# EMISSIONS TEST REPORT

for

# OXIDES OF NITROGEN ($NO_X$), CARBON MONOXIDE (CO), AND NON-METHANE NON-ETHANE ORGANIC COMPOUNDS (NMEOC)

**EUGMVH1-3**

**COOPER - COMPRESSOR ENGINES 1-3**

**DTE GAS**

**KALKASKA COMPRESSOR STATION**
**Kalkaska, Michigan**

**September 26-28, 2023**

**Prepared By:**
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**EXECUTIVE SUMMARY**

DTE Energy's Environmental Management and Safety (EM&S) Ecology, Monitoring, and Remediation Group performed emissions testing at the DTE Gas Kalkaska Compressor Station (SRN: B6478), located in Kalkaska, Michigan. The fieldwork was performed on September 26-28, 2023, to satisfy requirements of the Michigan Department of Environment, Great Lakes, and Energy (EGLE) Renewable Operating Permit (ROP) No. N3341-2022. Emissions tests were performed on EUGMVH1-3 (Cooper Compressor Engines 1-3) 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 – EUGMVH1-3**
**Kalkaska Compressor Station**
**Kalkaska, MI**

| | Oxides of Nitrogen (lb/hr[1]) | Carbon Monoxide (lb/hr[1]) | Volatile Organic Compounds (lb/hr[1]) |
|---|---|---|---|
| Unit 1 | 6.73 | 7.02 | 0.74 |
| Unit 2 | 7.30 | 5.81 | 0.64 |
| Unit 3 | 10.97 | 6.64 | 0.61 |
| Permit Limit | 64.2 | 7.7 | 6.0 |

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## 1.0 INTRODUCTION

DTE Energy's Environmental Management and Safety (EM&S) Ecology, Monitoring, and Remediation Group performed emissions testing at the DTE Gas Kalkaska Compressor Station (SRN: B6478), located in Kalkaska, Michigan. The fieldwork was performed on September 26-28, 2023, to satisfy requirements of the Michigan Department of Environment, Great Lakes, and Energy (EGLE) Renewable Operating Permit (ROP) No. N3341-2022. Emissions tests were performed on EUGMVH1-3 (Cooper Compressor Engines 1-3) 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), Methods 3A, 19, and ASTM D6348.

The fieldwork was performed in accordance with EPA Reference Methods, ASTM Method and EM&S's Intent to Test[1], which was approved by the Michigan Department of Environment, Great Lakes, and Energy (EGLE)[2]. The following EM&S personnel participated in the testing program: Mr. Mark Grigereit, Principal Engineer and Mr. Thomas Snyder, Senior Environmental Specialist. Mr. Snyder was the project leader.

Ms. Caryn Owens, EGLE, observed field activities and Mr. Andrew Riley, EGLE, reviewed the test plan.

## 2.0 SOURCE DESCRIPTION

The Kalkaska Compressor Station located at 1250 MichCon Lane, Kalkaska, Michigan, employs the use of three Cooper GMVH 2,700 Horsepower two-stroke, lean burn natural gas-fired reciprocating engines (Engines 1-3). The 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.

The emissions from the engines are exhausted directly to the atmosphere through individual exhaust stacks. The composition of the emissions from the engines depends both upon 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 engines can effectively operate.

During the emissions testing each engine was operated within 10% of its highest achievable load.

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[1] EGLE, Test Plan, Submitted July 13, 2023. (Attached-Appendix A)

[2] EGLE, Acceptance Letter, September 15, 2023. (Attached-Appendix A)

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Schematic representations of each engine's exhaust and sampling locations are 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, VOC, $CO_2$, Moisture Content | FTIR |

## 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, VOC, 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 $cm^{-1}$.

### *3.2.2 Sampling Train Calibration*

The FTIR was calibrated per procedures outlined in ASTM Method D6348. Direct measurements of nitrogen, nitric oxide (NO), 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, 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, CO, and $C_3H_8$ spiking was performed to verify the ability of the sampling system to quantitatively deliver a sample containing NO, 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, 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, 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, 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, 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 minute. The $NO_x$, CO, and VOC emissions were recorded in parts per million (ppm) dry volume basis. The moisture content was recorded in percent (%). The $CO_2$ emissions were recorded in percent (%) dry volume basis. Diluent concentrations were corrected for analyzer calibration drift according to Method 3A. The moisture content was recorded in percent (%).

FTIR Manufacture software calculated total non-methane- non-ethane VOC by summing the hydrocarbons measured, multiplied by each compounds' molar ratio to propane. VOCs measured consist of Propane, Butane, Ethylene, Acetylene, Propylene, Acetaldehyde, and Methanol.

The FTIR data was validated by Prism Analytical Technologies, Inc. The validation reports are in Appendix B. Emissions calculations are in Appendix D.

## 4.0 OPERATING PARAMETERS

The test program included the collection of engine torque (%), engine speed (RPM), Horsepower (BHp), inlet and exhaust manifold air temperature (°F) suction and discharge pressure (psig), fuel upper heating value (BTU), and fuel flow (100SCFH).

Operational data is in Appendix E.

## 5.0 DISCUSSION OF RESULTS

The Results of the $NO_x$, CO and NMOC testing for Engines 1-3 are presented in Tables 1-3. The $NO_x$, CO and NMOC emissions are presented in parts per million (ppm) and pounds per hour (lbs/hr). Process data presented includes the Unit load in percent (%), Engine Torque in brake horsepower-hour (Brake-Hp), and Heat Input in Million British Thermal Unit per hour (MMBtu/hr) for each test.

Compressor Engines 1-3 demonstrated compliance with $NO_x$, CO, and NMOC emission limits as stated in Michigan Renewable Operating Permit No. MI-ROP-N3341-2022.

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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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# RESULTS TABLES

Gaseous Emissions Testing Results
Compressor Engine No. 1
DTE Energy, Kalakaska Compressor Station
Kalkaska, Michigan

| Parameter | Run 1 | Run 2 | Run 3 | Average |
|---|---|---|---|---|
| Sampling Date | 09/26/23 | 09/26/23 | 09/26/23 | |
| Sampling Start Time (actual) | 8:08-9:08 | 9:21-10:21 | 10:32-11:32 | |
| Gross Dry BTU | 1036 | 1036 | 1036 | 1036 |
| Fc | 1036 | 1036 | 1036 | |
| Load (%) | 94.0 | 94.2 | 94.1 | 94 |
| RPM | 330 | 330 | 330 | 330 |
| Brake-HP | 2,538 | 2,543 | 2,540 | 2,540 |
| Fuel Flow (100 scf/hr) | 182.7 | 182.2 | 181.7 | 182.2 |
| Heat Input Rate (MMBtu/Hr) | 18.9 | 18.9 | 18.8 | 18.9 |
| Average Outlet $CO_2$ Content (% dry) | 3.4 | 3.4 | 3.5 | 3.4 |
| Average Outlet $CO_2$ Content (% dry, corrected)[1] | 3.5 | 3.5 | 3.5 | 3.5 |
| Average Outlet CO Concentration (ppmv) (dry) | 174.0 | 173.0 | 169.0 | 172.0 |
| Average Outlet CO Concentration (lb/MMBtu) | 0.377 | 0.375 | 0.364 | 0.372 |
| **Average Outlet CO Emission Rate (lb/hr, dry)** | **7.14** | **7.08** | **6.85** | **7.02** |
| **CO Emission Rate (gram/BHP-Hr, dry)** | **1.3** | **1.3** | **1.2** | **1.3** |
| Average Outlet $NO_x$ Concentration (ppmv) (dry) | 97.6 | 97.5 | 105.9 | 100.3 |
| Average Outlet $NO_x$ Concentration (lb/MMBtu) | 0.347 | 0.348 | 0.375 | 0.358 |
| **Average Outlet $NO_x$ Emission Rate (lb/hr, dry)** | **6.57** | **6.56** | **7.06** | **6.73** |
| **$NO_x$ Emission Rate (gram/BHP-Hr, dry)** | **1.2** | **1.2** | **1.3** | **1.2** |
| VOC Concentration (ppmv, as propane, dry) | 11.2 | 11.4 | 11.8 | 11.5 |
| VOC Concentration (lb/MMBtu) | 0.038 | 0.039 | 0.040 | 0.039 |
| **VOC Emission Rate (lb/hr)** | **0.72** | **0.73** | **0.75** | **0.74** |
| **THC Emission Rate (gram/BHP-Hr)** | **0.1** | **0.1** | **0.1** | **0.1** |

[1]corrected for analyzer drift as per USEPA Method 6C

$CO_2$ : carbon dioxide
CO : carbon monoxide
$NO_x$ : oxides of nitrogen

**Gaseous Emissions Testing Results**
**Compressor Engine No. 2**
**DTE Energy, Kalakaska Compressor Station**
**Kalkaska, Michigan**

| Parameter | Run 1 | Run 2 | Run 3 | Average |
|---|---|---|---|---|
| Sampling Date | 09/27/23 | 09/27/23 | 09/27/23 | |
| Sampling Start Time (actual) | 7:45-8:45 | 8:54-9:54 | 10:04-11:04 | |
| Gross Dry BTU | 1034 | 1034 | 1034 | 1034 |
| Fc | 1036 | 1036 | 1036 | |
| Load (%) | 97.6 | 97.7 | 97.6 | 98 |
| RPM | 330 | 330 | 330 | 330 |
| Brake-HP | 2,636 | 2,637 | 2,634 | 2,636 |
| Fuel Flow (100 scf/hr) | 180.8 | 180.1 | 179.8 | 180.3 |
| Heat Input Rate (MMBtu/Hr) | 18.7 | 18.6 | 18.6 | 18.6 |
| Average Outlet $CO_2$ Content (% dry) | 3.4 | 3.4 | 3.4 | 3.4 |
| Average Outlet $CO_2$ Content (% dry, corrected)[1] | 3.4 | 3.4 | 3.4 | 3.4 |
| Average Outlet CO Concentration (ppmv) (dry) | 142.2 | 141.3 | 140.9 | 141.5 |
| Average Outlet CO Concentration (lb/MMBtu) | 0.314 | 0.312 | 0.310 | 0.312 |
| **Average Outlet CO Emission Rate (lb/hr, dry)** | **5.88** | **5.80** | **5.76** | **5.81** |
| **CO Emission Rate (gram/BHP-Hr, dry)** | **1.0** | **1.0** | **1.0** | **1.0** |
| Average Outlet $NO_x$ Concentration (ppmv) (dry) | 107.0 | 108.6 | 108.9 | 108.2 |
| Average Outlet $NO_x$ Concentration (lb/MMBtu) | 0.389 | 0.393 | 0.394 | 0.393 |
| **Average Outlet $NO_x$ Emission Rate (lb/hr, dry)** | **7.27** | **7.32** | **7.32** | **7.30** |
| **$NO_x$ Emission Rate (gram/BHP-Hr, dry)** | **1.3** | **1.3** | **1.3** | **1.3** |
| VOC Concentration (ppmv, as propane, dry) | 9.8 | 9.9 | 9.8 | 9.9 |
| VOC Concentration (lb/MMBtu) | 0.034 | 0.034 | 0.034 | 0.034 |
| **VOC Emission Rate (lb/hr)** | **0.64** | **0.64** | **0.63** | **0.64** |
| **THC Emission Rate (gram/BHP-Hr)** | **0.1** | **0.1** | **0.1** | **0.1** |

[1]corrected for analyzer drift as per USEPA Method 6C

$CO_2$ : carbon dioxide
CO : carbon monoxide
$NO_x$ : oxides of nitrogen

**Gaseous Emissions Testing Results**
**Compressor Engine No. 3**
**DTE Energy, Kalakaska Compressor Station**
**Kalkaska, Michigan**

| Parameter | Run 1 | Run 2 | Run 3 | Average |
|---|---|---|---|---|
| Sampling Date | 09/28/23 | 09/28/23 | 09/28/23 | |
| Sampling Start Time (actual) | 7:50-8:50 | 9:01-10:01 | 10:12-11:12 | |
| | | | | |
| Gross Dry BTU | 1034 | 1034 | 1034 | 1034 |
| Fc | 1036 | 1036 | 1036 | |
| Load (%) | 97.7 | 97.0 | 97.9 | 98 |
| RPM | 330 | 330 | 330 | 330 |
| Brake-HP | 2,637 | 2,644 | 2,643 | 2,641 |
| Fuel Flow (100 scf/hr) | 176.2 | 175.5 | 175.5 | 175.8 |
| Heat Input Rate (MMBtu/Hr) | 18.2 | 18.1 | 18.1 | 18.2 |
| | | | | |
| Average Outlet $CO_2$ Content (% dry) | 3.3 | 3.3 | 3.3 | 3.3 |
| Average Outlet $CO_2$ Content (% dry, corrected)[1] | 3.3 | 3.3 | 3.3 | 3.3 |
| | | | | |
| Average Outlet CO Concentration (ppmv) (dry) | 162.0 | 161.5 | 161.4 | 161.6 |
| Average Outlet CO Concentration (lb/MMBtu) | 0.366 | 0.366 | 0.365 | 0.366 |
| **Average Outlet CO Emission Rate (lb/hr, dry)** | **6.67** | **6.65** | **6.62** | **6.64** |
| **CO Emission Rate (gram/BHP-Hr, dry)** | **1.1** | **1.1** | **1.1** | **1.1** |
| | | | | |
| Average Outlet $NO_x$ Concentration (ppmv) (dry) | 162.3 | 161.2 | 164.1 | 162.5 |
| Average Outlet $NO_x$ Concentration (lb/MMBtu) | 0.603 | 0.601 | 0.609 | 0.607 |
| **Average Outlet $NO_x$ Emission Rate (lb/hr, dry)** | **10.97** | **10.90** | **11.05** | **10.97** |
| **$NO_x$ Emission Rate (gram/BHP-Hr, dry)** | **1.9** | **1.9** | **1.9** | **1.9** |
| | | | | |
| VOC Concentration (ppmv, as propane, dry) | 9.2 | 9.4 | 9.6 | 9.4 |
| VOC Concentration (lb/MMBtu) | 0.033 | 0.034 | 0.034 | 0.033 |
| **VOC Emission Rate (lb/hr)** | **0.59** | **0.61** | **0.62** | **0.61** |
| **THC Emission Rate (gram/BHP-Hr)** | **0.1** | **0.1** | **0.1** | **0.1** |

[1]corrected for analyzer drift as per USEPA Method 6C

$CO_2$ : carbon dioxide
CO : carbon monoxide
$NO_x$ : oxides of nitrogen

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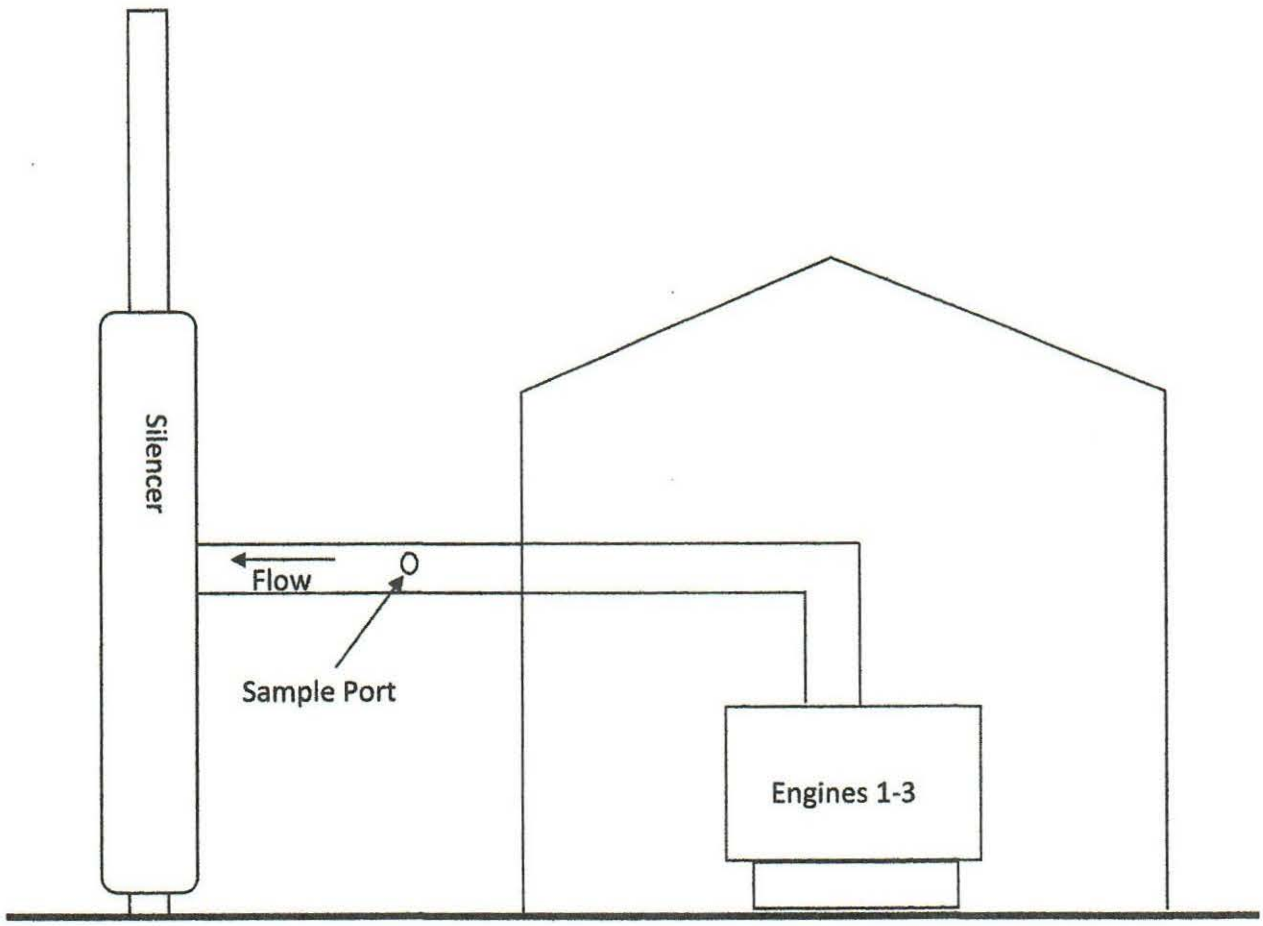
# FIGURES

**Figure 1 – Sampling Location**
**Kalkaska Compressor Station**
**September 26-28, 2023**

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## Figure 2 – USEPA Method 3A & ASTM D6348
## Kalkaska Compressor Station
## September 26-28, 2023