultiGas FTIR analyzers. A schematic of the sampling system can be found in Figure 2 in the Appendix.

Prior to testing, the detection limit (DL) and analytical uncertainty (AU) was determined for each constituent. The potential interferences for the analytes being tested were determined. The optical configuration that can measure all of the analytes within the absorbance range of 0.01 and 1.0 was determined. The sample system was assembled and allowed to reach stable operating temperatures and flow rates. A sample interface leak check was performed. Nitrogen or zero air was directed to the FTIR gas cell in order to determine a background spectrum. A sample spectrum was then recorded in succession. The peak to peak and RMS noise in the resultant spectrum in the wavelength region(s) used for the target compound analysis were measured and recorded.

A Calibration Transfer Standard (CTS) was introduced into the system and two spectra were recorded at least two minutes apart. As long as the second spectrum was no greater than the first and within the uncertainty of the gas standard, it was used as the CTS spectrum.

A QA spike was performed by introducing a certified standard for each constituent into the sampling system. Spectra was recorded for three independent spiked samples and the concentration of the spike was calculated. The average spiked concentration was within 70% and 130% of the expected concentration.

After all required pre-test procedures were performed, stack gas was sampled continuously. Sample interferograms, processed absorbance spectra, background interferograms, CTS sample interferograms, and CTS absorbance spectra were recorded. Sample conditions, instrument settings, and test records were recorded throughout the test. If signal transmittance changed by 5 percent or more in any analytical spectral region, a new background spectrum was obtained. A new CTS spectrum was obtained after each sampling run. The post-test CTS spectrum was compared to the pre-test spectrum. The peak absorbance from each spectrum was within 5% of the mean value.

A system recovery check using the analyte spiking technique was performed prior to testing. First, some of the effluent gas was sampled in order to determine native concentration of target analytes. The analyte spike calibration gas was then introduced

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to the FTIR gas cell only, and the results were determined using the analytical algorithm. Results from the calibration gas were recorded and compared to the certified value of the calibration gas. For reactive condensable gases such as formaldehyde (HCHO), the results were within 10% or 5 ppm. The analyte spike calibration gas was then directed through the entire sampling system and allowed to mix with effluent gas sample at a known flow rate. The flow ratio of calibration gas to ambient air or source effluent was no greater than 1:10 (one part calibration gas to ten parts total flow) for the determination of sample recovery. The dilution factor of the analyte spike concentration gas was calculated and the bias between the observed spike value and the expected response was determined. The percent recovery of the spiked analytes was calculated. Spike recovery results met the data quality objectives of the test program.

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-COMPWEST 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.