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Final Report

Performance Source Testing IC Engine #1
Fortistar
Marshall, MI Facility

September 2013

TRC Environmental Corporation
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TRC Project No. 198348.0050.0000

September 2013

FINAL REPORT

Performance Source Testing Turbine #1
Fortistar
Marshall, Mi Facility

Prepared for

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INTRODUCTION

1.1 OVERVIEW

Fortistar hired TRC Environmental Corporation (TRC) of Lombard, Illinois to conduct testing to determine the NOx, O_2, CO, HCL, HCHO, and TGNMOC emissions from Waukesha internal combustion (IC) Engine #1 located at the Fortistar Landfill in Marshall, Michigan. The purpose of the testing was to verify that the emissions meet the Michigan permit limits.

Emission testing was performed on IC Engine #1 on September 4, 2013. The testing determined emissions of Oxygen (O_2) by USEPA Method 3A, Nitrogen Dioxide (NOx) by USEPA Method 7E, Carbon Monoxide (CO) by USEPA Method 10, Total Gaseous non-Methane Organic Compounds (TGNMOC) and Methane by USEPA Method 18, Hydrochloric Acid (HCL) by USEPA Method 26, Formaldehyde (HCHO) by USEPA method 323, and sulfur content in the fuel by ASTM 3246 while firing methane landfill gas.

Sampling and analysis procedures described in this document were conducted using procedures deemed acceptable by the USEPA. TRC was responsible for the collection and analysis of all samples.

1.2 SCOPE OF WORK

The test program approach involved conducting a series of test runs at test ports located on the IC Engine exhaust. Testing was performed at 100% load. Each test determined the concentration and emission rate for NOx, O_2, HCL, HCHO, and TGNMOC. Exhaust stack flow rates were also determined during each run from the stoichiometric gas usage following method 19.

The results of the test program are presented in a format acceptable to the USEPA.

The required measurement parameters and test methods to accomplish these objectives were:

- 40 CFR Part 60, Appendix A, EPA Reference Methods (RM)

RM 3A	Oxygen (O_2)
RM7E	Nitrogen Dioxide (NOx)
RM10	Carbon Monoxide (CO)
RM26	Hydrochloric Acid (HCL)
RM323	Formaldehyde (HCHO)
RM 18	Total Gaseous Non-Methane Organics (TGNMO)
RM 19	F Factor Emission Rates, Btu/cf, and Sulfur content

1.3 REPORT SUMMARY

This report presents the results of the test program completed at the Fortistar Landfill in Marshall, MI. Included in the following pages are descriptions of the sampling locations, sampling and analytical procedures, calculations, and TRC's QA procedures, which ensure the integrity of the reported data. A summary of all test results is presented in Section 2. Additionally, appendices are included which contain all relevant field reduced data, field sampling data sheets, field recovery data sheets, flue gas analytical data reports, sampling equipment calibration documentation sheets and process data from the facility.

SECTION 2.0

SUMMARY OF RESULTS

This section presents a summary of the emissions testing conducted at the Fortistar Landfill in Marshall, MI. The field reduced data tables are located in Appendix A and the field data sheets are in Appendix B. Process and operating information can be found in Appendix C. The Laboratory analytical data can be found in Appendix D. The Calculation Formulas can be found in Appendix F.

Table 2-1 Emissions for IC Engine 1 NOx, CO2, and O2

IC Engine #1	NOx ppm	NOx ppm @ 15% O_2	NOx g/Hp-hr	NOx Lbs/hr	NOx TPM	SO_2 ppmv	SO_2 Lbs/hr	CO_2 %	O_2 %
Run 1	46.0	23.4	0.29	0.89	0.32	<1.0	<0.026	10.3	9.3
Run 2	33.7	17.4	0.21	0.66	0.24	<1.0	<0.026	10.1	9.5
Run 3	39.7	20.4	0.25	0.77	0.28	<1.0	<0.026	10.2	9.4
Averages	39.8	20.4	0.25	0.77	0.28	<1.0	<0.026	10.2	9.4
Permit Limits			0.90	2.93	1.07	N/A	N/A	N/A	N/A

Table 2-2 Emissions for IC Engine 1 CO and TGNMOC

IC Engine #1	CO ppm	CO ppm @15% O2	CO g/Hp-hr	CO Lb/Hr	CO TPM	TGNMOC ppm as Hexane	TGNMOC ppm @ 15% O_2	TGNMOC g/Hp-hr	TGNMOC Lbs/hr as Hexane	TGNMOC TPM
Run 1	428.2	217.6	1.64	4.91	1.77	6.91	3.51	0.083	0.29	0.10
Run 2	456.1	235.8	1.75	5.23	1.88	4.92	2.54	0.059	0.20	0.07
Run 3	443.4	228.5	1.70	5.08	1.83	3.19	1.64	0.038	0.13	0.05
Averages	442.6	227.3	1.69	5.07	1.83	5.01	2.57	0.060	.021	0.07
Permit Limits			2.30	7.33	2.68	N/A	N/A	0.25	0.81	0.30

Table 2-3 Emissions for IC Engine 1 HCL, HCHO

IC Engine #1	HCL ug	HCL ppm	HCL Lbs/hr	HCL TPM	HCHO µg	HCHO ppm	HCHO Lbs/hr	HCHO TPM
Run 1	8,100	4.52	0.08	0.03	242.5	8.35	0.114	0.041
Run 2	2,800	1.43	0.02	0.01	762.0	28.0	0.383	0.138
Run 3	2,480	1.27	0.02	0.01	919.4	30.8	0.420	0.151
Averages	4,460	2.41	0.04	0.01	685.5	23.6	0.323	0.110
Permit Limits			0.60	0.22	N/A	N/A	N/A	N/A

Table 2-4 Engine #1 Fuel Usage

Fuel Usage Data	Run 1	Run 2	Run 3	Average
Cubic Ft. Hour	305	305.1	305.1	305.1
Scf/hr				
Permit Limit	Maximum Allowable Usage 37,500 scf/hr			

SECTION 3.0
FIELD SAMPLING PROGRAM

3.1 OVERVIEW

This section describes the procedures that TRC followed during the field-sampling program. Throughout the program TRC followed EPA Reference Methods 40 CFR Part 60 Appendix A. Deviations from the specified test methods are fully documented in this final report.

The remainder of this section is divided into several subsections: Field Program Description, Pre-sampling Activities, and Onsite Sampling Activities.

3.2 FIELD PROGRAM DESCRIPTION

The field sampling was conducted by TRC over the course of two days. The Fortistar Landfill, MI facility operated the IC Engine #1 near 100% capacity during the testing. Each test run for gaseous emissions followed USEPA Methods 3A, 7E, 10, 26, 323, 18, and 19. Three one hour runs were performed on the IC Engine #1 exhaust stack for each test method.

3.3 PRE-SAMPLING ACTIVITIES

Pre-sampling activities included equipment calibration, pre-cleaning of the sample train probes, and other miscellaneous tasks. Each of these activities are described or referenced in the following subsections. Other pre-sampling activities include team meetings, equipment packing, and finalization of all details leading up to the coordinated initiation of the sampling program.

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3.3.1 Equipment Calibration

TRC follows an orderly program of positive actions to prevent the failure of equipment or instruments during use. This preventative maintenance and careful calibration help to ensure accurate measurements from field and laboratory instruments.

Once the equipment has gone through the cleaning and repair process it is then calibrated. All equipment that is scheduled for field use is cleaned and checked prior to calibration. Once the equipment has been calibrated, it is packed and stored to ensure the integrity of the equipment. An adequate supply of spare parts is taken in the field to minimize downtime from equipment failure.

Inspection and calibration of the equipment is a crucial step in ensuring the successful completion of the field effort. All equipment is inspected for proper operation and durability prior to calibration. Calibration of the following equipment is conducted in accordance with the procedures outlined in EPA documents entitled "*Quality Assurance Handbook for Air Pollution Measurement Systems; Volume III - Stationary Source Specific Methods*" (EPA-600/4-77-027b) and 40 CFR Part 60 Appendix A. All calibrations were performed prior to test program.

- Dry gas meters (EPA 40 CFR Part 60, Method 5, Section 5.3) - calibrated against a wet test meter. Acceptance criteria - pretest $Y_i = Y = \pm 0.02$; post test $Y = \pm 0.05 Y_i$.
- Thermocouples (QA Handbook, Vol III, Section 3.4.2, pp. 12-18) - verified against a mercury-in-glass thermometer at three points including the anticipated measurement range. Acceptance limits - impinger ∀ 2EF; DGM ∀ 5.4EF; stack ∀ 1.5 percent of stack temperature.
- Field barometer is (QA Handbook, Vol III, Section 3.4.2, pp. 18-19) - compared against a mercury-in-glass barometer or use Airport Station BP and corrected for elevation. Acceptance criteria: - ± 0.02 in. Hg: post-test check - same.

3.4 ONSITE SAMPLING ACTIVITIES

3.4.1 EPA Method 3A for Oxygen and Carbon Dioxide

Oxygen (O2) and Carbon Dioxide (CO2) concentrations were determined for each test run according to EPA Reference Method 3A, "Determination of Oxygen and Carbon Dioxide Concentrations in Emissions from Stationary Sources (Instrumental Analyzer Procedure)".

The sampling system consisted of a stainless-steel sampling probe connected to a heated (248°F ± 25°F) Teflon® sample line and a sample conditioner to remove the moisture from the gas stream. The sample was drawn through the system by a leak-free Teflon® double diaphragm pump to a stainless-steel sample manifold with an atmospheric by-pass rotometer.

The concentrations of O2 and CO2 are expressed as percent and were used to determine the emissions corrections, lbs/MMbtu's, and for calculating the volumetric flow.

3.4.2 EPA Methods 7E

EPA Reference Method 7E "Determination of Oxides of Nitrogen Emissions from Stationary Sources (Instrumental Analyzer Procedure)" was utilized for the measurement of NOx. The analyzer used was the California Analytical, Model 650, Serial No. SO 6014, chemiluminescent NO/NOx monitor. The instrument operation is based on the principal of the chemiluminescent reaction of nitric oxide (NO) and ozone. Light emission results when electronically excited nitrogen dioxide (NO2) molecules revert to their ground state. To measure NO concentrations, the gas sample to be analyzed, is blended with ozone (O3) in the instrument's reaction chamber. The resulting chemiluminescence is monitored through an optical filter by a highly sensitive photomultiplier tube (PMT) positioned at one end of the reaction chamber. The filter/photomultiplier combination responds to light in a narrow wavelength band unique to this chemiluminescent reaction (detailed below) the filter assists in eliminates interferences in this wavelength:

$$NO + O3 \rightarrow NO2 + O2 + hv$$

To measure NOx concentrations (NO plus NO2), the sample gas flow is diverted through a NO_2-to-NO converter. The chemiluminescent response in the reaction chamber to the converter effluent is linearly proportional to the NOx concentration entering the converter (sample gas). The system was operated in the NOx mode during all phases of the program.

3.4.3 EPA Methods 10

Carbon monoxide (CO) concentrations will be determined at the outlet stack for each test run according to EPA Reference Method 10, "*Determination of Carbon Monoxide Concentrations in Emissions from Stationary Sources.*" The analyzer used is a TECO 48C. The instrument utilizes a gas filter correlation non-dispersive infrared detector, which does not require a CO_2 absorber.

3.4.4 EPA Methods 26

Stack gas was withdrawn through a temperature-controlled (>248 °F) probe and high-efficiency, Teflon mat filter. The sampling apparatus contained a glass lined temperature-controlled (>248 °F) probe. The exit of the probe was connected to a heated jumper and then to a heated high efficiency Teflon mat filter supported in a glass filter holder inside a temperature-controlled (>248 °F) oven. The exit of the filter holder was connected to a series of six, full size impingers. The first and second impingers each had 100 milliliters of 0.1 N sulfuric acid solution. The third impinger was empty and the fourth and fifth impingers each had 100 milliliters of 0.1 N sodium hydroxide solution and the sixth contained 200 grams of silica gel. The impingers were immersed in an ice bath for the duration of each test. An integrated sample of at least 40 dry standard cubic feet was extracted from the gas stream and passed through this dilute sulfuric acid and sodium hydroxide. In the dilute acid, the HCl gas dissolved and formed chloride (Cl^-) ions and in the dilute base the Cl_2 dissolved and formed chlorine (Cl^-) ions.

The sampling apparatus was leak-checked before and after each test run. Sampling was performed at a single point.

Following the completion of each test run, the Method 26 train was transported to the recovery area. The sample recovery sequence was as follows:

- Note the condition of the train (i.e., filter, impinger contents color, silica gel color, etc.).
- The contents of the first three impingers were measured for volume and transferred to a polyethylene sample container with a sealed cap. The impingers, back-half filter housing, and U-tubes were rinsed with DI water into the sample container.
- The silica gel was weighed to obtain a final weight.
- All containers were checked to ensure proper sealing, proper labeling, and that all liquid levels are marked. All samples were logged onto a chain-of-custody record.

The samples were analyzed by ion chromatography. The hydrogen chloride analyses were performed by Chester LabNet located in Tigard, Oregon. Copies of the field data sheets can be found in Appendix B.

3.4.5 EPA Methods 323

Formaldehyde emissions were determined according to EPA Reference Method 323, "*Measurement of Formaldehyde Emissions from Natural Gas-Fired Stationary Sources - Acetyl Acetone Derivitization Method*" (40 CFR Part 63 Appendix A). Sampling consisted of three one-hour test runs at the engine outlet stack. During one run (Run 3), a duplicate sample was also obtained.

The sampling train consisted of a stainless steel probe and three midget impingers. The first impinger was the moisture knockout and left empty, the second impinger contained 20 ml of deionized (DI) water, and the third impinger contained silica gel to remove moisture prior to the dry gas meter.

Sampling was non-isokinetic and at a sampling rate of approximately 0.4 liters per minute. The impinger contents were surrounded with ice during sampling. A total sample gas volume of approximately 21 to 23 liters was collected during each run. Leak checks of the entire Method 323 sampling train were performed before and after each sampling run.

Following the completion of each test run, the Method 323 train was transported to the recovery area onsite. The recovery sequence proceeded as follows:

- Rinsed the probe and connecting tubing into a 40 ml amber VOA vial.
- Remove the sampling train to the recovery area.
- Note the condition of the train (i.e., impinger contents color, silica gel color, etc.).
- Place the contents of the first two impingers into the same 40 ml amber VOA vial. Rinsed the impingers with DI water and added the rinse to the same vial. DI water was finally added to the VOA vial to create zero headspace. The container was then sealed, labeled and the liquid level marked.

The Method 323 train produced the following sample:

- Container No. 1 - Contents of Impingers 1 and 2 plus rinse.

Additionally, a reagent blank for the DI water was collected, logged onto the chain of custody form and submitted for analysis. The samples were kept cold after collection and during shipment to the lab. The TRC Austin, Texas office performed the analysis. The laboratory data can be found in Appendix D.3.

3.4.6 EPA Method 18

Gaseous measurements were conducted at the facility following USEPA Method 18. A bag system was used to pull sample gas into a 10L Tedlar bag. A Lung sampler was used to accomplish the sampling. The bags were then sent overnight to TRC Bakersfield, CA for analysis by GC Carbon compounds C1 thru C6, Methane, and Ethane.

3.4.6 EPA Method 19

It was determined that the flow at the only available sample locations was cyclonic therefore volumetric flow was calculated using the fuel usage and methane content in accordance with EPA Reference Method 19. The calculations can be found in Appendix D with the plant data in Appendix C. Velocity measurements were calculated with an average F-Factor, Btu/cf, and fuel usage during the test series.

SECTION 4.0
ANALYTICAL PROCEDURES

This section delineates the analytical procedures and calculations used during the Performance Test Program.

4.1 Organic Analysis

Three one-hour Tedlar Bag samples were taken and analyzed for total hydrocarbons and methane by USEPA Method 18. The non-methane hydrocarbons C1 thru C6 along with methane, ethane, propane, butanes, pentanes, hexanes results were analyzed by a GC. All non-methane hydrocarbons were converted to methane then added together. This resulted in a total gaseous non-methane organic compounds (TGNMOC) expressed in ppm units.

The TGNMOC was converted to Hexane (C_6H_{14}) by dividing by 6 carbons. The TGNMOC ppm as hexane was used in the ppm @ 15% O_2, ppm wet and dry @ 3% O_2, and lbs/hr.

SECTION 5.0
QUALITY ASSURANCE

5.1 OVERVIEW

TRC Environmental Corporation management is fully committed to an effective Quality Assurance/Quality Control Program whose objective is the delivery of a quality product. For much of TRC's work, that product is data resulting from field measurements, sampling and analysis activities, IC Engineering assessments, and the analysis of gathered data for planning purposes. The Quality Assurance Program works to provide complete, precise, accurate, representative data in a timely manner for each project, considering both the project's needs and budget constraints.

This section highlights the specific QA/QC procedures to be followed on this Test Program.

5.2 FIELD QUALITY CONTROL SUMMARY

5.2.1 Instrument Calibrations

All instrument calibrations meet the performance criteria defined in 40 CFR 60 Appendix A, Methods 3A, 7E, 10, 18, 19, 26, and 323.

5.2.2 Calibration Procedures

Calibration of the field sampling equipment was performed prior to the field sampling effort. Calibrations were performed as described in the EPA publications "*Quality Assurance Handbook for Air Pollution Measurement Systems; Volume III - Stationary Source Specific Methods*" (EPA-600/4-77-027b) and EPA 40 CFR Part 60 Appendix A. Equipment calibrated includes the sample CEM system, and barometer. Copies of the equipment calibration forms can be found in Appendix E.

5.2.3 Equipment Leak Checks

Prior to sampling, each sampling train was leak checked according to the procedures outlined in EPA Reference Method 5. Before a test run, a leak check was conducted. Final leak checks were performed to ensure that no leaks developed in the train during the course of the test run.

5.3 DATA REDUCTION, VALIDATION, AND REPORTING

Specific QC measures were used to ensure the generation of reliable data from sampling and analysis activities. Proper collection and organization of accurate information followed by clear and concise reporting of the data is a primary goal in all projects.

5.3.1 Field Data Reduction

The Field Team Leader reviewed the data collected in the field. Appendix A provides the calculation worksheets used in the field and a listing of formulas to be used to reduce the field data.

5.3.2 Laboratory Analysis Data Reduction

Analytical results were reduced to concentration units specified by the analytical procedures.

5.3.3 Data Validation

TRC supervisory and QC personnel used validation methods and criteria appropriate to the type of data and the purpose of the measurement.

Field sampling data was validated by the Field Team Leader and/or the QC Coordinator based on their review of the adherence to an approved sampling protocol and written sample collection procedure.

Analytical data was validated by the laboratory QC or supervisory personnel using criteria outlined below. TRC QC personnel reviewed all laboratory raw analytical data to verify calculated results presented.

The following criteria were used to evaluate the field sampling data:

- Use of approved test procedures;
- Proper operation of the process being tested;
- Use of properly operating and calibrated equipment;
- Leak checks conducted;
- Use of reagents conforming to QC specified criteria;
- Proper chain-of-custody maintained.

The criteria listed below were used to evaluate the analytical data:

- Use of approved analytical procedures;
- Use of properly operating and calibrated instrumentation;
- Acceptable results from analyses of QC samples (i.e., the reported values should fall within the 95 percent confidence interval for these samples).