Carbon Monoxide Emissions Testing of EUENGINE-4 and EUENGINE-5

Cloverland Electric Cooperative

2535 West M-28
Dafter, Michigan 49724
SRN: B6107

Cloverland
ELECTRIC COOPERATIVE

Prepared for
Cloverland Electric Cooperative
Sault Ste. Marie, Michigan

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Executive Summary

Cloverland Electric Cooperative (Cloverland Electric) retained Bureau Veritas North America, Inc. (Bureau Veritas) to test air emissions at the Cloverland Electric facility at 2535 West M-28 in Dafter, Michigan. Cloverland Electric operates two reciprocating internal combustion engines installed for peak shaving and power outages. The purpose of the emission test program was to evaluate compliance with National Emission Standards for Hazardous Air Pollutants for Stationary Reciprocating Internal Combustion Engines (RICE) (40 CFR Part 63, Subpart ZZZZ) by measuring the oxygen (O_2) and carbon monoxide (CO) concentrations from the outlet of the two regulated engines.

The relevant emission standards are presented below:

Emission Standards

Pollutant	Limit	Equipment	USEPA Testing Method	Underlying Applicable Requirements
CO	23 ppmvd at 15% O_2 or reduce CO emissions by 70% or more	EUENGINE-4 EUENGINE-5	3A and 10	40 CFR Part 63, Subpart ZZZZ

O_2 oxygen
CO carbon monoxide
ppmvd part per million by volume, dry basis

The testing was completed in accordance with United States Environmental Protection Agency (USEPA) Reference Methods 3A and 10. The testing was conducted on December 9, 2014 and consisted of three 60-minute test runs at the exhaust of each source to measure O_2 and CO concentrations.

Detailed results are presented in Tables 1 and 2 after the Tables Tab of this report. The results of the testing are summarized in the table on the following page.

O_2 and CO Emissions Results Compared to Permit Emission Limits

Date (2014)	Source ID	Parameter	Units	Average Result	Emission Limit
Dec 9	EUENGINE-4	O_2	%	15.3	N/A
		CO	ppmvd	11.4	N/A
		CO	**ppmvd at 15% O_2**	**12.0**	**23**
Dec 9	EUENGINE-5	O_2	%	12.3	N/A
		CO	ppmvd	7.3	N/A
		CO	**ppmvd at 15% O_2**	**5.0**	**23**

O_2 oxygen
CO carbon monoxide
N/A not applicable
ppmvd part per million by volume, dry basis

The O_2 and CO measurements demonstrate EUENGINE-4 and EUENGINE-5 are operating within allowable limits.

1.0 Introduction

Cloverland Electric Cooperative (Cloverland Electric) retained Bureau Veritas North America, Inc. (Bureau Veritas) to test air emissions at the Cloverland Electric facility at 2535 West M-28 in Dafter, Michigan. The purpose of the emission test program was to evaluate compliance with National Emission Standards for Hazardous Air Pollutants for Stationary Reciprocating Internal Combustion Engines (RICE) (40 CFR Part 63, Subpart ZZZZ) by measuring the oxygen (O_2) and carbon monoxide (CO) concentrations from the outlet of the two regulated engines.

1.1 Summary of Test Program

Cloverland Electric operates a peak shaving facility in Dafter, Michigan. The facility operates two diesel fueled power generating engines that are operated for peak shaving, and as required by the Midcontinental Independent System Operator for system emergencies.

The testing was completed in accordance with United States Environmental Protection Agency (USEPA) Reference Methods 3A and 10. Three 60-minute tests were conducted on December 9, 2014 to measure the CO concentrations in part per million by volume, dry basis (ppmvd) corrected to 15% O_2.

1.2 Purpose of Testing

The purpose of the emission test program was to evaluate compliance with National Emission Standards for Hazardous Air Pollutants for Stationary Reciprocating Internal Combustion Engines (RICE) (40 CFR Part 63, Subpart ZZZZ) by measuring the oxygen (O_2) and carbon monoxide (CO) concentrations from the outlet of the two regulated engines. The relevant emission standards are presented in Table 1-1 below:

Table 1-1
Emission Standards

Pollutant	Limit	Equipment	USEPA Testing Method	Underlying Applicable Requirements
CO	23 ppmvd at 15% O_2 or reduce CO emissions by 70% or more	EUENGINE-4 EUENGINE-5	3A and 10	40 CFR Part 63, Subpart ZZZZ

O_2 oxygen
CO carbon monoxide
ppmvd part per million by volume, dry basis

1.3 Contact Information

Contact information is listed in Table 1-2. Mr. Dillon King, Consultant with Bureau Veritas led the emission testing program. Mr. Phil Schmitigal, Director of Generation with Cloverland Electric, provided process coordination and arranged for facility operating parameters to be recorded.

Table 1-2
Key Personnel

Cloverland Electric	Bureau Veritas
Phil Schmitigal Director of Generation **Cloverland Electric Cooperative** 725 East Portage Avenue Sault Ste. Marie, Michigan 49783 Telephone: 906.632.5185 Facsimile: 906.635.6815 pschmitiga@cloverland.com	Dillon King, QSTI Consultant **Bureau Veritas North America, Inc.** 22345 Roethel Drive Novi, Michigan 48375 Telephone: 248.344.3002 Facsimile: 248.344.2656 dillon.king@us.bureauveritas.com

2.0 Source and Sampling Locations

2.1 Process Description

Cloverland Electric operates a peak shaving facility in Dafter, Michigan. The facility operates two diesel fueled power generating engines that are operated for peak shaving, and as required by the Midcontinental Independent System Operator for system emergencies. Engines 1, 2, and 3 are no longer operated. EUENGINE-4 and EUENGINE-5 were tested as they are subject to 40 CFR Part 63, Subpart ZZZZ.

EUENGINE-4 and EUENGINE-5 are Norberg model FS-1316-HSC engines that drive a 3,000 kW generator. The four-stroke reciprocating engines were installed in 1962 and operate using 16 cylinders with a displacement of 619 liters. Specifications of the engines are presented in Table 2-1.

Table 2-1
Non-Emergency Area Source RICE Engines Tested

ID	Installation Date	Make	Model	Serial Number	Rating (brake hp)	Fuel
EUENGINE-4	1962	Nordberg	FS-1316-HSC	1030-0855	4,180	Diesel
EUENGINE-5	1962	Nordberg	FS-1316-HSC	1030-0854	4,180	Diesel

Operating parameters recorded during testing are included in Appendix E.

2.2 Control Equipment

The exhausts of the engines pass through oxidation catalysts prior to discharge to the atmosphere. The expected life expectancy of the catalysts is 10,000 hours. The emission-control equipment for the diesel generation units was installed in 2013 to meet regulatory requirements.

The installed diesel oxidation catalysts (DOC) promote oxidation of the exhaust gas components by oxygen. Active catalytic sites on the surface of the DOC absorb oxygen. The bonded oxygen reacts with the effluent engine flue causing a reaction. The oxidation of carbon monoxide forms carbon dioxide, thus reducing carbon monoxide emissions.

2.3 Flue Gas Sampling Locations

Figure 1 behind the Figures Tab of this report, depicts the EUENGINE-4 and EUENGINE-5 sampling ports and traverse point locations. Descriptions of the source sampling locations are presented in sections 2.3.1 and 2.3.2

2.3.1 EUENGINE-4

The EUENGINE-4 exhaust was sampled from one of two sampling ports oriented at 90° to one another. The sampling ports are located in a straight section of a 25-inch-internal-diameter duct. The ports are located:

- 3 feet (1.4 duct diameters) from the nearest downstream disturbance.
- 8 feet (3.8 duct diameters) from the nearest upstream disturbance.

The ports were accessible via a man-lift.

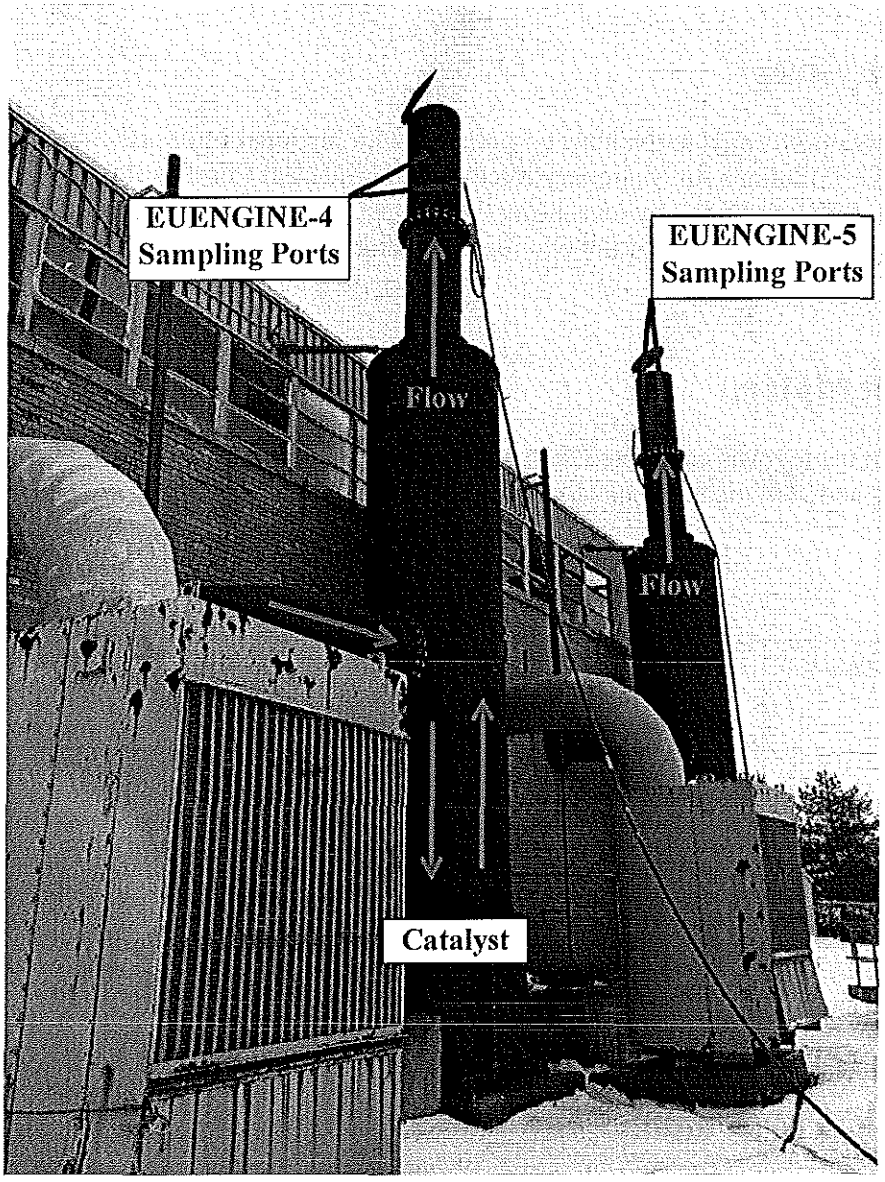
2.3.2 EUENGINE-5

The EUENGINE-5 exhaust was sampled from one of two sampling ports oriented at 90° to one another. The sampling ports are located in a straight section of a 25-inch-internal-diameter duct. The ports are located:

- 3 feet (1.4 duct diameters) from the nearest downstream disturbance.
- 8 feet (3.8 duct diameters) from the nearest upstream disturbance.

The ports were accessible via a man-lift. A photograph of the EUENGINE-4 and EUENGINE-5 sampling locations is presented in Figure 2-1.

Figure 2-1. EUENGINE-4 and EUENGINE-5 Sampling Locations



2.4 Process Sampling Locations

Process sampling was not required during this test program. A process sample is a sample that is analyzed for operational parameters, such as calorific value of a fuel (e.g., diesel, natural gas, coal), organic compound content (e.g., paint coatings), or composition (e.g., polymers).

3.0 Summary and Discussion of Results

3.1 Objectives

The testing was performed to evaluate compliance with National Emission Standards for Hazardous Air Pollutants for Stationary Reciprocating Internal Combustion Engines (RICE) (40 CFR Part 63, Subpart ZZZZ) by measuring the oxygen (O_2) and carbon monoxide (CO) concentrations from the outlet of the two regulated engines. The relevant emission standards are provided in Table 1-1.

3.2 Test Matrix

The emission testing was conducted to evaluate the objectives in Section 3.1. Table 3-1 presents the sampling and analytical test matrix.

Table 3-1
Test Matrix

Sampling Location	No. of Runs	Sample/Type of Pollutant	Sampling Method (USEPA)	Sampling Organization	Run Time (min)	Analytical Method
Outlet of EUENGINE-4	3	O_2 CO	3A 10	Bureau Veritas	60	Paramagnetic Infrared
Outlet of EUENGINE-5	3	O_2 CO	3A 10	Bureau Veritas	60	Paramagnetic Infrared

O_2 oxygen
CO carbon monoxide

3.3 Field Test Changes and Issues

Field test changes were not required to complete the emission testing.

3.4 Results

The results of the testing are compared to the applicable emission limits in Table 3-2. Detailed results are presented in Tables 1 and 2 after the Tables Tab of this report. Graphs of the

measured O_2 and CO concentrations are presented after the Graphs Tab of this report. Sample calculations are presented in Appendix B.

Table 3-2
O_2 and CO Emissions Results Compared to Permit Emission Limits

Date (2014)	Source ID	Parameter	Units	Average Result	Emission Limit
Dec 9	EUENGINE-4	O_2	%	15.3	N/A
		CO	ppmvd	11.4	N/A
		CO	**ppmvd at 15% O_2**	**12.0**	**23**
Dec 9	EUENGINE-5	O_2	%	12.3	N/A
		CO	ppmvd	7.3	N/A
		CO	**ppmvd at 15% O_2**	**5.0**	**23**

O_2 oxygen
CO carbon monoxide
N/A not applicable
ppmvd part per million by volume, dry basis

The O_2 and CO measurements demonstrate EUENGINE-4 and EUENGINE-5 are operating within allowable limits.

4.0 Sampling and Analytical Procedures

Bureau Veritas measured emissions in accordance with United States Environmental Protection Agency sampling methods 3A and 10, identified in Table 4 to Subpart ZZZZ of Part 63—Requirements for Performance Tests. The sampling and analytical methods used during this test program are listed in the following table.

Table 4-1
Sampling and Analytical Test Methods

USEPA Sampling Method	Parameter	Analysis
3A	Oxygen	Paramagnetic
10	Carbon monoxide	Nondispersive infrared

4.1 Test Methods

4.1.1 Oxygen and Carbon Monoxide (USEPA Methods 3A and 10)

USEPA Method 3A "Determination of Oxygen and Carbon Dioxide Concentrations in Emissions from Stationary Sources (Instrument Analyzer Procedure)" and USEPA Method 10 "Determination of Carbon Monoxide Emissions from Stationary Sources (Instrument Analyzer Procedure)" was used to measure O_2 and CO concentrations. Flue gas was continuously sampled from the stack and conveyed to a paramagnetic analyzer for O_2 concentration measurements and an infrared analyzer for CO concentration measurements. Flue gas was extracted from the stack through:

- A stainless-steel probe.
- Heated Teflon sample line to prevent condensation.
- A chilled Teflon impinger train (equipped with a peristaltic pump) to remove moisture from the sampled gas stream prior to entering the analyzer.
- O_2 and CO gas analyzers.

Refer to Figure 2 in the Appendix for a drawing of the USEPA Methods 3A and 10 sampling train. Data was recorded at 1-second intervals on a computer equipped with data acquisition software.

Flue gas was withdrawn from three sample points located at 16.7%, 50%, and 83.3% of the diameter of the stack. The sampling probe was moved to a new sampling point at 20-minute intervals during the 60-minute test runs.

The pollutant concentrations were measured using an O_2 and CO gas analyzers calibrated with zero-, mid-, and high-EPA-Traceability-Protocol-certified calibration gases.

A calibration error check was performed by introducing zero-, mid-, and high-level calibration gases directly into the analyzers. The calibration error check was performed to verify each analyzer response was within ±2% of the calibration span of the analyzer. Prior to each test run, a system-bias test was performed where known concentrations of calibration gases were introduced at the probe tip to measure if the analyzers' response was within ±5% of the calibration gas span. At the conclusion of each test run, an additional system-bias check was performed to evaluate the analyzers percent drift from the pre- and post-test system-bias checks. The system-bias check evaluated the analyzer drift against the ±3% QA/QC requirement. The analyzers' drift data was used to correct the measured flue gas concentrations. Recorded concentrations were averaged over the duration of each 60-minute test run.

4.2 Procedures for Obtaining Process Data

Process data were recorded by Cloverland Electric personnel. Refer to Section 2.1 and 2.2 for discussions of process and control device data and Appendix E for the operating parameters recorded during testing.

4.3 Sampling Identification and Custody

Gaseous pollutant concentrations were measured using analyzers processing the flue gas in real time; therefore, recovery and analytic procedures for laboratory samples were not necessary.

5.0 QA/QC Activities

Equipment used in this emissions test program passed quality assurance/quality control (QA/QC) procedures. Refer to Appendix A for equipment calibration and inspection sheets. Field data sheets are presented in Appendix C. Computer-generated Data Sheets are presented within Appendix D.

5.1 Pretest QA/QC Activities

Before testing, the sampling equipment was cleaned, inspected, and calibrated according to procedures outlined in the applicable USEPA sampling methods and USEPA's "Quality Assurance Handbook for Air Pollution Measurement Systems, Volume III, Stationary Source Specific Methods."

5.2 QA/QC Audits

The results of select sampling and equipment QA/QC audits and the acceptable tolerance are presented in the following sections. Analyzer calibration and gas certification sheets are presented in Appendix A.

5.2.1 Instrument Analyzer QA/QC Audits

The instrument analyzer sampling trains described in Section 4.1 were audited for measurement accuracy and data reliability. The analyzers passed the applicable calibration criteria. Calibration gas selection, error, bias, and drift checks are included in Appendix A. The gas cylinders used during the test program are presented in Table 5-1.

Table 5-1
Calibration Gas Cylinder Information

Parameter	Gas Vendor	Cylinder Serial Number	Cylinder Value	Expiration Date
Carbon Monoxide (CO)	The American Gas Group	EB0018925	26 ppm	6/22/2018
	Pangaea Gases	EB0054932	45 ppm	3/4/2022
Oxygen (O_2)	Airgas	CC17793	11.11%	10/31/2022
	Pangaea Gases	EB0049262	20.01%	3/6/2022
Nitrogen (N)	Airgas	CC39741	99.9995%	9/25/2022

5.3 QA/QC Blanks

Reagent and field train blanks were not applicable to this test program.

5.4 QA/QC Problems

No QA/QC problems were encountered during this test program.

Limitations

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