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TABLE OF CONTENTS

Appendices

I. INTRODUCTION

Network Environmental, Inc. was retained by the Zeeland Board of Public Works, to perform an emission study on their R.I.C.E. (Reciprocating Internal Combustion Engines) located at their Washington Avenue facility in Zeeland, MI. These engines are permitted in Michigan Department of Environment, Great Lakes and Energy (EGLE) - Air Quality Division ROP No. MI-ROP-B7977-2022 as FGRICEMACT (EU-ENGINE011, EU-ENGINE010, EU-ENGINE009, EU-ENGINE008, EU-ENGINE007, EU-ENGINE002 and EU-ENGINE001). The purpose of the study was to document compliance with MI-ROP-B7977-2022. The following emission limits have been established for these engines:

- Carbon Monoxide (CO) reduction (destruction efficiency) of 70% **Or** 23 PPM @ 15% O_2.

The CO reduction was determined by monitoring the CO concentrations at the inlet and outlet of each engine's catalytic oxidation emission control system.

The testing was designed to meet the requirements of MI-ROP-B7977-2022 and 40CFR Part 63 Subparts A & ZZZZ. The following reference test methods were employed to conduct the sampling:

- CO – U.S. EPA Method 10
- O_2 – U.S. EPA Method 3A

The sampling was performed over the period of August 1-4, 2023 by Stephan K. Byrd, Richard D. Eerdmans and David D. Engelhardt of Network Environmental, Inc. Assisting with the study were Mr. Robert Mulder of the Zeeland Board of Public Works and the operating staff of the facility. Mr. Chris Robinson of the Michigan Department of Environment, Great Lakes and Energy (EGLE) - Air Quality Division was present to observe portions of the sampling and source operation.

II. PRESENTATION OF RESULTS

II.1 TABLE 1
CO DESTRUCTION EFFICIENCY RESULTS
RECIPROCATING INTERNAL COMBUSTION ENGINES (R.I.C.E.)
WASHINGTON AVENUE FACILITY
ZEELAND BOARD OF PUBLIC WORKS
ZEELAND, MICHIGAN

Source	Sample	Date	Time	CO Concentration PPM (1)		CO % Destruction Efficiency
				Inlet	Outlet	
Engine #1 (EU-ENGINE001)	1	08/03/23	15:30-16:30	439.15	56.45	87.14
	2	08/03/23	16:45-17:45	463.93	55.51	88.04
	3	08/03/23	18:00-19:00	460.08	54.42	88.17
	Average			**454.39**	**55.46**	**87.78**
Engine #2 (EU-ENGINE002)	1	08/04/23	08:50-09:50	483.92	29.38	93.93
	2	08/04/23	10:05-11:05	500.73	28.73	94.26
	3	08/04/23	11:20-12:20	459.57	26.24	94.29
	Average			**481.41**	**28.11**	**94.16**
Engine #7 (EU-ENGINE007)	1	08/02/23	14:30-15:30	462.17	70.01	84.85
	2	08/02/23	15:45-16:45	457.64	66.87	85.39
	3	08/02/23	17:00-18:00	494.13	69.54	85.93
	Average			**471.31**	**68.81**	**85.39**

(1) PPM = Parts Per Million (v/v) On A Dry Basis Corrected To 15% O_2
(2) MI-ROP-B7977-2022 has established an emission limit of 70% CO reduction (destruction efficiency) for these engines.

II.1 TABLE 1 (CONTINUED)
CO DESTRUCTION EFFICIENCY RESULTS
RECIPROCATING INTERNAL COMBUSTION ENGINES (R.I.C.E.)
WASHINGTON AVENUE FACILITY
ZEELAND BOARD OF PUBLIC WORKS
ZEELAND, MICHIGAN

Source	Sample	Date	Time	CO Concentration PPM (1)		CO % Destruction Efficiency
				Inlet	Outlet	
Engine #8 (EU-ENGINE008)	1	08/02/23	09:20-10:20	529.09	28.38	94.64
	2	08/02/23	10:35-11:35	612.94	29.17	95.24
	3	08/02/23	11:50-12:50	549.68	26.88	95.11
	Average			**563.90**	**28.14**	**95.00**
Engine #9 (EU-ENGINE009)	1	08/01/23	11:16-12:16	553.85	118.90	78.53
	2	08/01/23	12:30-13:30	630.73	117.15	81.43
	3	08/01/23	13:45-14:45	613.25	92.11	84.98
	Average			**599.28**	**109.38**	**81.65**
Engine #10 (EU-ENGINE010)	1	08/01/23	16:35-17:35	344.64	52.51	84.76
	2	08/01/23	17:50-18:50	345.11	52.19	84.88
	3	08/01/23	19:05-20:05	348.94	52.59	84.93
	Average			**346.23**	**52.43**	**84.86**

(1) PPM = Parts Per Million (v/v) On A Dry Basis Corrected To 15% O_2
(2) MI-ROP-B7977-2022 has established an emission limit of 70% CO reduction (destruction efficiency) for these engines.

II.1 TABLE 1 (CONTINUED)
CO DESTRUCTION EFFICIENCY RESULTS
RECIPROCATING INTERNAL COMBUSTION ENGINES (R.I.C.E.)
WASHINGTON AVENUE FACILITY
ZEELAND BOARD OF PUBLIC WORKS
ZEELAND, MICHIGAN

Source	Sample	Date	Time	CO Concentration PPM (1)		CO % Destruction Efficiency
				Inlet	Outlet	
Engine #11 (EU-ENGINE011)	1	08/03/23	08:50-09:50	361.35	54.45	84.93
	2	08/03/23	10:05-11:05	364.82	54.67	85.01
	3	08/03/23	11:20-12:20	360.58	54.07	85.01
	Average			**362.25**	**54.40**	**84.98**

(1) PPM = Parts Per Million (v/v) On A Dry Basis Corrected To 15% O_2
(2) MI-ROP-B7977-2022 has established an emission limit of 70% CO reduction (destruction efficiency) for these engines.

III. DISCUSSION OF RESULTS

The results of the emission sampling are summarized in Table 1 (Section II.1). The results are presented as follows:

III.1 Carbon Monoxide (CO) Destruction Efficiency Results (Table 1)

Table 1 summarizes the CO DE results for the engines as follows:

- Source
- Sample
- Date
- Time
- Inlet & Outlet CO Concentrations (PPM) – Parts Per Million (v/v) On A Dry Basis Corrected To 15% O_2
- CO Percent Destruction Efficiency (DE)

IV. SOURCE DESCRIPTION

The sources tested were reciprocating internal combustion engines (R.I.C.E.) of various makes, models, capacities and ages. Catalysts were installed on the exhausts to reduce emissions from the engines. The engines were operated at a level greater than 90% of maximum load during the testing. Process operating data collected during the sampling and engine specifications (as listed in the ROP) can be found in Appendix E.

V. SAMPLING AND ANALYTICAL PROTOCOL

The sampling methods used for the reference method determinations were as follows:

V.1 Carbon Monoxide – The CO sampling was conducted in accordance with U.S. EPA Reference Method 10. A Thermo Environmental Model 48C gas analyzer was used to monitor the catalyst inlets. A Thermo Environmental Model 48 gas analyzer was used to monitor the catalyst outlets. Heated Teflon sample lines were used to transport the inlet and outlet 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 CO concentrations (PPM).

The analyzers were calibrated by direct injection prior to the testing. A span gas of 998.0 PPM (inlets) and 168.0 PPM (outlets) were used to establish the initial instrument calibrations. Calibration gases of 486.0

PPM & 251.0 PPM for the inlets and 92.90 PPM & 51.10 PPM for the outlets were used to determine the calibration error of the analyzers. The sampling systems (from the back of the stack probes to the analyzers) were injected using the 92.90 PPM gas (outlets) and the 486.0 PPM gas (inlets) to determine the system bias. After each sample, a system zero and system injection of 92.90 PPM (outlets) and 486.0 PPM (inlets) 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 engines. A diagram of the CO sampling train is shown in Figure 1.

V.2 Oxygen (Outlets Only) – The O_2 sampling was conducted in accordance with U.S. EPA Reference Method 3A. A Servomex Model 1400M portable stack gas analyzer was used to monitor the outlets. 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 O_2 concentrations (%).

The analyzer was calibrated by direct injection prior to the testing. A span gas of 21.0% was used to establish the initial instrument calibration. Calibration gases of 12.0% and 6.03% were 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 6.03% gas to determine the system bias. After each sample, a system zero and system injection of 6.03% 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 outlets. A diagram of the O_2 sampling train is shown in Figure 1.

V.3 Oxygen (Inlets Only) – Integrated bag samples were collected on the inlets of each engine during each of the three (3) test runs. The bags were run on the O_2 analyzer to confirm that the inlet concentrations equaled the outlet.

This report was prepared by:

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This report was reviewed by:

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President

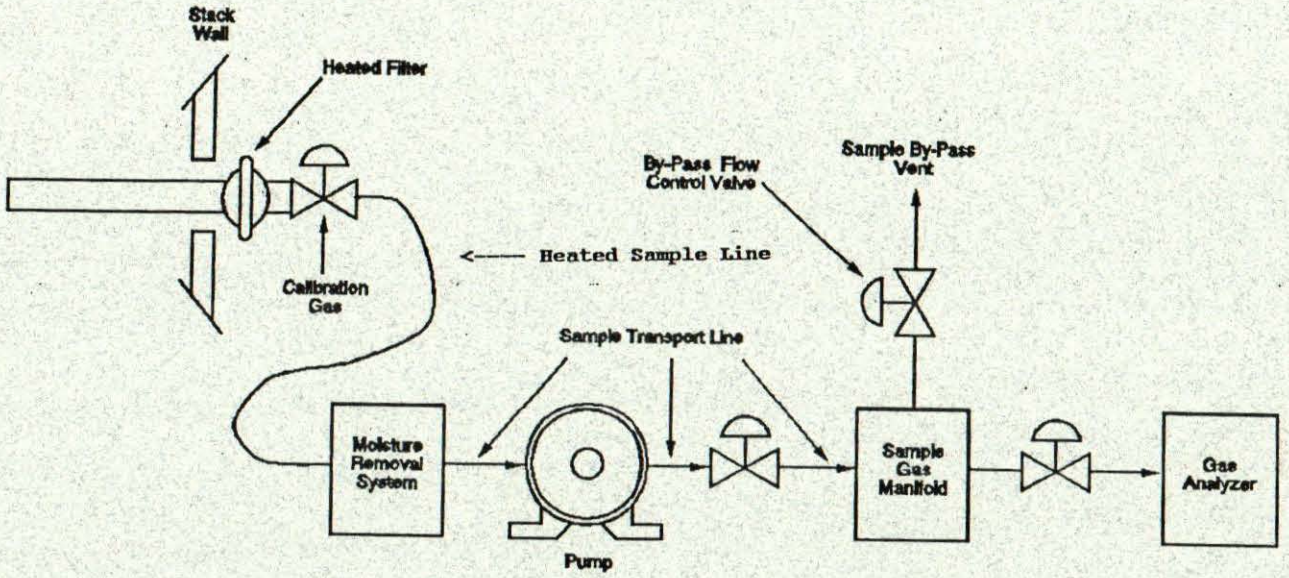

Figure 1

CO & O_2
Sampling Train