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EMISSIONS TEST REPORT

for

OXIDES OF NITROGEN (NO_X), CARBON MONOXIDE (CO), AND NON-METHANE ORGANIC COMPOUNDS (NMOC)

Z-330 - COMPRESSOR ENGINES 4 & 5

DTE GAS

BELLE RIVER MILLS COMPRESSOR STATION
East China, Michigan

August 21-22, 2018

Prepared By
Environmental Management & Resources
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EXECUTIVE SUMMARY

DTE Energy's Environmental Management and Resources (EM&R) Field Services Group performed emissions testing at the DTE Gas Belle River Mills Compressor Station (SRN: B6478), located in East China, Michigan. The fieldwork was performed on August 21-22, 2018, to satisfy requirements of the Michigan Department of Environmental Quality (MDEQ) Renewable Operating Permit (ROP) No. B6478-2016 and 40CFR Part 60 Subpart JJJJ. Emissions tests were performed on Z-330 Compressor Engines 4 & 5 for oxides of nitrogen (NO_x), carbon monoxide (CO), and non-methane non-ethane organic compounds (NMEOC).

The results of the emissions testing are highlighted below:

Emissions Testing Summary – Compressor Engines 4 & 5
Belle River Mills Compressor Station
East China, MI
August 21-22, 2018

	Oxides of Nitrogen (g/hp-hr)	Carbon Monoxide (g/hp-hr)	Non-Methane Organic Compounds (g/hp-hr)
Compressor Engine No. 4	**2.9**	**1.3**	**ND**
Compressor Engine No. 5	**2.7**	**1.5**	**ND**
Permit Limit	3.0	3.0	1.0

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1.0 INTRODUCTION

DTE Energy's Environmental Management and Resources (EM&R) Field Services Group performed emissions testing at the DTE Gas Belle River Mills Compressor Station (SRN: B6478), located in East China, Michigan. The fieldwork was performed on August 21-22, 2018, to satisfy requirements of the Michigan Department of Environmental Quality (MDEQ) Renewable Operating Permit (ROP) No. B6478-2016 and 40CFR Part 60 Subpart JJJJ. Emissions tests were performed on Z-330 Compressor Engines 4 & 5 for oxides of nitrogen (NO_x), carbon monoxide (CO), and non-methane non-ethane organic compounds (NMEOC).

Testing was performed pursuant to Title 40, *Code of Federal Regulations*, Part 60, Appendix A (40 CFR §60 App. A), Method 19, 25A, and ASTM D6348.

The fieldwork was performed in accordance with EPA Reference Methods, ASTM Methods and EM&R's Intent to Test[1], which was approved by the Michigan Department of Environmental Quality (MDEQ)[2]. The following EM&R personnel participated in the testing program: Mr. Mark Grigereit, Principal Engineer and Mr. Thom Snyder, Environmental Specialist. Mr. Grigereit was the project leader.

Ms. Susan King, DTE Gas, provided on-site support of the testing. Ms. Regina Hines and Mr. Robert Elmouchi, MDEQ, reviewed the test plan and observed portions of the testing.

2.0 SOURCE DESCRIPTION

The Belle River Mills Compressor Station located at 5440 Puttygut Road, East China, Michigan, employs the use of two (#4 and #5) natural gas-fired Cooper Z-330 2-stroke lean burn 10,000 Horse Power reciprocating engines (derated to 9,000 Hp). The Z-330 compressor engines generate line pressure assisting the transmission of natural gas into and out of the gas storage field as well as to and from the pipeline transmission system in south east Michigan.

The emissions from both Z-330 engines exhaust directly to the atmosphere through individual exhaust stacks. Compressor Engine No. 5 was operated at greater than 90% of the maximum load during the testing. The composition of the emissions from the engine depends on both the speed of the engine and the torque delivered to the compressor. Ambient atmospheric conditions, as it affects the density of air, may limit the speed and torque at which the engine can effectively operate.

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[1] MDEQ, Test Plan, Submitted July 21, 2018. (Attached-Appendix A)

[2] MDEQ, Acceptance Letter, August 6, 2018. (Attached-Appendix A)

A schematic representation of the engine exhaust and sampling location is presented in Figure 1.

3.0 SAMPLING AND ANALYTICAL PROCEDURES

DTE Energy obtained emissions measurements in accordance with procedures specified in the USEPA *Standards of Performance for New Stationary Sources.* The sampling and analytical methods used in the testing program are indicated in the table below

Sampling Method	Parameter	Analysis
ASTM Method D6348	NO_x, CO, Methane, Ethane, CO_2, Moisture Content	FTIR
USEPA Method 25A	Total VOC	FID

3.1 MOISTURE (ASTM METHOD D6348)

3.1.1 Sampling Method

Moisture content in the exhaust was evaluated using ASTM Method D6348, "Measurement of Vapor Phase Organic Emissions by Extractive Fourier Transform Infrared (FTIR)".

3.2 OXIDES of NITROGEN, CARBON MONOXIDE, METHANE, ETHANE, CARBON DIOXIDE (ASTM METHOD D6348)

3.2.1 Sampling Method

Oxides of Nitrogen, Carbon Monoxide, Methane, Ethane, and Carbon Dioxide emissions were evaluated using ASTM Method D6348, "Measurement of Vapor Phase Organic Emissions by Extractive Fourier Transform Infrared (FTIR)". Triplicate 60-minute test runs were performed.

The ASTM D6348 sampling system (Figure 2) consisted of the following:

(1) Single-point sampling probe
(2) Flexible heated PTFE sampling line

(3) Air Dimensions Heated Head Diaphragm Pump
(4) MKS MultiGas 2030 FTIR spectrometer
(5) Appropriate calibration gases
(6) Data Acquisition System

The FTIR was equipped with a temperature controlled, 5.11 meter multipass gas cell maintained at 191°C. Gas flows and sampling system pressures were monitored using a rotometer and pressure transducer. All data was collected at 0.5 cm^{-1} resolution.

3.2.2 Sampling Train Calibration

The FTIR was calibrated per procedures outlined in ASTM Method D6348. Direct measurements of nitrogen, oxides of nitrogen (NO_x), carbon monoxide (CO), propane (C_3H_8), and ethylene (C_2H_4) gas standards were made at the test location to confirm concentrations.

A calibration transfer standard (CTS) was analyzed before and after testing at each location. The concentration determined for all CTS runs were within ±5% of the certified value of the standard. Ethylene was passed through the entire system to determine the sampling system response time and to ensure that the entire sampling system was leak-free.

Nitrogen was purged through the sampling system at each test location to confirm the system was free of contaminants.

NO_x, CO, and C_3H_8 gas standards were passed through the sampling system at each test location to determine the response time and confirm recovery.

NO_x, CO, and C_3H_8 spiking was performed to verify the ability of the sampling system to quantitatively deliver a sample containing NO_x, CO, and C_3H_8 from the base of the probe to the FTIR. Analyte spiking assures the ability of the FTIR to quantify NO_x, CO, and C_3H_8 in the presence of effluent gas.

As part of the spiking procedure, samples from each engine were measured to determine NO_x, CO, and C_3H_8 concentrations to be used in the spike recovery calculations. The determined sulfur hexafluoride (SF_6) concentration in the spiked and unspiked samples was used to calculate the dilution factor of the spike and thus used to calculate the concentration of the spiked NO_x, CO, and C_3H_8. The following equation illustrates the percent recovery calculation.

$$DF = \frac{SF_{6(spike)}}{SF_{6(direct)}}$$ (Sec. 9.2.3 (3) ASTM Method D6348)

$$CS = DF * Spike_{dir} + Unspike \ (1 - DF)$$ (Sec. 9.2.3 (4) ASTM Method D6348)

DF = Dilution factor of the spike gas
$SF_{6(direct)}$ = SF6 concentration measured directly in undiluted spike gas
$SF_{6(spike)}$ = Diluted SF_6 concentration measured in a spiked sample
$Spike_{dir}$ = Concentration of the analyte in the spike standard measured by the FTIR directly
CS = Expected concentration of the spiked samples
Unspike = Native concentration of analytes in unspiked samples

All analyte spikes were introduced using an instrument grade stainless steel rotometer. The spike target dilution ratio was 1:10 or less. All NO_x, CO, and C_3H_8 spike recoveries were within the ASTM D6348 allowance of ±30%.

3.2.3 *Quality Control and Assurance*

As part of the data validation procedure, reference spectra are manually fit to that of the sample spectra and a concentration is determined. The reference spectra are scaled to match the peak amplitude of the sample, thus providing a scale factor. The scale factor multiplied by the reference spectra concentration is used to determine the concentration value for the sample spectra. Sample pressure and temperature corrections are then applied to compute the final sample concentration. The manually calculated results are then compared with the software-generated results. The data is then validated if the two concentrations are within ± 5% agreement. If there is a difference greater than ± 5%, the spectra are reviewed for possible spectral interferences or any other possible causes that might lead to inaccurately quantified data. PRISM Analytical Technologies, Inc. validated the FTIR data. The data validation reports are in Appendix D.

3.2.4 *Data Reduction*

Each spectrum was derived from the coaddition of 64 scans, with a new data point generated approximately every one minute. The NO_x, CO, Methane, and Ethane emissions were recorded in parts per million (ppm) dry volume basis. The CO_2 emissions were recorded in percent (%) dry volume basis. The moisture content was recorded in percent (%). The FTIR data was validated by Prism Analytical Technologies, Inc. The validation reports are in Appendix D.

3.3 TOTAL HYDROCARBON COMPOUNDS (USEPA METHOD 25A)

3.3.1 Sampling Method

Total hydrocarbon compound (THC) emissions were evaluated using USEPA Method 25A, "Determination of Total Hydrocarbon Emissions from Stationary Sources (Instrumental Analyzer Method)". The THC analyzer utilizes a flame ionization detector (FID). The FID measures total hydrocarbon compounds (including Methane). Triplicate 60-minute tests were performed on the engine exhaust.

The Method 25A sampling system (Figure 3) consisted of the following:

(1) Single-point sampling probe (placed in the center of the stack)
(2) Heated PTFE sampling line
(3) JUM 109A® Total Hydrocarbon gas analyzer
(4) Appropriate USEPA Protocol 1 calibration gasses
(5) Data Acquisition System

3.3.2 Sampling Train Calibration

In accordance with USEPA Method 25A, a 4-point (zero, low, mid, and high) calibration check was performed on the THC analyzer. The analyzer was calibrated with propane in the 0-1,000 ppm range. Calibration drift checks were performed at the completion of each run.

3.3.3 Quality Control and Assurance

The THC sampling equipment was calibrated with propane (C_3H_8) per the guidelines referenced in Methods 25A. Calibration gases were EPA Protocol 1 gases and the concentrations were within the acceptable ranges (25-35% low range, 45-55% mid-range and 80-100% of span). Calibration gas certification sheets are in Appendix C.

3.3.4 Data Reduction

Data collected during the emissions testing was recorded at 10-second intervals and averaged in 1-minute increments. The THC emissions were recorded in parts per million (ppm) as propane (C_3H_8). The 1-minute readings collected are in Appendix B.

The NMEOC emissions were reported in grams per Brake Horsepower Hour (g/BHp-Hr) as required by the Method. The 1-minute readings collected are in Appendix B. Emissions calculations, based on equations located in USEPA Methods 25A and 19 are in Appendix E.

4.0 OPERATING PARAMETERS

The test program included the collection of generator load (kW), engine speed (RPM), inlet manifold air pressure (psi), fuel upper heating value (BTU), fuel flow (scfm) and generator operating hours (kW-hour).

Operational data is in Appendix F.

5.0 DISCUSSION OF RESULTS

Table Nos. 1 & 2 presents the emission testing results from Compressor Engines 4 & 5 while operating at greater than 90% of full load conditions. The NO_x, CO, and NMOC emissions are presented in grams per brake horsepower hour (g/bHP-Hr). Additional test data presented for each test includes the engine load in percentage (%), heat input (MMBtu/hr), and emissions (ppm). Compressor Engines 4 & 5 demonstrated compliance with NO_x, CO, and NMOC emission limits as stated in Michigan Renewable Operating Permit No. MI-ROP-B6478-2016 and 40 CFR60.4244 Subpart JJJJ.

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6.0 CERTIFICATION STATEMENT

"I certify that I believe the information provided in this document is true, accurate, and complete. Results of testing are based on the good faith application of sound professional judgment, using techniques, factors, or standards approved by the Local, State, or Federal Governing body, or generally accepted in the trade."

Thomas Snyder, QSTI

This report prepared by: ______________________

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This report reviewed by: ______________________

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TABLE NO. 1
NOx, CO, and NMEOC EMISSION TESTING RESULTS
Belle River Mills Compressor Station Z330 Compressor Engine No. 4
August 22, 2018

Test	Test Time	Load	Brake-Hp	Heat Input	NO_x Emissions[1]		CO Emissions[1]		NMEOC Emissions[1]			
		(%)		(MMBtu/hr)	(ppm_{dry})	(gram/BHp-Hr)[2]	(ppm_{dry})	(gram/BHp-Hr)[2]	Total VOC as Propane (ppm_{dry})	Methane (ppm_{dry})	Ethane (ppm_{dry})	NMEOC (gram/BHp-Hr)[2]
1	8:02-9:02	97	8,382	64.7	205.0	2.8	160.3	1.3	254.3	732.0	43.0	ND
2	9:13-10:13	97	8,364	64.4	213.6	2.9	156.6	1.3	258.8	719.8	42.3	ND
3	10:26-11:26	97	8,385	64.6	206.3	2.8	160.2	1.3	263.5	732.1	43.0	ND
	Average:	*97*	*8,377*	*64.6*	*208.3*	*2.8*	*159.0*	*1.3*	*258.9*	*728.0*	*42.8*	*ND*

ND = Non Detect

(1) Emissions were corrected for analyzer drift per USEPA Method 7E

(2) ROP Permit Limit:

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TABLE NO. 2
NOx, CO, and NMEOC EMISSION TESTING RESULTS
Belle River Mills Compressor Station Z330 Compressor Engine No. 5
August 21, 2018

Test	Test Time	Load	Brake-Hp	Heat Input	NO_x Emissions[1]		CO Emissions[1]		NMEOC Emissions[1]			
		(%)		(MMBtu/hr)	(ppm_{dry})	(gram/BHp-Hr)[2]	(ppm_{dry})	(gram/BHp-Hr)[2]	Total VOC as Propane (ppm_{dry})	Methane (ppm_{dry})	Ethane (ppm_{dry})	NMEOC (gram/BHp-Hr)[2]
1	8:49-9:49	95	8,338	67.3	194.5	2.7	186.1	1.6	282.8	820.8	41.9	ND
2	10:03-11:03	95	8,359	66.8	181.6	2.5	189.9	1.6	305.2	846.3	39.4	ND
3	11:14-12:14	95	8,363	66.1	214.9	2.9	178.1	1.5	291.9	773.8	45.1	ND
	Average:	*95*	*8,353*	*66.7*	*197.0*	*2.7*	*184.7*	*1.6*	*293.3*	*813.6*	*42.1*	*ND*

ND = Non Detect

(1) Emissions were corrected for analyzer drift per USEPA Method 7E

(2) ROP Permit Limit

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Figure 1 – Sampling Locations
Compressor Engines 4 & 5 - Z330
Belle River Mills Compressor Station
August 21-22, 2018

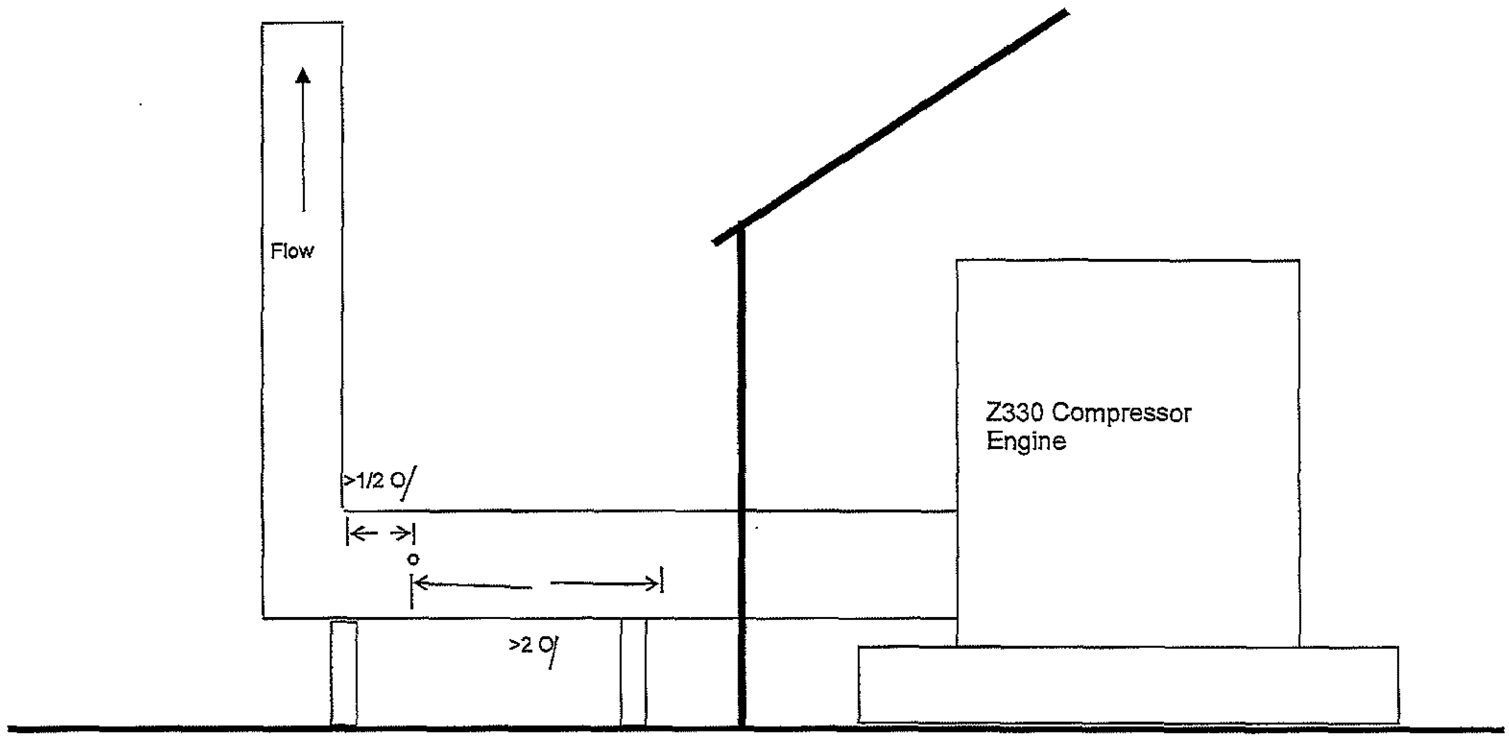

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Figure 2 – ASTM D6348
Compressor Engines 4 & 5 - Z330
Belle River Mills Compressor Station
August 21-22, 2018

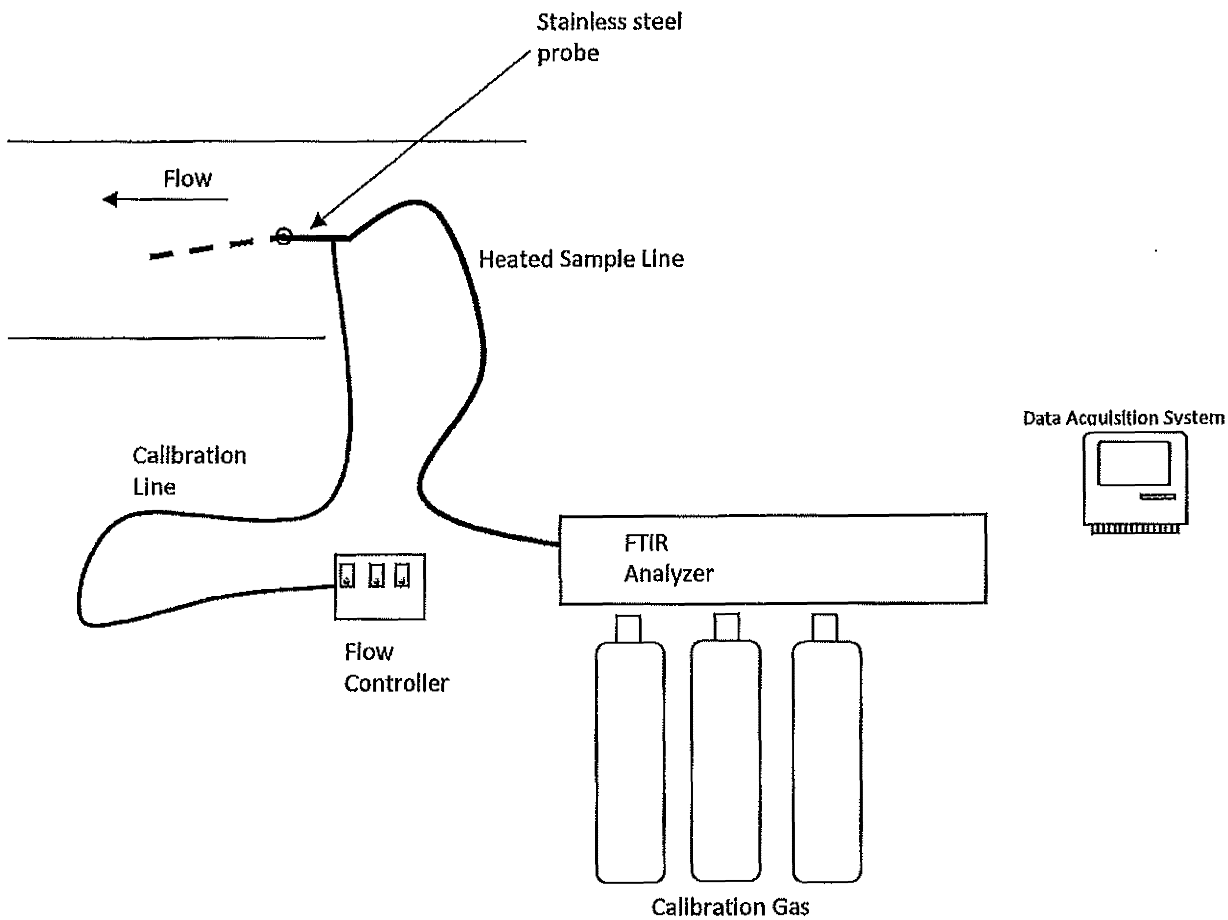

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Figure 3 – EPA Method 25A
Compressor Engines 4 & 5 - Z330
Belle River Mills Compressor Station
August 21 & 22, 2018