1.0 INTRODUCTION

1.1 Identification, Location and Dates of Tests

Environmental Stack Testing (EST) was retained by Spectrum Health of Grand Rapids, Michigan to provide emissions air testing for carbon monoxide (CO), nitrogen oxides (NOX) and total volatile organic compounds not including methane (VOC) at the Tower 35 engine generator exhaust located in Grand Rapids, Michigan. Testing at Spectrum Health was performed on October 8, 2021.

1.2 Purpose of Testing

The purpose of the testing is to verify compliance with emission limits specified in the Michigan Environment, Great Lakes and Energy (EGLE) Permit to Install (PTI) No. 112-18, SRN M2032 and requirements for stationary spark ignition internal combustion engines (40 CFR Part 60 Subpart JJJJ).

1.3 Project Contact Information

Location	Contact
Test Facility	Mr. Michael Schmuker 616.391.8014 Michael.schmuker@spectrumhealth.org
Test Company Representative	Ms. Brooke Gillespie 616.828.2745 Environmentalstacktesting@gmail.com
State Representative	Mr. Trevor Drost 517.245.5781 Drostt@michigan.gov

State Representative	Mr. Michael Cox 616.240.3607 CoxM9@michigan.gov

2.0 SUMMARY OF RESULTS

The testing was performed with the engine operating at approximately 90 percent of capacity. The average results are shown in the following table. The emission results are recorded in Grams per Brake Horsepower Hour (g/bhp-hr). Comprehensive results are presented in Table 1 at the end of this report.

Summary of EUENGENE1 Emissions

Test Parameter	Emission Rate (G/bhp-hr)	Permit Limit (G/bhp-hr)
Nitrogen Oxides	1.0	2.0
Carbon Monoxide	1.9	4.0
Volatile Organic Compounds	0.2	1.0

3.0 SOURCE DESCRIPTION

Spectrum Health operates EU-COMBLABGEN, which is a natural gas fired emergency engine generator (CAT G3516). The rated capacity of the engine is 1462 bhp. Source operating data during the testing can be found in Appendix D.

4.0 SAMPLING AND ANALYTICAL PROCEDURES

Triplicate one-hour test runs were performed for the following United States Environmental Protection Agency (U.S. EPA) Reference Test Methods:

- Method 1 – *Sample and Velocity Traverses for Stationary Sources*

- Method 2 - *Determination of Stack Gas Velocity and Volumetric Flow Rate (Type S Pitot Tube)*
- Method 3A – *Determination of Oxygen and Carbon Dioxide Concentrations in Emissions From Stationary sources (Instrumental Analyzer Procedure)*
- Method 4 - *Determination of Moisture Content in Stack Gases*
- Method 7E – *Determination of Nitrogen Oxides Emissions From Stationary Sources (Instrumental Analyzer Procedure)*
- Method 10 – *Determination of Carbon Monoxide Emissions From Stationary Sources*
- Method 18 – *Volatile Organic Compounds by Gas Chromatography*
- Method 25A - *Determination of Total Gaseous Organic Concentration Using a Flame Ionization Analyzer*

4.1 Traverse Points Location

The number of traverse and sampling points for the exhaust stacks were determined using U.S. EPA Method 1 *Sample and Velocity Traverses for Stationary Sources.*

The stack associated with EU-COMBLABGEN measured 12 inches in diameter at the sampling site. Four traverse points were selected for each of the two sampling ports. Schematics showing traverse point locations are shown in Figure 1.

4.2 Velocity and Temperature

The exhaust gas velocities and temperatures were determined using U.S. EPA Reference Method 2, Determination of Stack Gas Temperature and Velocity (Type S Pitot Tube). The stack gas velocity was measured using an S-Type pitot tube with an attached thermocouple probe. The Pitot tube was connected to an inclined water column manometer and checked for leaks at five inches of water. The stack gas temperature was measured using a K-Type thermocouple. The procedure described in Section 2.4 of Method 1 was employed to ensure the absence of cyclonic flow at each test site. This procedure known as the Nulling Technique, was employed by positioning the S-Type Pitot tube at each traverse point so that the face openings were perpendicular to the stack cross-sectional plane or at the "0° reference" point. Differential pressure (delta P) measurements were noted at each traverse point. If the observed delta P was zero, the cyclonic angle was recorded as 0°. If the delta P was not zero, the Pitot tube was rotated up to ± 90° angle until a zero or null reading was obtained. Each cyclonic angle was measured with a leveled protractor, reported to the nearest degree, and then averaged. In order for a test site to be considered non-cyclonic, the average must be less than 20

degrees. The average cyclonic angle for each sample location met the criteria for testing.

4.3 Molecular Weight

A calibrated O2 and CO2 analyzer was used to measure stack gas molecular weight utilizing U.S. EPA Method 3A, Determination of Oxygen and Carbon Dioxide Concentrations in Emissions from Stationary Sources (Instrumental Analyzer Procedure). The analyzer was calibrated at a minimum of three points; low-level gas (zero gas), mid-level gas (40-60% of calibration span) and high-level gas (concentration equal to the calibration span) for the testing.

4.4 Moisture

The stack gas moisture content was determined using U.S. EPA Reference Method 4, Determination of Moisture Content in Stack Gases. The sample passed through a series of four connected impingers. The first and second impingers initially contained 100 mL of water. The third impinger was empty and was used as a moisture knockout. The fourth impinger contained approximately 300 grams of indicating silica gel. The impingers were contained in an ice bath maintained at, or less than, 68 degrees Fahrenheit to assure condensation of the gas stream moisture. Any moisture that did not condense in the first three impingers was captured in the final impinger containing silica gel. Each impinger was measured volumetrically or gravimetrically before and after each test with the data subsequently entered into the moisture content calculations.

4.5 Nitrogen Oxides

A chemiluminescence analyzer was used to measure concentrations of nitrogen oxides in the dry sample gas following the guidelines of U.S. EPA Method 7E, Determination of Nitrogen Oxides from Stationary Sources (Instrumental Analyzer Procedure). The analyzer measures the concentration of NOx by converting NO2 to NO and then measuring the light emitted by the reaction of NO with ozone. The NOx sampling system was calibrated at three points; zero, mid range (40-60 percent of span), and high range (equal to the calibration span) for the testing.

4.6 Carbon Monoxide

The CO emissions were measured following the guidelines of U.S. EPA Reference Method 10, Determination of Carbon Monoxide Emissions from Stationary Sources (Instrumental Analyzer Procedure). The CO sampling system was calibrated at three points; zero, mid range (40-60 percent of

span), and high range (equal to the calibration span) for the testing.

4.7 Volatile Organic Compounds

VOC concentrations were determined during the testing following the guidelines of U.S. EPA Reference Method 25A, Determination of Total Gaseous Organic Concentration Using a Flame Ionization Analyzer. The analyzer was calibrated at a minimum of four points: zero level gas, low-level gas (less than or equal to 20 percent of calibration span), mid-level gas (40 to 60 percent of calibration span), and high-level gas (concentration equal to the calibration span) for testing.

Methane sampling was conducted in accordance to U.S. EPA Method 18. Integrated bag samples were collected in Tedlar bags during each of the three sixty minute test runs. EST collected one Tedlar bag sample per run for each emission source. At completion of testing the Tedlar bag samples were delivered to the laboratory for analysis. The samples were analyzed by gas chromatograph for methane in accordance with the method. All the quality assurance and quality control procedures listed in the methods were incorporated in the sampling and analysis.

6.0 QUALITY ASSURANCE

Each promulgated U.S. EPA reference method described above is accompanied by a statement indicating that to obtain reliable results, persons using these methods should have a thorough knowledge of the techniques associated with each. To that end, EST attempts to minimize any factors in the field that could increase error by implementing a quality assurance program into every testing activity segment. The pitot tubes and thermocouples used to measure the exhaust gas during this test program were calibrated according to the procedures outlined in the Quality Assurance Handbook for Air Pollution Measurement Systems: Volume III, Stationary Source-Specific Methods, Method 2, Type S Pitot Tube Inspection, and Calibration Procedure 2E Temperature Sensor.

U.S. EPA Protocol No. 1 gas standards were used to calibrate the analyzers during the test program. These gases are certified according to the U.S. EPA Traceability Protocol for Assay & Certification of Gaseous Calibration Standards; Procedure G-1; September, 1997, and are certified to have a total relative uncertainty of ±1 percent.

Data acquisition was provided using a data logger system programmed to collect and record at one minute intervals.

7.0 TEST RESULTS

Based on the data obtained during the test program, the NOx, CO and VOC emissions measured at EU-COMBLABGEN is below the specific limits described in PTI No. 112-18, SRN M2032.

TABLES

TABLE 1

Spectrum Health - Tower 35

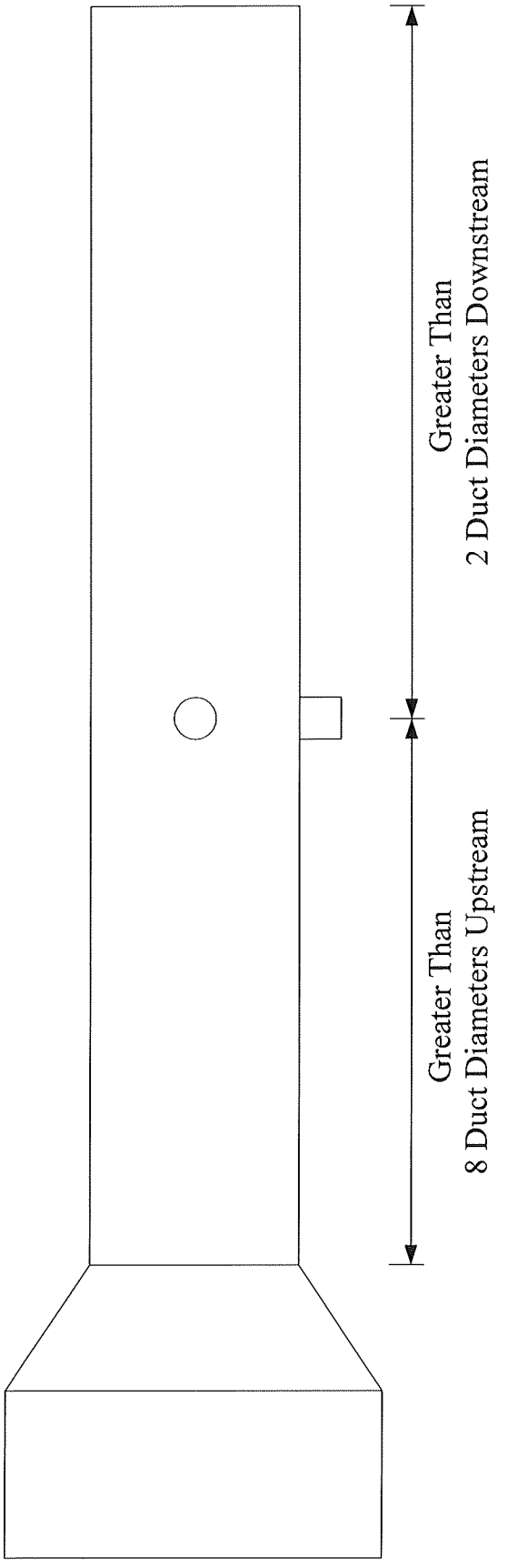
SUMMARY OF NO_X, CO AND VOC CONCENTRATIONS AND EMISSIONS

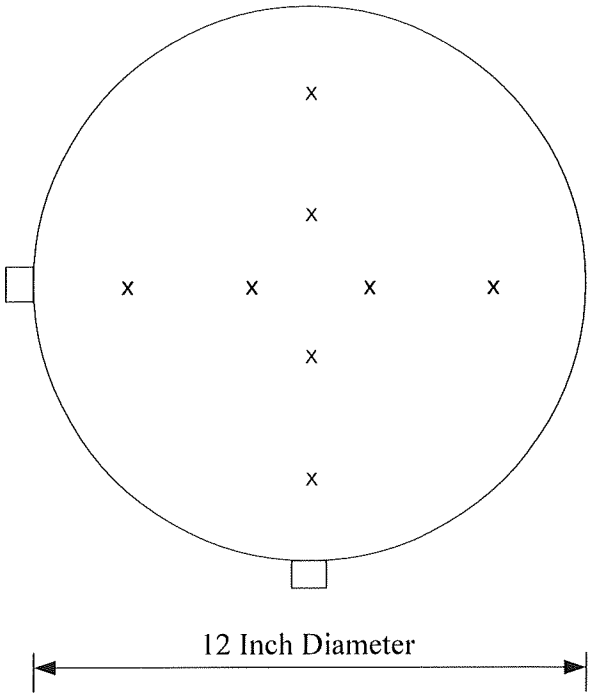
EU-COMBLABGEN

TEST DATE: October 8, 2021

Test Run No.	1	2	3	Average
Test Run Date:	10/8/2021	10/8/2021	10/8/2021	
Test Run Time:	805-905	940-1040	1125-1225	
	Process Conditions			
	Volumetric Flow Rates			
Stack Gas Flow Rate, ACFM:	8,974	8,873	8,891	8,913
Stack Gas Flow Rate, SCFM:	3,597	3,556	3,556	3,569
Stack Gas Flow Rate, DSCFM:	3,553	3,151	3,081	3,262
Stack Gas Flow Rate, DSCMH:	6,036	5,353	5,235	5,541
	Fixed Gases			
Oxygen, % by volume, dry	9.44	9.59	9.39	9.47
Carbon dioxide, % by volume, dry	6.36	6.25	6.32	6.31
Carbon monoxide, % by volume, dry:	0.04	0.04	0.04	0.04
Moisture, % by volume	1.23	11.40	13.34	8.65
Test Run No.	1	2	3	Average
	Measured Concentration			
Carbon Monoxide, ppmvd:	375.2	369.1	360.2	368.14
Nitrogen Oxides, ppmvd:	129.8	128.6	106.8	121.73
VOC Concentration, ppmvd as propane:	20.6	29.1	21.5	23.7
	Calculated Emission Rate			
Carbon Monoxide, g/bhp/hr:	2.1	1.8	1.7	1.9
Carbon Monoxide Permit Limit, g/bhp/hr:				**4.0**
Nitrogen Oxides, g/bhp/hr:	1.18	1.03	0.84	1.0
Nitrogen Oxides Permit Limit, g/bhp/hr:				**2.0**
VOC, g/bhp/hr:	0.18	0.22	0.16	0.2
VOC Permit Limit, g/bhp/hr:				**1.0**

FIGURES





Traverse Point	Point Location Inches
1	0.8
2	3.0
3	9.0
4	11.2
Port Length	2.0

Figure 1

Sampling And Traverse Point Location

Environmental Stack Testing

Spectrum Health-Tower 35

EU-COMBLABGEN

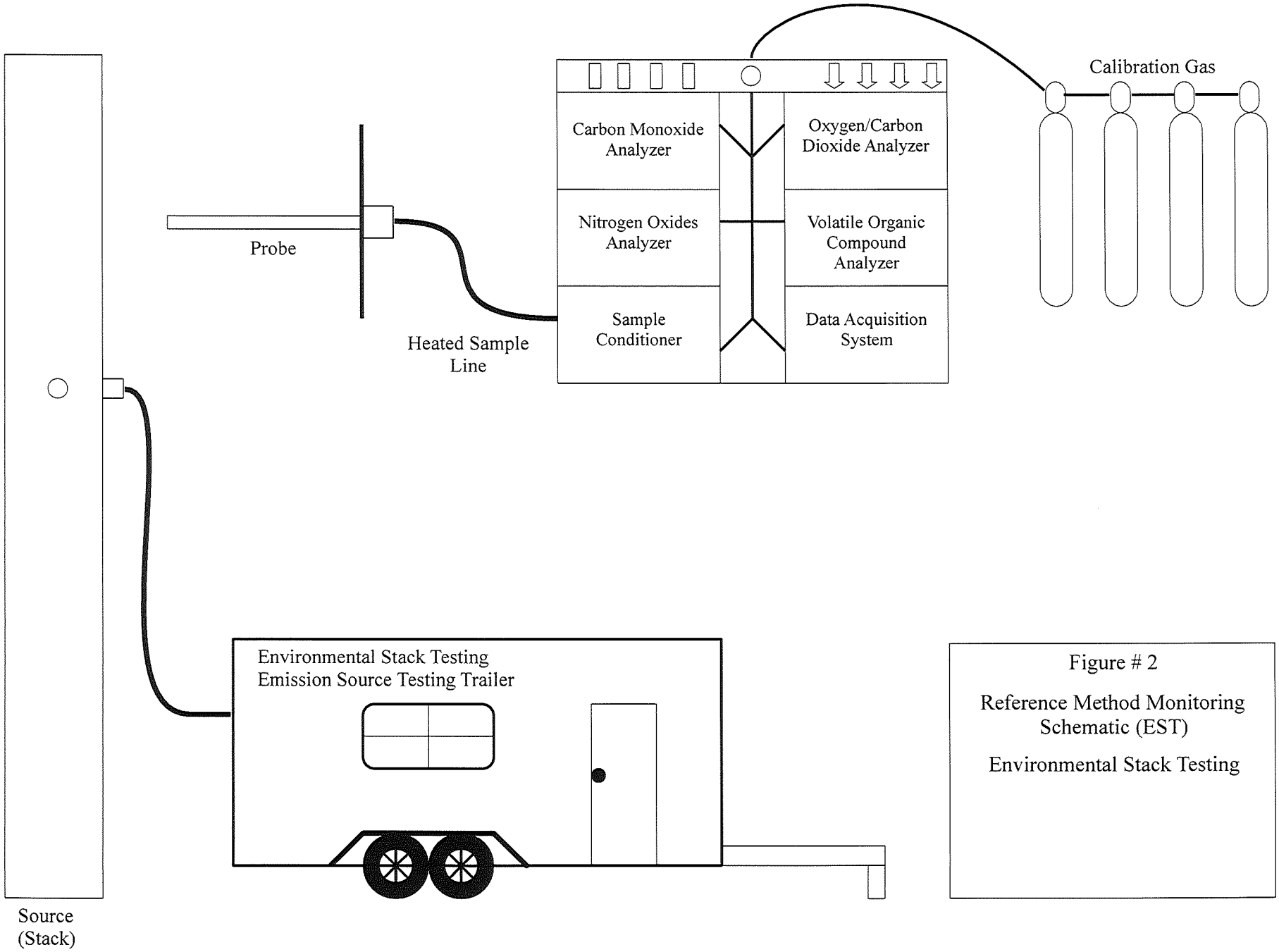


Figure # 2

Reference Method Monitoring Schematic (EST)

Environmental Stack Testing