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Executive Summary

GRANGER ELECTRIC OF BRENT RUN, LLC
CAT® G3520C LANDFILL GAS FUELED IC ENGINE EMISSIONS RESULTS

Granger Energy and Electric contracted Derenzo and Associates, Inc., to conduct a performance demonstration for the determination of nitrogen oxides (NOx), carbon monoxide (CO), and volatile organic compounds (VOC) concentrations and emission rates from one (1) Caterpillar (CAT®) Model No. G3520C landfill gas-fired reciprocating internal combustion engines and electricity generator sets operated at the Granger Electric of Brent Run, LLC facility in Montrose, MI.

Michigan Department of Environmental Quality (MDEQ) Air Quality Division (AQD) Renewable Operating Permit (ROP) No. MI-ROP-N5987-2010a requires that performance testing be performed on the CAT® G3520C engines within 365 days of startup and every 8,760 hours of operation (or every three years, whichever comes first) in accordance with the provisions of 40 CFR Part 60 Subpart JJJJ (NSPS for spark ignition internal combustion engines). The annual performance testing was conducted on January 13, 2014.

The following table presents the emissions results from the performance demonstration.

Emission Unit Identification	NOx Emission Rate (lbs/hr)	NOx Emission Factor (g/bhp-hr)	CO Emission Rate (lbs/hr)	CO Emission Factor (g/bhp-hr)	VOC Emission Factor (g/bhp-hr)
EUENGINE3	3.22	0.68	13.76	2.9	0.15
Permit Limits	4.94	1.00	16.30	3.3	1.0

lb/hr = pounds per hour, g/bhp-hr = grams per brake horse power-hour

The following table presents the operating data recorded during the performance demonstration.

Emission Unit Identification	Fuel Usage (scfm)	Fuel Quality (Btu/scf)	Electricity Generation (kW)	Engine Output (bHp-hr)	Exhaust Flowrate (scfm)	Exhaust Flowrate (dscfm)
EUENGINE3	488.2	529.4	1,535	2,151	4,970	4,427

scfm=standard cubic feet per minute, Btu/scf= British thermal unit per standard cubic foot, kW=kilowatt, bHp-hr=brake horse power hour, dscfm=dry standard cubic feet per minute

The data above indicates EUENGINE3 operated at normal base load conditions and is in compliance with the emission standards presented in 40 CFR 60.4233(e) and MDEQ-AQD ROP No. MI-ROP-N5987-2010a.

EMISSIONS TEST REPORT

Title	Compliance Test Report for the IC Engine Generator Sets operated by Granger Electric at the Granger – Brent Run facility in Montrose, Michigan.
Report Date	February 14, 2014
Test Date(s)	January 13, 2014

Facility Information	
Name	Granger Electric Company of Brent Run, LLC
Street Address	8247 Vienna Road
City, County	Montrose, Genesee

Facility Permit Information			
Facility SRN:	N5987	Renewable Operating Permit No.:	MI-ROP-N5987-2010a

Testing Contractor	
Company	Derenzo and Associates, Inc.
Mailing Address	39395 Schoolcraft Road Livonia, MI 48150
Phone	(734) 464-3880
Project No.	1310005

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Compliance Test Report
for a
CAT® G3520C Internal Combustion Engine Generator Set
operated at
Granger Electric of Brent Run, LLC
located in
Montrose, Michigan

1.0 INTRODUCTION

Granger Electric of Brent Run, LLC (Granger) operates two (2) Caterpillar (CAT) Model No. G3520C gas internal combustion (IC) engines and electricity generator sets under Renewable Operating Permit (ROP) ID: MI-ROP-N5987-2010a issued by the Michigan Department of Environmental Quality (MDEQ). The two (2) landfill gas (LFG) fueled IC engine generator sets are operated as emission units EUENGINE3 and EUENGINE4. Granger Electric of Brent Run, LLC is located at 8247 Vienna Road, Montrose, Genesee County, Michigan.

Conditions of the facility's ROP (No.: MI-ROP-N5987-2010a) require that a performance test be conducted on one of the CAT G3520C engines.

Section 2, Condition V.1 of the ROP No. MI-ROP-N5987-2010a specifies that:

> *The Permittee shall conduct....subsequent performance testing for EUENGINE3 every 8760 hours of operation or three years, whichever comes first, to demonstrate compliance.*

The compliance demonstration consisted of triplicate; one-hour test runs for the determination of nitrogen oxides (NO_X), carbon monoxide (CO), and volatile organic compounds (VOC, as non-methane hydrocarbons) on EUENGINE3. Exhaust gas velocity, moisture, oxygen (O_2) content, and carbon dioxide (CO_2) content was determined for each test period to calculate volumetric exhaust gas flowrate and pollutant mass emission rates. Instrument analyzers were used for real time analysis of NO_X, CO, VOC, O_2, and CO_2.

The compliance testing was performed on January 13, 2014, by Derenzo and Associates, Inc., an environmental consulting and testing company based in Livonia, MI. Derenzo and Associates personnel Michael Brack, and Jason Logan performed the testing. Mr. Nathan Hude of the MDEQ Technical Programs Unit witnessed the test event. Mr. Dan Zimmerman with Granger Electric coordinated the collection of process data.

The exhaust gas sampling and analysis performance demonstration was performed using procedures specified in the Test Protocol dated November 12, 2013.

Questions regarding this emission test report should be directed to:

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2.0 SUMMARY OF RESULTS

The exhaust gas for the LFG-fueled IC engines was monitored for three (3) one-hour test periods during which the NO_X, CO, VOC, O_2, and CO_2 concentrations were measured using instrumental analyzers. Exhaust gas flowrate was measured prior to and following each one-hour test period, where the average flowrates are used to calculate pollutant mass emission rates.

Testing was performed while the IC engines were operated at normal base load conditions (i.e., 1600 kW peak electricity output +/- 10%).

The following table presents a summary of the test results and comparison of the results to the permitted pollutant emission rates.

Emission Unit (FGENGINES)	NO_X Emission Rate (lb/hr)	NO_X Emission Factor (g/bhp-hr)	CO Emission Rate (lb/hr)	CO Emission Factor (g/bhp-hr)	VOC Emission Factor (g/bhp-hr)
EUENGINE3	3.22	0.68	13.76	2.90	0.15
Permit Limit	4.94	1.0	16.30	3.30	1.0

3.0 SOURCE AND SAMPLING LOCATION DESCRIPTION

3.1 General Process Description

Landfill gas (LFG) is produced in the Brent Run Landfill from the anaerobic decomposition of disposed waste materials. The LFG is collected from both active and capped landfill cells using a system of wells that are connected to a central header (gas collection system). The collected LFG is treated and then directed to the Granger Electric facility where it is used as fuel for the IC engine generators that produces electricity for transfer to the local utility.

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3.2 Rated Capacities, Type and Quantity of Raw Materials Used

The CAT® G3520C IC engine was tested and operated at baseload conditions (i.e., +/- 10% of the design capacity of 2,242 brake horsepower) to produce a peak electricity output of 1,600 kilowatts (kW). The three-test average output for EUENGINE3 was 1,535 kW.

Fuel (treated landfill gas) consumption is regulated to maintain the required heat input rate to support engine operations and is dependent on the fuel heat value (methane content). The average engine fuel consumption rate for EUENGINE3 during the test periods was 488.2 standard cubic feet per minute (scfm) based on data recorded from the fuel flow meter installed and operated by Granger.

Appendix B provides engine generator process data collected during the compliance test.

3.3 Emission Control System Description

The CAT® G3520C IC engine uses an electronic air-to-fuel ratio controller to fire lean fuel mixtures and produce low combustion by-product emissions. Emissions from the combustion of LFG are released uncontrolled into the ambient air through a stack connected to the IC engine exhaust manifold and noise control system (noise muffler).

3.4 Sampling Locations (USEPA Method 1)

The exhaust stack sampling port for the CAT® G3520C engines tested satisfied the USEPA Method 1 criteria for a representative sample location. The inner diameter of the engine exhaust stack is 13.5 inches. The stack is equipped with two (2) sample ports, opposed 90°, that provide a sampling location 114 inches (8.4 duct diameters) downstream and 300 inches (22.2 duct diameters) upstream from any flow disturbance.

Velocity pressure traverse locations for the sampling points were determined in accordance with USEPA Method 1.

Figure 2 presents a diagram of the performance test sampling and measurement locations.

4.0 <u>TEST RESULTS AND DISCUSSION</u>

4.1 Purpose and Objectives of the Tests

ROP No. MI-ROP-N5987-2010a, Section 2, Condition V.1 requires an initial and subsequent performance evaluations for the determination of NOx, CO, and VOC emission rates. This test event satisfied the subsequent performance demonstration for this facility.

The pollutant mass emission limits specified in 40 CFR Part 60 Subpart JJJJ is 3.0 grams per brake horsepower-hour (g/bhp-hr) for NO_X, 5.0 g/bhp-hr for CO, and 1.0 g/bhp-hr for VOC. The pollutant mass emission rate limits established in ROP No. MI-ROP-N5987-2010a are 1.0 grams g/bhp-hr and 4.94 pounds per hour (pph) for NO_X, 3.3 g/bhp-hr and 16.3pph for CO, and 1.0 g/bhp-hr for VOC.

Granger Electric of Brent Run, LLC is operating in compliance with the state and federal emission limits

4.2 Variations from Normal Sampling Procedures or Operating Conditions

The compliance tests for all pollutants were performed in accordance with the Test Protocol dated November 12, 2013, and the specified USEPA test methods.

Instrument calibrations and sampling period results satisfied the quality assurance verifications required by USEPA Methods 3A, 7E, 10, and ALT 096. No variations from the normal operating conditions of the IC engines occurred during the testing program.

4.3 Operating Conditions during Compliance Tests

The LFG-fueled IC engines were operated at base load (100% capacity +/- 10%) conditions during the compliance testing. The average electricity generator output and fuel use values were recorded by the facility during each test event. Based on data provided by the facility operators, EUENGINE3 operated at an average electricity generation rate of 1,535 kW during the test periods.

4.4 Air Pollutant Sampling Results

The IC engines performance tests were performed on January 13, 2014. The exhaust for the LFG-fueled IC engine (EUENGINE3) was monitored for three (3) one-hour test periods during which the NO_X, CO, VOC, O_2, and CO_2 concentrations were measured using instrumental analyzers. The measured pollutant concentrations were drift and bias corrected pursuant to equations in specified in the USEPA reference test methods.

Exhaust gas moisture content was determined by gravimetric analysis of the weight gain in chilled impingers in accordance with USEPA Method 4. Velocity and volumetric flow rates were measured during pre-test and post-test times for the gaseous samples. NO_X, CO and VOC mass emission rates were calculated from the pre-test and post-test flowrate averages for each 60-minute sampling period.

The average measured exhaust gas volumetric flow rate for EUENGINE3 was 4,427 dry standard cubic feet per minute (dscfm). The average measured exhaust gas NO_X and CO concentrations were 101.5 parts per million by volume, dry basis (ppmvd) and 712.1 ppmvd, respectively. Based on the measured exhaust gas flowrate, these concentrations correspond to a mass emission rate of 3.22 pounds per hour (lb/hr) NO_x, which is equivalent to 0.68 g/bhp-hr NO_x, and 13.76 lb/hr CO, which is equivalent to 2.90 g/bhp-hr CO.

Exhaust gas VOC concentrations, measured as NMHC, were determined to be 20.1 ppmv (as propane). The measured exhaust gas flowrate for EUENGINE3 was 4,970 scfm, which resulted in calculated VOC emission factor of 0.15 g/bhp-hr.

Table 1 presents measured gas conditions and calculated pollutant emission rates and emission factors for the tested LFG-fueled IC engines.

Appendix C provides computer calculated and field data sheets for the IC engine tests.

Appendix D provides raw instrumental analyzer response data for each test period.

5.0 SAMPLING AND ANALYTICAL PROCEDURES

A test protocol for the compliance testing was prepared by Derenzo and Associates and reviewed by the MDEQ-AQD. This section provides a summary of the sampling and analytical procedures that were used during the test and presented in the test plan.

Appendix E presents sample procedures and diagrams for the USEPA Methods sampling methods.

5.1 Exhaust Gas Velocity and Flowrate Determination (USEPA Method 2)

IC engine exhaust stack gas velocity was determined using USEPA Method 2 prior to and following each 60-minute sampling period. An S-type Pitot tube connected to a red-oil manometer was used to determine velocity pressure. Gas temperature was measured using a K-type thermocouple mounted to the Pitot tube. The Pitot tube and connective tubing were leak-checked to verify the integrity of the measurement system.

The absence of cyclonic flow for each sampling location was verified using an S-type Pitot tube and oil manometer. The Pitot tube was positioned at all of the velocity traverse points with the planes of the face openings of the Pitot tube perpendicular to the stack cross-sectional plane. The Pitot tube was then rotated to determine the null angle (rotational angle as measured from the perpendicular, or reference, position at which the differential pressure is equal to zero).

The calculated pre-test and post-test volumetric flowrate values were averaged and used for calculating the mass emission rate for each pollutant for that test period.

5.2 Exhaust Gas Molecular Weight Determination (USEPA Method 3A)

CO_2 and O_2 content in the IC engine exhaust gas stream was measured continuously throughout each one-hour test period in accordance with USEPA Method 3A. The CO_2 content of the exhaust was monitored using a non-dispersive infrared (NDIR) gas analyzer. The O_2 content of the exhaust was monitored using a gas analyzer that utilizes a paramagnetic ion sensor.

During each one-hour sampling period, a continuous sample of the IC engine exhaust gas stream was extracted from the stack using a stainless steel probe connected to a Teflon® heated sample line. The sampled gas was conditioned by removing moisture prior to being introduced to the analyzer. Therefore, measurement of O_2 and CO_2 concentrations correspond to standard dry gas conditions. The instrument was calibrated using appropriate calibration gases to determine accuracy and system bias (described in Section 6.4 of this document).

Figure 3 presents the instrument analyzer train.

Appendix E presents detailed gas sampling procedures for the USEPA sampling trains.

5.3 Exhaust Gas Moisture Content Determinations (Method 4)

Moisture content of the IC engine exhaust gas was determined in accordance with USEPA Method 4 using a chilled impinger sampling train, which was performed concurrently with the instrumental analyzer sampling methodologies. A non-heated probe was used for the moisture determinations as the engine exhaust temperature exceeded 800 °F. During each sampling period, a gas sample was extracted at a predetermined rate from the source where moisture was removed from the sampled gas stream using impingers that were submersed in an ice bath. At the conclusion of each sampling period, the moisture gain in the impingers was determined gravimetrically by weighing each impinger to determine net weight gain.

Figure 3 presents the moisture sampling train schematic. Appendix E presents detailed gas sampling procedures for the USEPA sampling trains.

5.4 NO_X and CO Concentration Measurements (USEPA Method 7E and 10)

NO_X and CO pollutant concentrations in the exhaust of the IC engine were determined using a chemiluminescence NO_X analyzer and NDIR CO analyzer.

Throughout each one-hour test period, a continuous sample of the engine exhaust gas was extracted from the stack using the Teflon® heated sample line and gas conditioning system, and delivered to the instrumental analyzers. Instrument response for each analyzer was recorded on a data logging system that monitored the analog output of the instrumental analyzers continuously and logged data as one-minute averages. Prior to, and at the conclusion of each test, the instruments were calibrated using appropriate upscale calibration and zero gas to determine analyzer calibration error and system bias. Sampling times were recorded on field data sheets.

Figure 3 presents the instrument analyzer train.

Appendix E presents detailed gas sampling procedures for the USEPA sampling trains.

5.5 VOC Concentration Measurements (USEPA Method ALT 096)

The exhaust gas VOC concentration was measured using a Flame Ionization Analyzer (FIA) in accordance with USEPA Alt 096 for direct measurement of VOC (non-methane organic compounds) concentrations. The TEI Model 55I methane, non-methane hydrocarbon analyzer has been approved by the USEPA for the measurement of IC engine exhaust gas VOC concentration when demonstrating compliance with NSPS Subpart JJJJ.

Samples of the exhaust gas were delivered to the instrument analyzer using an extractive gas sampling system that prevents condensation or contamination of the sample. The exhaust gas samples were delivered directly to the instrument analyzer. Therefore, VOC measurements correspond to standard conditions with no moisture correction (wet basis).

The specified instrument analyzer was calibrated using certified propane concentrations in hydrocarbon-free air.

Figure 3 presents the instrument analyzer train. Appendix E presents detailed gas sampling procedures for the USEPA sampling trains.

Appendix C presents the computer calculated and field data from the testing program.

6.0 INTERNAL QA/QC ACTIVITIES

6.1 NO_X Converter Efficiency Test

The NO_2 – NO conversion efficiency of the TEI Model 42C instrumental analyzer was verified prior to the commencement of the performance tests. The instrument analyzer NO_2 – NO converter uses a catalyst at high temperatures to convert the NO_2 to NO for measurement. A USEPA Protocol 1 certified NO_2 calibration gas was used to verify the efficiency of the NO_2 – NO converter.

The NO_2 – NO conversion efficiency test satisfied the USEPA Method 7E criteria (the calculated NO_2 – NO conversion efficiency is greater than or equal to 90%).

6.2 Sampling System Response Time Determination

The response time of the sampling system was determined prior to the compliance test program by introducing upscale gas and zero gas, in series, into the sampling system using a tee connection at the base of the sample probe. The elapsed time for the analyzer to display a reading of 95% of the expected concentration was determined using a stopwatch.

Sampling periods did not commence until the sampling probe had been in place for at least twice the system response time.

6.3 Instrumental Analyzer Interference Check

The instrumental analyzers used to measure NO_X, CO, O_2 and CO_2 have had an interference response test performed prior to their use in the field, pursuant to the interference response test procedures specified in USEPA Method 7E. The appropriate interference test gases (i.e. gases that would be encountered in the exhaust gas stream) were introduced into each analyzer, separately and as a mixture with the analyte that each analyzer is designed to measure. All of analyzers exhibited a composite deviation of less than 3.0% of the span for all measured interferent gases. No major analytical components of the analyzers have been replaced since performing the original interference tests.

6.4 Instrument Calibration and System Bias Checks

At the beginning of the test day, initial three-point instrument calibrations were performed by injecting calibration gas directly into the inlet sample port for each instrument. System bias checks were preformed prior to and at the conclusion of each sampling period by introducing the appropriate upscale calibration gas and zero gas into the sampling system (at the base of the stainless steel sampling probe prior to the particulate filter and Teflon® heated sample line) and verifying the instrument response against the initial instrument calibration readings. If the drift error is within 3% of the span over the period of the test run, the test run is considered acceptable.

The instruments were calibrated with USEPA Protocol 1 certified concentrations of CO_2, O_2, NO_X, CO, propane, and zeroed using pure nitrogen or hydrocarbon free air.

6.5 Gas Divider Certification

A STEC Model SGD-710C 10-step gas divider was used to obtain appropriate calibration span gases. The ten-step STEC gas divider was NIST certified (on July 11, 2013) with a primary flow standard in accordance with Method 205. When cut with an appropriate zero gas, the ten-step STEC gas divider delivers calibration gas values ranging from 0% to 100% (in 10% step increments) of the USEPA Protocol 1 calibration gas introduced into the system. The field evaluation procedures presented in Section 3.2 of Method 205 were followed prior to use of gas divider.

6.6 Meter Box Calibrations

The dry gas meter sampling console used for moisture testing was calibrated prior to and after the testing program. This calibration uses the critical orifice calibration technique presented in USEPA Method 5. The metering console calibration exhibited no data outside the acceptable ranges presented in USEPA Method 5.

Appendix F presents test equipment quality assurance data (meter box calibration records, pitot tube certification, NO_2 – NO conversion efficiency test data, instrument calibration and system bias check records, calibration gas certifications, interference test results, gas divider certifications,).

Report Prepared By:

for: Jason Logan
Environmental Consultant

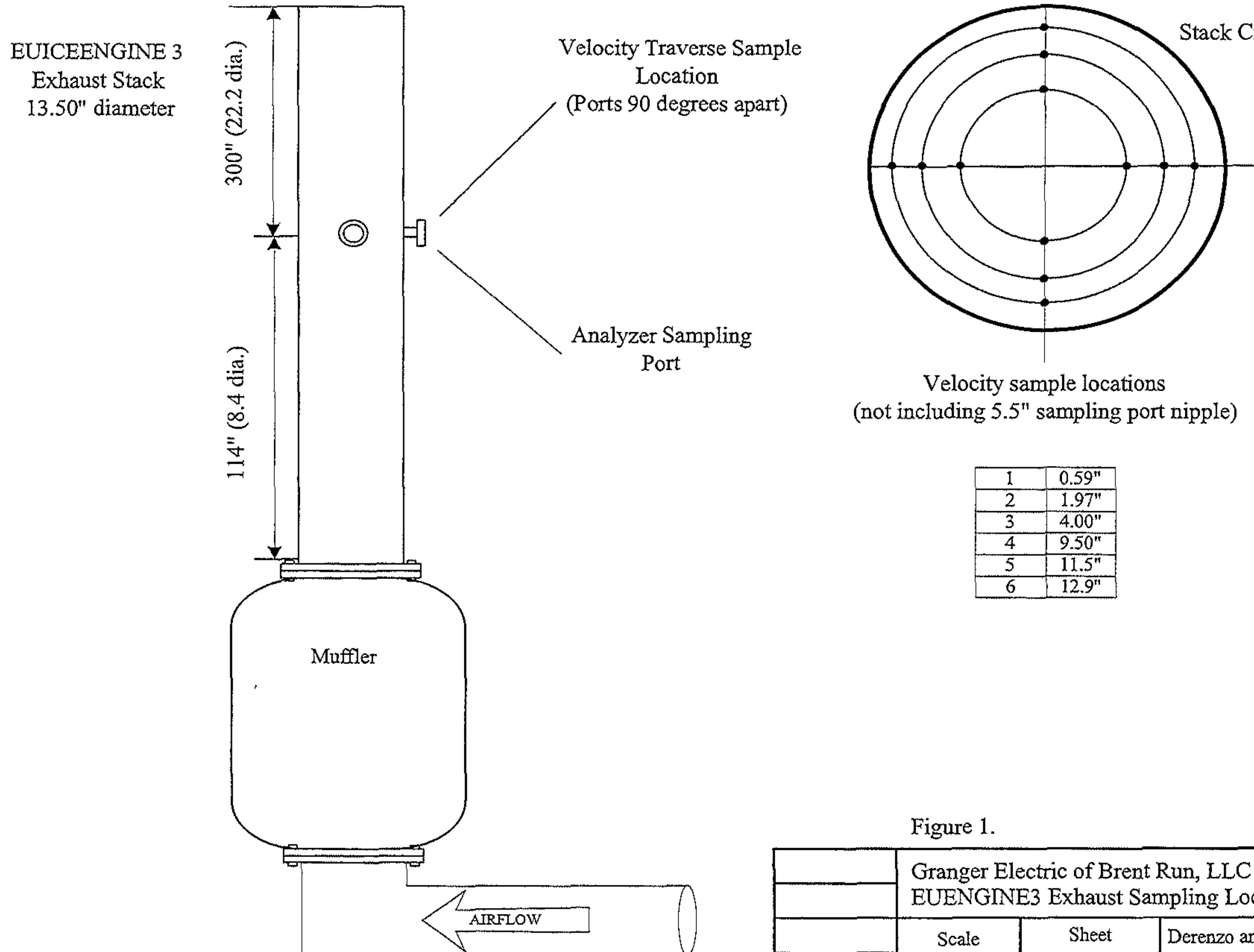
Report Reviewed By:

Michael J. Brack
Field Services Manager

Table 1. Summary of CAT G3520C Engine #3 (EUENGINE3) Test Results
Granger Electric-Genesee, Montrose, Michigan

Test No. Test date Test period (24-hr clock)	1 01/13/14 10:15-11:15	2 01/13/14 11:50-12:50	3 01/13/14 13:20-14:20	Three Test Averages
Generator Output (kW)	1,543	1,525	1,536	1,535
Engine Horsepower (Hp)	2,162	2,138	2,152	2,151
Exhaust gas composition				
CO_2 content (% vol)	11.02	10.94	10.93	10.97
O_2 content (% vol)	8.80	8.87	8.89	8.85
Moisture (% vol)	10.6	11.0	11.1	10.9
Exhaust gas flowrate				
Standard conditions (scfm)	4,992	4,953	4,964	4,970
Dry basis (dscfm)	4,465	4,406	4,411	4,427
Nitrogen oxides emission rates				
NO_X concentration (ppmvd)*	100.2	101.2	103.0	101.5
NO_X emissions (lb/hr NO_2)	3.21	3.20	3.26	3.22
NO_X permit limit (lb/hr)				*4.94*
NO_X emissions (g/bhp-hr)	0.67	0.68	0.69	0.68
NO_X permit limit (g/bhp-hr)				*1.00*
Carbon monoxide emission rates				
CO concentration (ppmvd)*	713.3	709.1	714.0	712.1
CO emissions (lb/hr)	13.90	13.63	13.74	13.76
CO permit limit (lb/hr)				*16.30*
CO emissions (g/bhp-hr)	2.92	2.89	2.90	2.90
CO permit limit (g/bhp-hr)				*3.30*
VOC/NMHC emission rates				
VOC concentration (ppmv C_3)*	20.6	19.9	19.6	20.1
VOC emissions (g/bhp-hr)	0.15	0.15	0.14	0.15
VOC permit limit (g/bhp-hr)				*1.00*

* Corrected for calibration bias.



1	0.59"
2	1.97"
3	4.00"
4	9.50"
5	11.5"
6	12.9"

Figure 1.

Granger Electric of Brent Run, LLC EUENGINE3 Exhaust Sampling Locations		
Scale None	Sheet 1 of 1	Derenzo and Associates Project No. 1310005

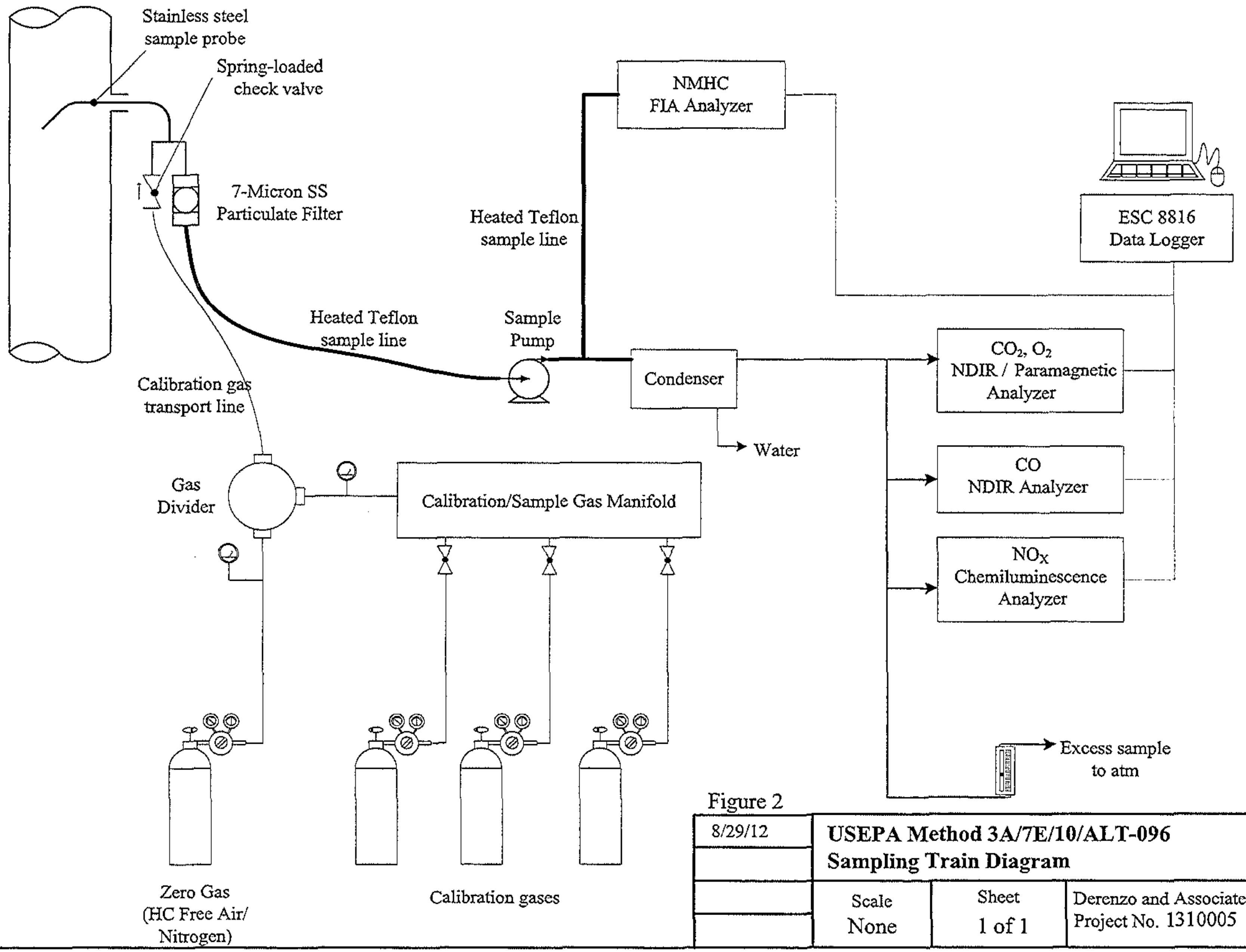


Figure 2

8/29/12	**USEPA Method 3A/7E/10/ALT-096 Sampling Train Diagram**		
	Scale None	Sheet 1 of 1	Derenzo and Associates Project No. 1310005

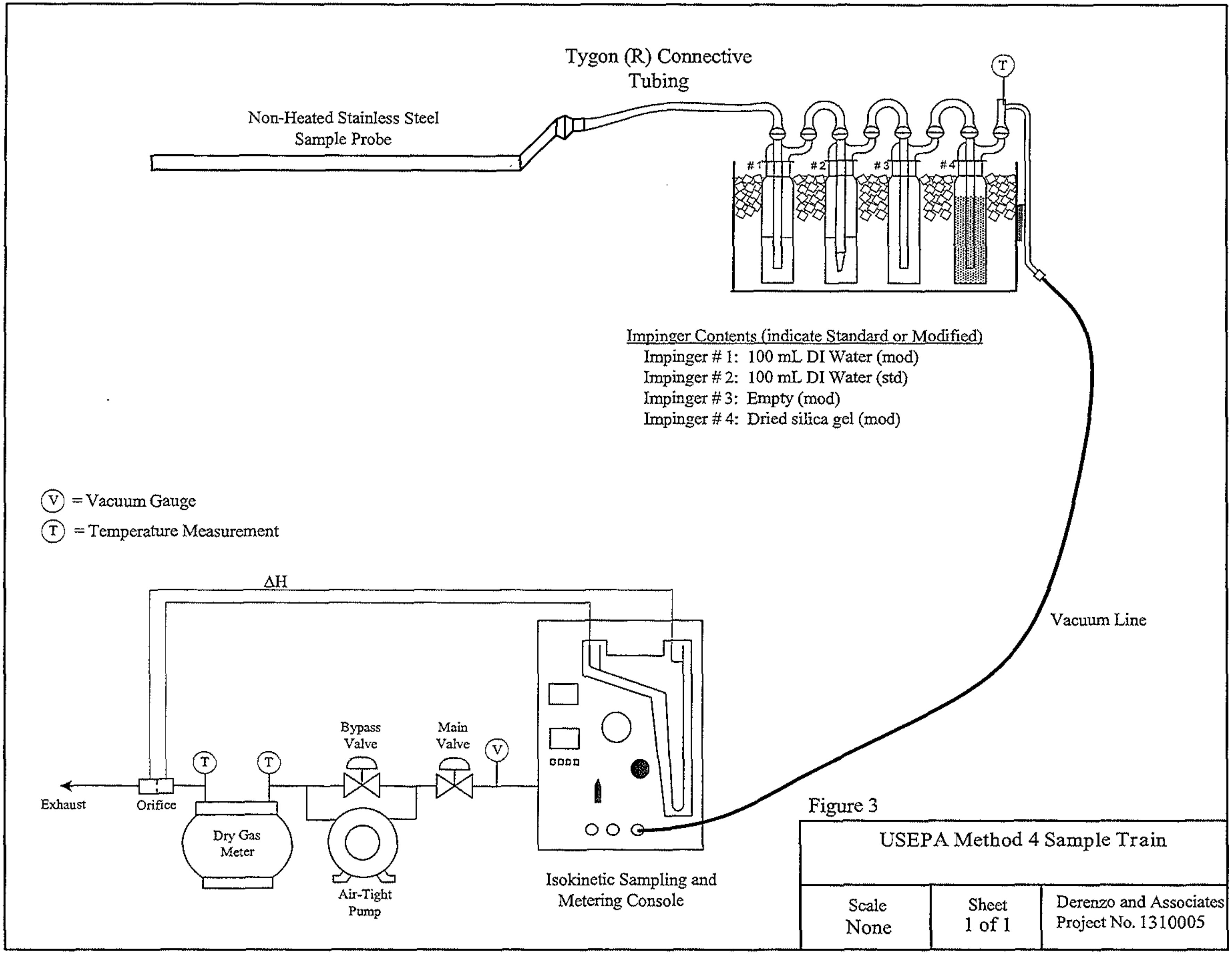


Figure 3

USEPA Method 4 Sample Train