## I. INTRODUCTION

Network Environmental, Inc. was retained by the Holland Board of Public Works to perform emission sampling on the natural gas fired emergency engine (EU-NGENGINE) located at the Holland Energy Park (HEP) in Holland, MI. The testing was required by Michigan Department of Environment, Great Lakes and Energy (EGLE) ROP Permit No. MI-ROP-P0465-2018 which includes the NSPS requirements for stationary spark ignition internal combustion engines (40 CFR Part 60, Subpart JJJJ).

The scope of this project was to determine the oxides of nitrogen ($NO_x$), carbon monoxide (CO), and total hydrocarbon (VOC) emissions from the emergency engine.

The following reference test methods were employed to conduct the sampling:

- Carbon Monoxide (CO) – U.S. EPA Method 10
- Oxides of Nitrogen ($NO_x$) – U.S. EPA Method 7E
- Total Hydrocarbons (VOC) minus Methane – U.S. EPA Methods 25A & 18
- Exhaust Gas Parameters (flow rate, temperature, moisture & density) – U.S. EPA Methods 1 through 4

The sampling was performed on June 18, 2020 by Stephan K. Byrd, Richard D. Eerdmans and David D. Engelhardt of Network Environmental, Inc.. Assisting with the sampling was Ms. Trista Gregorski of the Holland Board of Public Works. Ms. Kaitlyn DeVries and Mr. Jeremy Howe of the Michigan Department of Environment, Great Lakes and Energy (EGLE) - Air Quality Division were present to observe the sampling and source operation.

## II. PRESENTATION OF RESULTS

### II.1 TABLE 1
### CARBON MONOXIDE (CO) EMISSION RESULTS
### NATURAL GAS FIRED EMERGENCY ENGINE (EU-NGENGINE)
### HOLLAND BOARD OF PUBLIC WORKS
### HOLLAND ENERGY PARK
### HOLLAND, MI
### JUNE 18, 2020

| Sample | Time | Air Flow Rate DSCFM (1) | CO Concentration PPM (2) | CO Mass Rate Lbs/Hr (3) | CO Mass Rate g/BHP-Hr (4) |
|---|---|---|---|---|---|
| 1 | 09:51-10:51 | 2,914 | 13.8 | 0.17 | 0.06 |
| 2 | 11:44-12:44 | 2,891 | 15.1 | 0.19 | 0.07 |
| 3 | 13:19-14:19 | 2,900 | 16.4 | 0.21 | 0.07 |
| **Average** | | **2,902** | **15.1** | **0.19** | **0.07** |

(1) DSCFM = Dry Standard Cubic Feet Per Minute (Standard Temperature & Pressure = 68 °F & 29.92 in. Hg)
(2) PPM = Parts Per Million (v/v) On A Dry Basis
(3) Lbs/Hr = Pounds of CO Per Hour
(4) g/BHP-Hr = Gram of CO Per Brake Horse Power Hour. Calculated using 1,298 BHP/Hr (supplied by Holland BPW)
(5) **The CO emission limit from MI-ROP-P0465-2018 is 0.8 g/BHP-Hr**

## II.2 TABLE 2
## OXIDES OF NITROGEN ($NO_x$) EMISSION RESULTS
## NATURAL GAS FIRED EMERGENCY ENGINE (EU-NGENGINE)
## HOLLAND BOARD OF PUBLIC WORKS
## HOLLAND ENERGY PARK
## HOLLAND, MI
## JUNE 18, 2020

| Sample | Time | Air Flow Rate DSCFM (1) | $NO_x$ Concentration PPM (2) | $NO_x$ Mass Rate Lbs/Hr (3) | $NO_x$ Mass Rate g/BHP-Hr (4) |
|---|---|---|---|---|---|
| 1 | 09:51-10:51 | 2,914 | 267.6 | 5.57 | 1.95 |
| 2 | 11:44-12:44 | 2,891 | 264.2 | 5.46 | 1.91 |
| 3 | 13:19-14:19 | 2,900 | 263.5 | 5.46 | 1.91 |
| **Average** | | **2,902** | **265.1** | **5.50** | **1.92** |

(1) DSCFM = Dry Standard Cubic Feet Per Minute (Standard Temperature & Pressure = 68 °F & 29.92 in. Hg)
(2) PPM = Parts Per Million (v/v) On A Dry Basis
(3) Lbs/Hr = Pounds of $NO_x$ Per Hour
(4) g/BHP-Hr = Gram of $NO_x$ Per Brake Horse Power Hour. Calculated using 1,298 BHP/Hr (supplied by Holland BPW)
(5) **The $NO_x$ emission limit from MI-ROP-P0465-2018 is 2 g/BHP-Hr**

# II.3 TABLE 3
# TOTAL HYDROCARBON (VOC) EMISSION RESULTS
# NATURAL GAS FIRED EMERGENCY ENGINE (EU-NGENGINE)
# HOLLAND BOARD OF PUBLIC WORKS
# HOLLAND ENERGY PARK
# HOLLAND, MI
# JUNE 18, 2020

| Sample | Date | Time | Air Flow Rate SCFM (1) | THC Concentration PPM (2) | Methane Concentration PPM (3) | VOC Concentration (THC minus Methane) PPM (4) | VOC Mass Rate Lbs/Hr (5) | VOC Mass Rate g/BHP-Hr (6) |
|---|---|---|---|---|---|---|---|---|
| 1 | 6/18/20 | 09:51-10:51 | 3,358 | 165.1 | 128.0 | 37.1 | 0.85 | 0.30 |
| 2 | 6/18/20 | 11:44-12:44 | 3,342 | 165.5 | 129.0 | 36.5 | 0.83 | 0.29 |
| 3 | 6/18/20 | 13:19-14:19 | 3,340 | 168.4 | 127.0 | 41.4 | 0.94 | 0.33 |
| **Average** | | | **3,347** | **166.3** | **128.0** | **38.3** | **0.88** | **0.31** |

(1) SCFM = Standard Cubic Feet Per Minute (Standard Temperature & Pressure = 68 °F & 29.92 in. Hg)
(2) THC PPM = Parts Per Million (v/v) Of Total Hydrocarbons On A Wet (Actual) Basis As Propane
(3) Methane PPM = Parts Per Million (v/v) Of Methane On a Wet (Actual) Basis Calculated As Propane
(4) VOC PPM (THC Minus Methane) = Part Per Million (v/v) of VOC (THC Minus Methane) On A Wet (Actual) Basis As Propane
(5) VOC Lbs/Hr = Pounds Of VOC (THC Minus Methane) Per Hour Calculated As Propane
(6) g/BHP-Hr = Gram of VOC Per Brake Horse Power Hour. Calculated using 1,298 BHP/Hr (supplied by Holland BPW)
(7) **The VOC emission limit from MI-ROP-P0465-2018 is 0.5 g/BHP-Hr**

## III. DISCUSSION OF RESULTS

The results of the emission sampling are summarized in Tables 1 through 3 (Sections II.1 through II.3). The results are presented as follows:

### III.1 CO

Table 1 – Carbon Monoxide (CO) Emission Results Summary

- Sample
- Time
- Air Flow Rate (DSCFM) – Dry Standard Cubic Feet Per Minute (STP = 68 °F & 29.92 in. Hg)
- CO Concentration (PPM) – Parts Per Million (v/v) on a Dry Basis
- CO Mass Emission Rate (Lbs/Hr) – Pounds of CO Per Hour
- CO Mass Emission Rate (g/BHP-Hr) – Grams of CO Per Brake Horse Power Hour. Calculated using 1,298 BHP/Hr (supplied by Holland BPW).

All the CO raw sample data was calibration corrected using Equation 7E-5 from U.S. EPA Method 7E.

### III.2 $NO_x$

Table 2 – Oxides of Nitrogen ($NO_x$) Emission Results Summary

- Sample
- Time
- Air Flow Rate (DSCFM) – Dry Standard Cubic Feet Per Minute (STP = 68 °F & 29.92 in. Hg)
- $NO_x$ Concentration (PPM) – Parts Per Million (v/v) on a Dry Basis
- $NO_x$ Mass Emission Rate (Lbs/Hr) – Pounds of $NO_x$ Per Hour
- $NO_x$ Mass Emission Rate (g/BHP-Hr) – Grams of $NO_x$ Per Brake Horse Power Hour. Calculated using 1,298 BHP/Hr (supplied by Holland BPW).

All the $NO_x$ raw sample data was calibration corrected using Equation 7E-5 from U.S. EPA Method 7E.

### III.3 VOC

Table 3 – Total Hydrocarbon (VOC) Emission Results Summary

- Sample
- Date
- Time
- Air Flow Rate (SCFM) – Standard Cubic Feet Per Minute (STP = 68 °F & 29.92 in. Hg)

- THC Concentration (PPM) – Parts Per Million of THC (v/v) on a Wet (Actual) Basis as Propane
- Methane Concentration (PPM) – Parts Per Million of Methane (v/v) on a Wet (Actual) Basis as Propane
- VOC Concentration (THC Minus Methane) – Parts Per Million of VOC (THC Minus Methane) on a Wet (Actual) Basis as Propane
- VOC Mass Emission Rate (Lbs/Hr) – Pounds of VOC (THC Minus Methane) Per Hour As Propane
- VOC Mass Emission Rate (g/BHP-Hr) – Grams of VOC Per Brake Horse Power Hour. Calculated using 1,298 BHP/Hr (supplied by Holland BPW).

All the VOC raw sample data was calibration corrected using Equation 7E-5 from U.S. EPA Method 7E.

The methane concentrations were converted to a propane basis using a response factor of 3.0 (PPM Methane as Propane = PPM Methane/3.0). The VOC results were calculated taking the THC results minus the methane results (on a propane basis).

### III.4 Emission Limits

The emission limits as specified in Permit No. MI-ROP-P0465-2018 are as follows:

| Test Parameter | Limit |
|---|---|
| CO | 0.8 grams/bhp-hr |
| $NO_x$ | 2 grams/bhp-hr |
| VOC | 0.5 grams/bhp-hr |

## IV. SOURCE DESCRIPTION

The source sampled is a non-certified emergency engine (CAT G351LE) serving a 1,040kW generator. The engine is used to charge the batteries in the uninterruptible power supply (UPS) Battery System. The engine is equipped with an oxidation catalyst system. The rated capacity of this engine is 1,462 bhp. The engine was running at 1,298 bhp during the sampling. Source operating data during the testing can be found in Appendix B.

## V. SAMPLING AND ANALYTICAL PROTOCOL

The sampling location was on the 11 inch I.D. exhaust stack with 2 sample ports in a location approximately 6 duct diameters downstream and approximately 8 duct diameters upstream from the nearest disturbances.

**V.1 Carbon Monoxide –** The CO sampling was conducted in accordance with U.S. EPA Reference Method 10. A Thermo Environmental Model 48 gas analyzer was used to monitor the exhaust. A heated teflon sample line was used to transport the exhaust gases to a gas conditioner to remove moisture and reduce the temperature. From the gas conditioner stack gases were passed to the analyzer. The analyzer produces instantaneous readouts of the CO concentrations (PPM).

The analyzer was calibrated by direct injection prior to the testing. A span gas of 89.7 PPM was used to establish the initial instrument calibration. A Calibration gas of 49.5 PPM was used to determine the calibration error of the analyzer. The sampling system (from the back of the stack probe to the analyzer) was injected using the 49.5 PPM gas to determine the system bias. After each sample, a system zero and system injection of 49.5 PPM were performed to establish system drift and system bias during the test period. All calibration gases were EPA Protocol 1 Certified.

The analyzer was calibrated to the output of the data acquisition system (DAS) used to collect the data from the exhaust. The analyzer averages were corrected for calibration error and drift using formula EQ.7E-5 from 40 CFR Part 60, Appendix A, Method 7E. A diagram of the sampling train is shown in Figure 1.

**V.2 Oxides of Nitrogen –** The $NO_x$ sampling was conducted in accordance with U.S. EPA Reference Method 7E. A Thermo Environmental Model 42H gas analyzer was used to monitor the exhaust. A heated teflon sample line was used to transport the exhaust gases to a gas conditioner to remove moisture and reduce the temperature. From the gas conditioner stack gases were passed to the analyzer. The analyzer produces instantaneous readouts of the $NO_x$ concentrations (PPM).

The analyzer was calibrated by direct injection prior to the testing. A span gas of 486.9 PPM was used to establish the initial instrument calibration. Calibration gases of 127.0 PPM and 250.1 PPM were used to determine the calibration error of the analyzer. A direct injection of 50.8 PPM nitrogen dioxide ($NO_2$) was performed to show the conversion efficiency of the monitor. The conversion efficiency was 94.49% (48.0 PPM). The sampling system (from the back of the stack probe to the analyzer) was injected using the 250.1 PPM gas to determine the system bias. After each sample, a system zero and system injection of

250.1 PPM were performed to establish system drift and system bias during the test period. All calibration gases were EPA Protocol 1 Certified.

The analyzer was calibrated to the output of the data acquisition system (DAS) used to collect the data from the exhaust. The analyzer averages were corrected for calibration error and drift using formula EQ.7E-5 from 40 CFR Part 60, Appendix A, Method 7E. A diagram of the sampling train is shown in Figure 1.

**V.3 Total Hydrocarbons (THC)** – The THC sampling was conducted in accordance with U.S. EPA Reference Method 25A. A J.U.M. Model 3-500 flame ionization detector (FID) analyzer was used to monitor the exhaust. Sample gas was extracted through a heated probe. A heated teflon sample line was used to transport the exhaust gases to the analyzer. The analyzer produces instantaneous readouts of the total hydrocarbon (THC) concentrations (PPM).

The analyzer was calibrated by system injection (from the back of the stack probe to the analyzer) prior to the testing. A span gas of 491.0 PPM was used to establish the initial instrument calibration. Calibration gases of 152.0 PPM and 250.0 PPM were used to determine the calibration error of the analyzer. After each sample, a system zero and system injection of 152.0 PPM were performed to establish system drift and system bias during the test period. All calibration gases used were EPA Protocol Propane Calibration Gases. Three (3) samples were collected from the exhaust. Each sample was sixty (60) minutes in duration.

The analyzer was calibrated to the output of the data acquisition system (DAS) used to collect the data from the exhaust. The analyzer averages were corrected for calibration error and drift using formula EQ.7E-5 from 40 CFR Part 60, Appendix A, Method 7E. Figure 2 is a diagram of the VOC sampling train.

**V.4 Methane** – The methane emissions were determined in accordance with U.S. EPA Reference Method 18. Integrated bag samples were collected from the exhaust of the FID sampling train. A heated teflon sample line was used to transport the exhaust gases to the train where the bags were collected. The samples were collected in Tedlar bags and analyzed for methane by GC/FID. Figure 2 is a diagram of the methane sampling train.

**V.5 Oxygen & Carbon Dioxide** – The $O_2$ & $CO_2$ sampling was conducted in accordance with U.S. EPA Reference Method 3A. Servomex Model 1400M portable stack gas analyzers were used to monitor the exhaust. A heated teflon sample line was used to transport the exhaust gases to a gas conditioner to remove moisture and reduce the temperature. From the gas conditioner stack gases were passed to the analyzers. The analyzers produce instantaneous readouts of the $O_2$ & $CO_2$ concentrations (%).

The analyzers were calibrated by direct injection prior to the testing. Span gases of 21.0% $O_2$ and 21.04% $CO_2$ were used to establish the initial instrument calibrations. Calibration gases of 12.0% $O_2$/5.95% $CO_2$ and 5.97% $O_2$/11.7% $CO_2$ were used to determine the calibration error of the analyzers. The sampling system (from the back of the stack probe to the analyzers) was injected using the 12.0% $O_2$/5.95% $CO_2$ gas to determine the system bias. After each sample, a system zero and system injection of 12.0% $O_2$/5.95% $CO_2$ were performed to establish system drift and system bias during the test period. All calibration gases were EPA Protocol 1 Certified.

The analyzers were calibrated to the output of the data acquisition system (DAS) used to collect the data from the exhaust. The analyzer averages were corrected for calibration error and drift using formula EQ.7E-5 from 40 CFR Part 60, Appendix A, Method 7E. A diagram of the sampling train is shown in Figure 1.

**V.6 Exhaust Gas Parameters –** The exhaust gas parameters (air flow rate, temperature, moisture and density) were determined in conjunction with the other sampling by employing U.S. EPA Methods 1 through 4.

Three (3) velocity traverses and three (3) moisture sample were collected. All the quality assurance and quality control procedures listed in the methods were incorporated in the sampling and analysis.

This report was prepared by:

David D. Engelhardt

David D. Engelhardt
Vice President

This report was reviewed by:

Stephan K. Byrd

Stephan K. Byrd
President

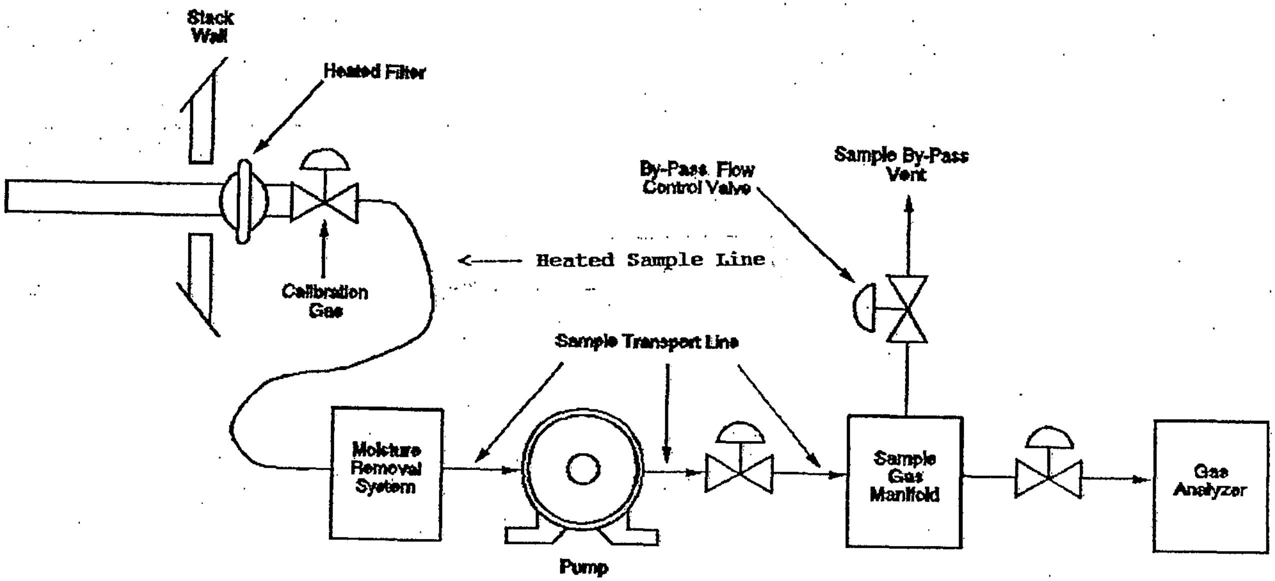

**Figure 1**

**$NO_x$, $CO$, $O_2$ & $CO_2$ Sampling Train**

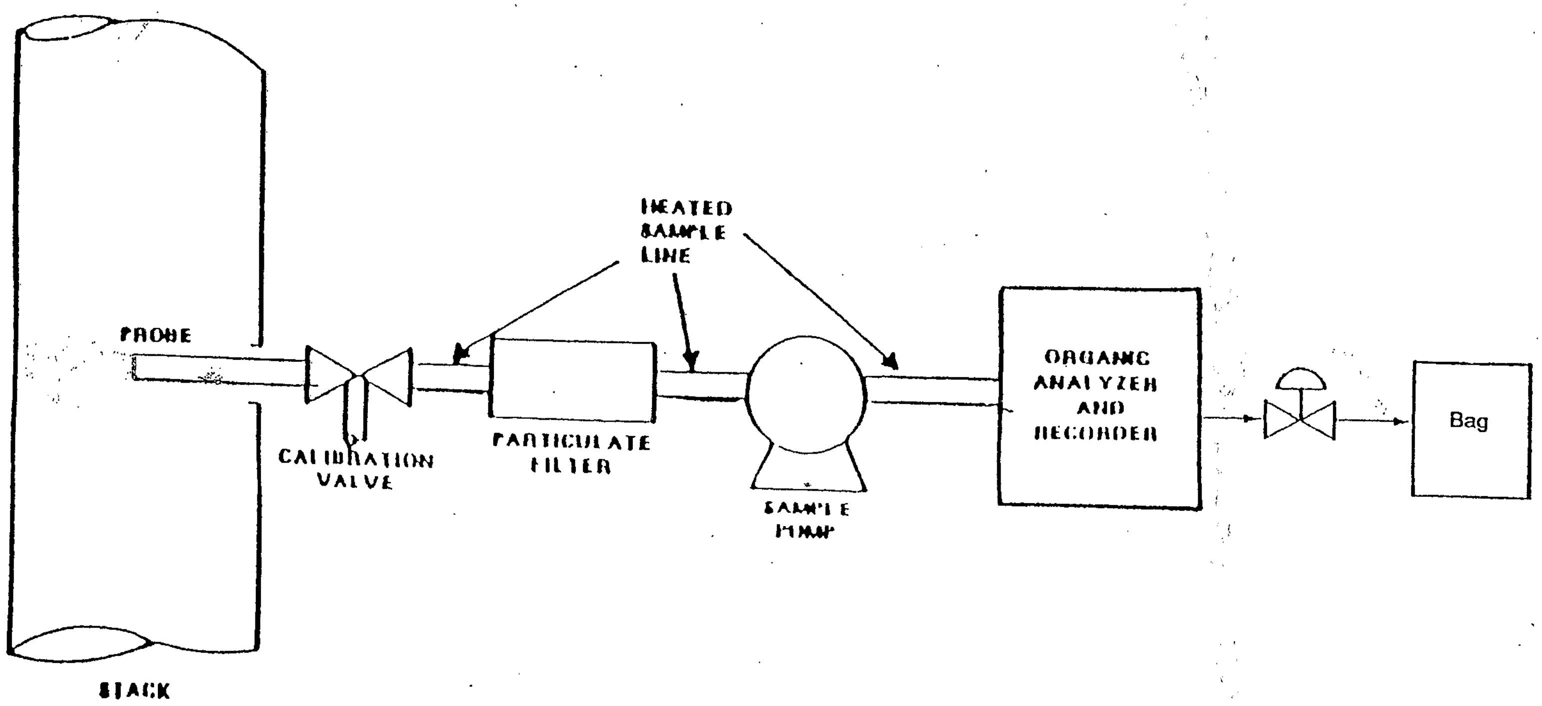

Figure 2

Total Hydrocarbon & Methane Sampling Train