Consumers Energy

Count on Us

Compliance Test Report

EUENGINE31, EUENGINE32, EUENGINE33, EUENGINE34 & EUENGINE35

Ray Compressor Station
69333 Omo Road
Armada, Michigan 48005

State Registration Number (SRN) B6636

Test Dates: July 12 - 14, 2016

Report Submitted:
September 6, 2016

Report Revision 0

Test Performed by the Consumers Energy Company
Regulatory Compliance Testing Section
Laboratory Services Department

1.0 INTRODUCTION

Identification, location and dates of tests

Consumers Energy Company's (CEC) Regulatory Compliance Testing Section (RCTS) performed air emission testing on five (5) 4-stroke lean burn (4SLB) natural gas-fired, reciprocating internal combustion engines (RICE) identified as EUENGINE31, EUENGINE32, EUENGINE33, EUENGINE34, EUENGINE35 installed and operating at CEC's Ray Compressor Station in Armada, Michigan on July 12 - 14, 2016. A Test Protocol dated May 5, 2016 was submitted and subsequently approved by the Michigan Department of Environmental Quality (MDEQ) in their letter dated June 10, 2016, as found in Attachment 8 of this report.

Please note this document follows the MDEQ format described in the December, 2013, *Format for Submittal of Source Emission Test Plans and Reports* and reproducing only a portion may omit critical substantiating documentation or cause information to be taken out of context. If any portion of this report is reproduced, please exercise due care in this regard.

Purpose of testing

This test event was performed to evaluate compliance with (a) the RICE National Emission Standards for Hazardous Air Pollutants (NESHAP) in 40 CFR Part 63, Subpart ZZZZ, and (b) the Standards of Performance for Stationary Spark Ignition (SI) Internal Combustion Engines (ICE) in 40 CFR Part 60, Subpart JJJJ, as outlined in the facility Renewable Operating Permit (ROP) No. MI-ROP-B6636-2015a. A summary of specific test parameters is shown in Table 1:

TABLE 1

Summary of Test Parameters

Test Parameter	Measurement Unit	Test Location(s)	Regulation
Carbon Monoxide (CO) Efficiency	ppmvd (part per million by volume, dry basis), corrected to 15% Oxygen (O_2)	Pre and Post Oxidation Catalyst	40 CFR Part 63 Subpart ZZZZ
Nitrogen Oxides (NO_x), CO[1] & Volatile Organic Compounds (VOCs), as Non-Methane Organic Compound (NMOC)	grams per horsepower hour (g/HP-hr)	Post Oxidation Catalyst (Engine Exhaust)	40 CFR Part 60 Subpart JJJJ
VOCs, as Non-Methane, Non-Ethane Organic Compound (NMNEOC)	grams per horsepower hour (g/HP-hr)	Post Oxidation Catalyst (Engine Exhaust)	ROP 40 CFR 52.21(j)

[1] Please note that 40 CFR Part 60, Subpart JJJJ, Table 1, footnote (b), indicates RICE units (such as the Ray Compressor RICE in this report) which successfully meet the CO requirements of 40 CFR Part 63, Subpart ZZZZ, are not subject to the 40 CFR Part 60, Subpart JJJJ CO standards. However, to facilitate report formatting the measured RICE CO parameters in this report shall be presented hereafter in conjunction with Subpart JJJJ NO_x and VOC as NMOC parameters.

2.0 SUMMARY OF RESULTS

The 40 CFR Part 63, Subpart ZZZZ results are provided in Table 2 below.

TABLE 2

Summary of 40 CFR 63 Subpart ZZZZ Emission Results

Test Parameter	EUENGINE 31	EUENGINE 32	EUENGINE 33	EUENGINE 34	EUENGINE 35	ZZZZ Limit (%)
CO Efficiency (%)	99.1	99.05	99.16	98.64	99.08	≥93

The preceding dry basis CO concentrations, measured before and after the oxidation catalysts and corrected to 15% O_2, indicate each engine easily complies with the minimum 93 percent CO efficiency requirement in 40 CFR Part 63, Subpart ZZZZ.

The 40 CFR Part 60, Subpart JJJJ and ROP emission results are provided in Table 3 below.

TABLE 3

Summary of 40 CFR 60 Subpart JJJJ and ROP Emission Results

Test Parameter	EUENGINE 31	EUENGINE 32	EUENGINE 33	EUENGINE 34	EUENGINE 35	ROP/JJJJ Limit g/HP-hr
NOx, g/HP-hr	0.424	0.353	0.358	0.494	0.385	0.5/2.0
CO, g/HP-hr	0.008	0.009	0.008	0.012	0.008	0.2/4.0
VOC, (as NMNEOC), g/HP-hr	0.036	0.035	0.029	0.041	0.031	0.19 (ROP)
VOC, (as NMOC), g/HP-hr	0.362	0.498	0.541	0.457	0.469	1.0 (JJJJ)

The preceding table of emission rate results indicate each engine is in compliance with the Subpart JJJJ NO_x, CO and VOC (as NMOC) g/HP-hr emission limits, as well as the facility-specific ROP VOC (as NMNEOC) emission limit.

Brief description of source

The Ray Compressor Station operates Caterpillar Model 3616 4SLB engines for the purpose of maintaining natural gas pipeline system and storage reservoir pressure. Each engine is fired with pipeline quality natural gas exclusively and equipped with modular oxidation catalysts designed to reduce CO and VOC emissions.

Names, addresses, and telephone numbers of the contacts for information regarding the test and the test report, and names and affiliation of all personnel involved in conducting the testing

The July 12 – 14, 2016 RICE test program was conducted by CEC RCTS employees Joe Mason, Brian Miska and Cody Bayn. Mr. Charles Kelly, CEC Gas O&M Field Leader, coordinated the test along with CEC Corporate Environmental Senior Engineer Ms. Amy Kapuga, whom also collected RICE operating data. MDEQ representatives Mr. Thomas Maza and Mr. Robert Elmouchi were onsite to witness portions of the testing. Table 4 contains test program participant contact information.

TABLE 4

Ray Compressor Station RICE Test Program Participants

Responsible Party	Address	Contact
Test Facility	Ray Compressor Station 69333 Omo Road Armada, Michigan 48005	Mr. Charles Kelly 586-784-2096 charles.kelly@cmsenergy.com
Corporate Air Quality Contact	Consumers Energy Company Environmental Services Department 1945 West Parnall Road Jackson, Michigan 49201	Ms. Amy Kapuga 517-788-2201 amy.kapuga@cmsenergy.com
Test Representative	Consumers Energy Company Regulatory Compliance Testing Section 17010 Croswell Street West Olive, Michigan 49460	Mr. Joe Mason, QSTI 616-738-3385 joe.mason@cmsenergy.com
State Representative	Michigan Department of Environmental Quality Technical Programs Unit 525 W. Allegan, Constitution Hall Lansing, Michigan 48909	Mr. Thomas Maza MDEQ-AQD Detroit Field Office 313-456-4709 mazat@michigan.gov
State Representative	Michigan Department of Environmental Quality Southeast Michigan District 27700 Donald Court Lansing, Michigan 48909	Mr. Robert Elmouchi 586-753-3731 elmouchir@michigan.gov

Operating Data

RICE operating data collected throughout each run included catalyst inlet temperature, catalyst pressure drop, engine load, ambient temperature, barometric pressure, fuel flow rate, suction pressure, discharge pressure and horsepower. Engine horsepower was used to verify engine load during the performance test, as Subpart ZZZZ § 63.6620 (b) states *the test must be conducted at any load condition within plus or minus 10 percent of 100 percent load.*

Applicable Permit Number

Ray Compressor Station operates pursuant to the terms and conditions of ROP No. MI-ROP-B6636-2015a.

3.0 SOURCE DESCRIPTION

Description of Process

The Ray Compressor Station is a natural gas compressor station. The purpose of the facility is to maintain pressure of natural gas in order to move it in and out of storage reservoirs and along the pipeline system. The five RICE driven compressor units associated with this test program were installed in 2013 to maintain station reliability, working in conjunction with other RICE and turbines at the facility.

NO_x emissions from each engine are minimized through the use of lean-burn combustion technology. Lean-burn combustion refers to a high level of excess air (generally 50% to 100% relative to the stoichiometric amount) in the combustion chamber. The excess air absorbs heat during the combustion process, thereby reducing the combustion temperature and pressure and resulting in lower NO_x emissions.

CO and VOC emissions from each engine are controlled by modular oxidation catalysts manufactured from proprietary materials which effectively reduce CO and volatile organic compound oxidation temperatures to that produced from RICE engine exhaust ducts. The catalyst vendor guarantees a CO reduction efficiency of 93% and estimates formaldehyde and non-methane, non-ethane hydrocarbon (NMNEHC) efficiencies of 85% and 75%, respectively.

During previous Subpart ZZZZ carbon monoxide (CO) reduction efficiency test events at Ray Compressor, one pre-catalyst/engine exhaust (Inlet) location and one post-test catalyst/stack exhaust (Outlet) location was measured to determine the percent CO reduction. However, with the installation of sound deadening equipment within the exhaust silencer, the single inlet location no longer qualified as a representative sample site. Two inlet measurement locations (upstream of the former location) are now installed, in conjunction with the single outlet measurement location for CO.

Process Flow Sheet or Diagram

NA

Type and Quantity of Raw Material Processed During the Tests

NA

Maximum and Normal Rated Capacity of the Process

Each Caterpillar Model 3616 4SLB RICE engine at Ray Compressor Station has a rated heat input of 32 million British thermal unit (mmBtu) per hour and a rated output of 4,735 horsepower. Table 5 contains pertinent vendor provided engine specifications.

TABLE 5
Summary of RICE Specifications [1], EUENGINE31 - EUENGINE35

Make	Caterpillar
Model	G3616
Output (brake-horsepower)	4,735
Heat Input, LHV (mmBtu/hour)	32.0
Exhaust Gas Temp. (°F)	856

[1] Vendor supplied engine specifications are based upon 100% of rated engine capacity.

Description of Process Instrumentation Monitored During the Test

RICE operating data collected throughout each run included catalyst inlet temperature, pressure drop across catalyst, engine load, ambient temperature, barometric pressure, fuel flow rate, suction pressure, discharge pressure and horsepower. Engine horsepower was used to verify engine load during the performance test, as Subpart ZZZZ § 63.6620 (b) states *the test must be conducted at any load condition within plus or minus 10 percent of 100 percent load.*

4.0 SAMPLING AND ANALYTICAL PROCEDURES

Description of sampling train(s) and field procedures

Triplicate one-hour runs were conducted at the engine oxidation catalyst inlet for CO, O_2 and CO_2 simultaneously with measurements of NO_x, CO, VOC, O_2 and CO_2 at the engine (oxidation catalyst) exhaust. CO efficiency calculations were determined using specifications in 40 CFR Part 63, Subpart ZZZZ §63.6620 Equation 1 and Table 4, and NO_x, CO and VOC emission rates were based on Equations 1-3 and Table 2 in 40 CFR Part 60, Subpart JJJJ §60.4244.

There were no deviations in the testing, sampling, analytical, and calibration procedures outlined in the May 5, 2016 facility test protocol; however on June 13, 2016, MDEQ representative Thomas Maza and CEC discussed RCTS' CO sampling approach at the two newly installed catalyst inlet sample locations during a phone call. In the call, CEC proposed and received MDEQ approval to use one CO analyzer to measure both inlet locations simultaneously vs. using two separate analyzers, since both inlet locations were likely to have the same approximate CO concentrations. Therefore, CO samples from each engine exhaust/catalyst inlet were drawn simultaneously at the same rate into one gas sample conditioner, where the gases were blended, conditioned and delivered to a single, calibrated CO analyzer. The analyzer was calibrated following the ACE guidelines of U.S. EPA Method 7E, *Determination of Nitrogen Oxides from Stationary Sources (Instrumental Analyzer Procedure).* Subsequent pre and post-test sample system bias checks were performed by introducing low and upscale calibration gases at each inlet probe outlet simultaneously, emulating the manner in which the gas sample was collected, with sample system response times documented to ensure each sample rate was within 10% of its associated paired inlet.

Please note that O_2 diluent gas was used to correct CO concentrations to 15% O_2 when determining percent CO reduction. CO_2 was measured as well since Subpart ZZZZ allows for CO_2 correction factors based on O_2 to CO_2 fuel factor ratios described in §63.6620 (e)(2)(ii)(Eq.3). In the event O_2 diluent measurements were not possible, CO concentrations could be corrected to 15% O_2 based on dry basis CO_2 concentrations as described in Equation 4, § 63.6620 (e)(2)(iii), utilizing CO_2 correction factors derived from F_c and F_d fuel factors obtained from natural gas fuel sample analyses.

All components of the CO_2, O_2, NO_x, CO and VOC extractive sample systems in contact with flue gas were constructed of Type 316 stainless steel and/or Teflon. The CO_2, O_2, NO_x, and CO analyzers were calibrated with U.S. EPA Protocol calibration gases at a minimum of three points: low (0-20% of calibration span), mid-level (40-60% of calibration span) and high-level gas (equal to the calibration span) following specifications in U.S. EPA Method 7E. The field VOC instrument was calibrated with zero air and three propane and methane in air gases following U.S. EPA Method 25A specifications at the zero level, low (25 to 35 percent of calibration span), mid (45 to 55 percent of calibration span) and high (equivalent to instrument span). The output signal from each analyzer was connected to a computerized data acquisition system (DAS) and each instrument was operated to insure zero drift, calibration gas drift, bias and calibration error met the applicable method requirements. The *Methods 3A, 7E, 10 & 25A Sampling Apparatus Schematic* is shown in Figure 1.

The CO_2, O_2, NO_x and CO engine exhaust gases were conveyed via a heated sample line to an electronic gas sample conditioner to remove moisture and any particulate matter from the gas prior to analyzer injection. The VOC instrument measures concentrations on a wet basis as ppmv, so a separate heated sample line was used to convey the wet sample to the VOC instrument.

After correcting the post-test analyzer data for drift and bias, the average catalyst inlet and outlet dry basis CO concentrations were corrected to 15 percent O_2 and the percent CO efficiency was calculated. The NO_x and VOC emission rates were also calculated on a g/HP-hr, dry basis. Please note that since the field VOC instrument measures on a wet basis, exhaust gas moisture content was measured in conjunction with each VOC run for converting wet VOC concentrations to a dry basis until moisture content results determined from daily natural gas fuel samples collected as required by 40 CFR Part 60 Subpart JJJJ were applied to the final VOC concentrations and emission rates. CO_2 and O_2, concentrations were measured as percent by volume, dry basis.

4.1 Traverse Points

The EUENGINE31 through 35 catalyst inlet traverse points were determined based on U.S. EPA Method 1 *Sample and Velocity Traverses for Stationary Sources* criteria. During run 1 at each engine, gas concentrations were obtained from twelve traverse points. After determining the ducts were minimally stratified, three traverse points were used for each run thereafter. Three traverse points located based on Method 7E, § 8.1.2 specifications were traversed at the engine exhaust/stack outlet. Figure 2 of this report illustrates the path of engine effluent as it enters and exits the oxidation catalyst.

4.2 Diluent/Molecular Weight

CO_2 and O_2 concentrations were measured at the catalyst inlet and outlet using a non-dispersive infrared (NDIR) analyzer equipped with paramagnetic O_2 analysis capacity, following the guidelines of U.S. EPA Method 3A, *Determination of Oxygen and Carbon Dioxide Concentrations in Emissions from a Stationary Source (Instrumental Analyzer Procedure).*

4.3 Moisture Content

The catalyst exhaust gas moisture content was measured in the field using U.S. EPA Alternate Method 008, *Alternative Moisture Measurement Method Midget Impingers* in conjunction with each Subpart JJJJ test. Effluent gas was drawn through a series of four impingers; the first two of which contained water, the third was empty and the fourth contained indicating silica gel. The impingers were immersed in an ice bath during each test to achieve efficient moisture condensation, and collected water vapor was determined gravimetrically for calculating percent moisture. Alternate Method 008 was used as a surrogate moisture value in the field until moisture content results determined from daily natural gas fuel samples collected as required by 40 CFR Part 60 Subpart JJJJ were received, whereupon the alternate fuel factor (F-Factor) approach in 40 CFR Part 60, Appendix A Method 4, *Determination of Moisture Content in Stack Gases*, § 16.4 was used to calculate moisture content by summing the moisture mole fraction of the ambient air, the free water in the fuel fired, and the hydrogen in the fuel. The natural gas fuel sample analyses are contained in Attachment 6 of this report.

4.4 Nitrogen Oxides

NO_x concentrations were measured at the engine exhaust using a chemiluminescent analyzer following the guidelines of U.S. EPA Method 7E, *Determination of Nitrogen Oxides from Stationary Sources (Instrumental Analyzer Procedure).*

4.5 Carbon Monoxide

CO concentrations were measured at the catalyst inlet and outlet using a gas filter correlation (GFC) analyzer following the guidelines of U.S. EPA Reference Method 10, *Determination of Carbon Monoxide Emissions from Stationary Sources (Instrumental Analyzer Procedure).*

4.6 Volatile Organic Compounds as NMOC

VOC as NMOC concentrations were monitored at each engine exhaust using a Thermo Model 55i Direct Methane and Non-methane Analyzer following the guidelines of U.S. EPA Method 25A, *Determination of Total Gaseous Organic Concentration Using a Flame Ionization Analyzer (FIA)*. The flame ionization detector (FID) analytical principal is employed to determine the total hydrocarbon concentration and a gas chromatographic column is used to separate methane from other organic compounds.

Sample gas is injected into the column. Due to methane's low molecular weight and high volatility, the compound moves through the column more quickly than other existing organic compounds and exits the column to be analyzed in the FID. The column is then flushed with inert carrier gas and the remaining non-methane organic compounds are analyzed in the FID. This analytical technique allows separate measurements for methane and non-methane organic compounds via the use of a single FID.

4.7 VOC as NMNEOC

VOC as NMNEOC concentrations were determined by an outside contracted laboratory using U.S. EPA Method 18, *Measurement of Gaseous Organic Compound Emission By Gas Chromatography*. Triplicate bags manufactured from polyvinyl fluoride (PVF) film, also known as Tedlar film, were collected in the field directly from each engine exhaust.

Method 18 was then used to measure the gaseous organic mixture in each bag by separating the major organic components using a gas chromatograph (GC) and measuring them with a suitable detector. To identify and quantify the major components, the retention times of each separated component were compared with those of known compounds under identical conditions. The approximate concentrations of the organic emission components were identified beforehand and standard mixtures prepared so the GC was calibrated under physical conditions identical to those used for the samples. Method 18 also requires the sample results to be corrected based on results obtained from a spike recovery study. For the bag sampling technique to be considered valid for a compound, the recovery must be between 70% <R < 130%. The recovery study performed on the Ray Compressor engine Tedlar bag samples successfully achieved the R value requirement and that value was applied to the reported methane, ethane and VOC as propane concentrations as shown in Attachment 5 of this report.

Sampling and Analytical Quality Assurance Procedures

Each U.S. EPA reference method performed during this test contains specific language stating that to obtain reliable results, persons using these methods should have a thorough knowledge of the techniques associated with each method. To that end, CEC RCTS attempts to minimize any factors which could cause sampling errors by implementing a quality assurance (QA) program into every component of field testing, including the following information.

U.S. EPA Protocol gas standards certified according to the U.S. EPA Traceability Protocol for Assay & Certification of Gaseous Calibration Standards; Procedure G-1; September, 1997 or May, 2012 version and certified to have a total relative uncertainty of ±1 percent were used to calibrate the analyzers during the test program. Although not required in the context of this Parts 60 and 63 test program, the vendors providing the calibration gases also participate in the Protocol Gas Verification Program (PGVP), an EPA audited program recently developed for 40 CFR Part 75.

The extractive sample system instruments were calibrated and operated following the appropriate method guidelines, based on specifications contained in Method 7E (as referenced in Methods 3A and 10). Before daily testing began, an analyzer calibration error (ACE) test was conducted by introducing the calibration gases directly into each analyzer. If the measured response was greater than ±2 percent of instrument span (or greater than 0.5 ppmv absolute difference), corrective action was taken followed by another ACE. Thereafter, an initial system bias check was conducted by injecting low and upscale calibration gases consecutively into the sampling system at the probe outlet which emulates the manner in which an exhaust gas sample is collected. The sample system response time to the calibration gas is documented and the sample system bias requirement of ≤ 5.0 percent of instrument span is verified. If the bias criteria are not met, additional corrective action is taken to do so. After completing these QA requirements, the first run began after waiting twice the system response time. After each run was completed, low and upscale bias calibrations were performed to again quantify sample system drift and bias before waiting twice the system response time to start the next run.

Description of recovery and analytical procedures
NA

Dimensioned sketch showing all sampling ports in relation to breeching and to upstream and downstream disturbances or obstructions of gas flow and a sketch of cross-sectional view of stack indicating traverse point locations and exact stack dimensions
Figures 2 and 3 show the Caterpillar Model G3616 engines (i.e., EUENGINE31, EUENGINE32, EUENGINE33, EUENGINE34 and EUENGINE35) exhaust stack configuration, including catalyst outlet and inlet test port locations.

5.0 TEST RESULTS AND DISCUSSION

Detailed tabulation of results, including process operating conditions and flue gas conditions

Except as noted, Tables within this report contain a summary of percent CO reduction and NO_x, CO and VOC emission rates from each RICE. RICE operating data, calculation spreadsheets, field data sheets, calibration information, fuel and NMNEOC analyses and the test protocol approval letter are contained in Attachments 1 - 8.

Discussion of significance of results relative to operating parameters and emission regulations

<u>40 CFR 63 Subpart ZZZZ</u>

The measured CO percent reduction at each engine met the 93 percent reduction efficiency requirement and is therefore considered compliant with 40 CFR 63, Subpart ZZZZ.

<u>40 CFR 60 Subpart JJJJ</u>

The NO_x, CO and VOC (as NMOC) emission rates are within the ROP and 40 CFR 60 Subpart JJJJ emission limits for each engine.

<u>40 CFR 52.21(j)</u>

The VOC (as NMNEOC) emission rates are within the ROP emission limits for each engine.

Discussion of any variations from normal sampling procedures or operating conditions, which could have affected the results

During the test program, the measured VOC (as NMOC) field concentrations and emissions using the Thermo Environmental Model 55I were greater than the facility ROP VOC (as NMNEOC) emission limit. Since the Thermo 55I provides only methane and non-methane channels, and the natural gas being used as fuel now contains a higher percentage of shale-source natural gas (with a higher concentration of ethane), CEC proposed and received MDEQ approval to collect and analyze separate independent exhaust gas samples for methane, ethane, and NMNEOC at an outside contracted laboratory. The analysis revealed a significant ethane contribution, which the Thermo 55I appears to have incorporated into the NMOC field measured value. Please note that triplicate engine exhaust Tedlar bag samples collected for VOC analysis were not required or requested by the MDEQ, but were collected in the event one or more of the samples became compromised in some way, effectively negating the results. For instance, the analysis performed on the first bag collected at the exhaust of EUENGINE35 appears to have been compromised prior to analysis, as the methane concentration is less than 10% of the other 14 methane concentrations. Therefore, the VOC as NMNEOC results for EUENGINE35 are reported as the average of two rather than three bags, which is consistent with MDEQ Representative Mr. Thomas Maza's request for reporting a triplicate NMNEOC sample average for each set of engine exhaust Tedlar bag samples collected.

Prior to the test program, CEC proposed and received MDEQ approval to use one CO analyzer to measure two inlet locations simultaneously vs. using two separate analyzers, since both inlet locations were likely to have about the same CO concentrations. Therefore, CO samples from each engine exhaust/catalyst inlet were drawn simultaneously at the same rate into one gas sample conditioner, where the gases were blended, conditioned and delivered to a single, calibrated CO analyzer.

While not required by Method 25A, the VOC as NMOC field data was adjusted for analyzer drift using U.S. EPA Method 7E, *Determination of Nitrogen Oxides from Stationary Sources (Instrumental Analyzer Procedure* specifications. This adjustment was not specifically requested by the MDEQ in their protocol approval letter response; however this presentation is consistent with previous MDEQ Method 25A data requests. For the purposes of this test program, RCTS did not quality assure the methane channel on the Thermo Model 55i analyzer.

Documentation of any process or control equipment upset condition which occurred during the testing
NA

Description of any major maintenance performed on the air pollution control device(s) during the three month period prior to testing
NA

In the event of a re-test, a description of any changes made to the process or air pollution control device(s)
NA

Results of any quality assurance audit sample analyses required by the reference method
NA

Calibration sheets for the dry gas meter, orifice meter, pitot tube, and any other equipment or analytical procedures which require calibration
Attachment 4 contains the analyzer calibration data, response time test results, NO_2 to NO converter efficiency check and calibration gas Certificates of Analysis.

Sample calculations of all the formulas used to calculate the results
Sample calculations for all formulas used in the test report are contained in Attachment 6.

Copies of all field data sheets, including any pre-testing, aborted tests, and/or repeat attempts

Please refer to Attachment 1 for process data collected during the test runs; Attachment 2 for calculation spreadsheets for each of the test runs; and Attachment 3 for data sheets with the measured concentrations for each test run.

Copies of all laboratory data including QA/QC

For this testing event, laboratory data includes the results of the natural gas fuel analyses which are presented in Attachment 6.

TABLE 6
RAY COMPRESSOR STATION
SUMMARY OF RICE EFFICIENCY AND EMISSIONS, EUENGINE31
July 12, 2016

Time Period	Run 1 0830-0930	Run 2 1007-1107	Run 3 1132-1232	Average
Engine Process Conditions				
Engine Speed, Revolutions Per Minute:	945.3	951.7	954.4	**950.5**
Brake Horsepower:	4515	4523	4522	**4520**
Load, Percent:	101	100	100	**100**
Fuel Flow, SCFM	524.37	528.03	527.71	**526.70**
Suction Pressure, PSIG	581.85	587.51	584.22	**584.53**
Discharge Pressure, PSIG	1275.79	1265.58	1264.77	**1268.71**
Catalyst Inlet Gas Conditions				
Drift Corrected Oxygen Concentration, Dry (Percent):	11.51	11.47	11.44	**11.45**
Drift Corrected CO Concentration, Dry (ppmvd):	329.80	343.38	340.54	**337.91**
Corrected CO Concentration (ppmvd @ 15% O2):	207.11	214.83	212.32	**211.42**
Catalyst Outlet Gas Conditions				
Drift Corrected Oxygen Concentration, Dry (percent):	11.50	11.21	11.21	**11.30**
Drift Corrected CO Concentration, Dry (ppmvd):	3.32	3.00	2.92	**3.08**
Corrected CO Concentration (ppmvd @ 15% O2):	2.09	1.83	1.78	**1.90**
CO Reduction Efficiency				
CO Reduction Efficiency (≥93%):	98.99	99.15	99.16	**99.10**
CO Emissions				
Emission Rate, g/bph-hr:	0.016	0.004	0.004	**0.008**
ROP Emission Limit, g/bhp-hr[1]:	0.2	0.2	0.2	**0.2**
NO_x Emissions				
Drift Corrected Nitrogen Oxides Concentration (ppmvd):	54.92	54.92	58.73	**56.19**
Emission Rate, g/bhp-hr:	0.4	0.4	0.4	**0.4**
ROP Emission Limit, g/bhp-hr:	0.5	0.5	0.5	**0.5**
VOC Emissions				
VOC (as NMNEOC) Concentration, Dry (ppmvd), Expressed as Propane:	5.01	5.01	5.00	**5.01**
VOC (as NMNEOC) Emission Rate, g/bhp-hr:	0.037	0.036	0.036	**0.036**
ROP Emission Limit, g/bhp-hr[1]:	0.19	0.19	0.19	**0.19**
VOC (as NMOC) Concentration, Dry (ppmvd), Expressed as Propane:	55.02	56.98	37.93	**49.98**
VOC (as NMOC) Emission Rate, g/bhp-hr:	0.41	0.41	0.27	**0.36**
Subpart JJJJ Emission Limit, g/bhp-hr[1]:	1.0	1.0	1.0	**1.0**

[1] The PTI CO, NO_x and VOC emission limits are more stringent than the applicable limits in 40 CFR Part 60, Subpart JJJJ, which are as follows: CO = 4.0 grams/HP-hr; NO_x = 2.0 grams/HP-hr; VOC = 1.0 grams/HP-hr

TABLE 7
RAY COMPRESSOR STATION
SUMMARY OF RICE EFFICIENCY AND EMISSIONS, EUENGINE32
July 13, 2016

Time Period	Run 1 0831-0931	Run 2 0950-1050	Run 3 1120-1220	Average
Engine Process Conditions				
Engine Speed, Revolutions Per Minute:	923.1	925.2	954.4	**934.3**
Brake Horsepower:	4522	4524	4522	**4522**
Load, Percent:	103	103	102	**103**
Fuel Flow, SCFM	532.06	533.03	527.71	**530.93**
Suction Pressure, PSIG	622.19	620.02	603.17	**615.13**
Discharge Pressure, PSIG	1271.89	1273.64	1283.99	**1276.51**
Catalyst Inlet Gas Conditions				
Drift Corrected Oxygen Concentration, Dry (Percent):	11.35	11.36	11.37	**11.36**
Drift Corrected CO Concentration, Dry (ppmvd):	376.54	376.15	374.62	**375.77**
Corrected CO Concentration (ppmvd @ 15% O2):	232.74	232.69	231.81	**232.41**
Catalyst Outlet Gas Conditions				
Drift Corrected Oxygen Concentration, Dry (percent):	11.44	11.30	11.31	**11.35**
Drift Corrected CO Concentration, Dry (ppmvd):	3.56	3.65	3.55	**3.59**
Corrected CO Concentration (ppmvd @ 15% O2):	2.22	2.24	2.18	**2.21**
CO Reduction Efficiency				
CO Reduction Efficiency (≥93%):	99.05	99.04	99.06	**99.05**
CO Emissions				
Emission Rate, g/bph-hr:	0.017	0.005	0.005	**0.009**
ROP Emission Limit, g/bhp-hr[1]:	0.2	0.2	0.2	**0.2**
NO_x Emissions				
Drift Corrected Nitrogen Oxides Concentration (ppmvd):	45.37	45.53	46.15	**45.68**
Emission Rate, g/bhp-hr:	0.4	0.4	0.4	**0.4**
ROP Emission Limit, g/bhp-hr:	0.5	0.5	0.5	**0.5**
VOC Emissions				
VOC (as NMNEOC) Concentration, Dry (ppmvd), Expressed as Propane:	4.80	4.79	4.77	**4.79**
VOC (as NMNEOC) Emission Rate, g/bhp-hr:	0.036	0.035	0.035	**0.035**
ROP Emission Limit, g/bhp-hr[1]:	0.19	0.19	0.19	**0.19**
VOC (as NMOC) Concentration, Dry (ppmvd), Expressed as Propane:	68.96	69.62	70.90	**69.83**
VOC (as NMOC) Emission Rate, g/bhp-hr:	0.46	0.52	0.52	**0.50**
Subpart JJJJ Emission Limit, g/bhp-hr[1]:	1.0	1.0	1.0	**1.0**

[1] The PTI CO, NO_x and VOC emission limits are more stringent than the applicable limits in 40 CFR Part 60, Subpart JJJJ, which are as follows: CO = 4.0 grams/HP-hr; NO_x = 2.0 grams/HP-hr; VOC = 1.0 grams/HP-hr

TABLE 8
RAY COMPRESSOR STATION
SUMMARY OF RICE EFFICIENCY AND EMISSIONS, EUENGINE33
July 14, 2016

Time Period	Run 1 0835-0935	Run 2 0957-1057	Run 3 1117-1217	Average
Engine Process Conditions				
Engine Speed, Revolutions Per Minute:	903.1	902.0	907.8	**902.3**
Brake Horsepower:	4389	4388	4379	**4386**
Load, Percent:	102	103	103	**103**
Fuel Flow, SCFM	511.14	511.63	512.20	**511.66**
Suction Pressure, PSIG	609.92	606.38	600.54	**605.13**
Discharge Pressure, PSIG	1274.03	1274.34	1274.02	**1274.13**
Catalyst Inlet Gas Conditions				
Drift Corrected Oxygen Concentration, Dry (Percent):	11.54	11.55	11.39	**11.47**
Drift Corrected CO Concentration, Dry (ppmvd):	377.83	382.63	384.93	**381.80**
Corrected CO Concentration (ppmvd @ 15% O2):	238.24	241.39	238.88	**239.50**
Catalyst Outlet Gas Conditions				
Drift Corrected Oxygen Concentration, Dry (percent):	11.56	11.51	11.47	**11.51**
Drift Corrected CO Concentration, Dry (ppmvd):	3.23	3.22	3.19	**3.21**
Corrected CO Concentration (ppmvd @ 15% O2):	2.04	2.02	2.00	**2.02**
CO Reduction Efficiency				
CO Reduction Efficiency (≥93%):	99.15	99.16	99.16	**99.16**
CO Emissions				
Emission Rate, g/bph-hr:	0.015	0.004	0.004	**0.008**
ROP Emission Limit, g/bhp-hr[1]:	0.2	0.2	0.2	**0.2**
NO_x Emissions				
Drift Corrected Nitrogen Oxides Concentration (ppmvd):	45.13	46.95	47.07	**46.38**
Emission Rate, g/bhp-hr:	0.3	0.4	0.4	**0.4**
ROP Emission Limit, g/bhp-hr:	0.5	0.5	0.5	**0.5**
VOC Emissions				
VOC (as NMNEOC) Concentration, Dry (ppmvd), Expressed as Propane:	3.99	3.98	3.96	**3.97**
VOC (as NMNEOC) Emission Rate, g/bhp-hr:	0.030	0.029	0.029	**0.029**
ROP Emission Limit, g/bhp-hr[1]:	0.19	0.19	0.19	**0.19**
VOC (as NMOC) Concentration, Dry (ppmvd), Expressed as Propane:	76.01	76.25	75.86	**76.04**
VOC (as NMOC) Emission Rate, g/bhp-hr:	0.50	0.56	0.56	**0.54**
Subpart JJJJ Emission Limit, g/bhp-hr[1]:	1.0	1.0	1.0	**1.0**

[1] The PTI CO, NO_x and VOC emission limits are more stringent than the applicable limits in 40 CFR Part 60, Subpart JJJJ, which are as follows: CO = 4.0 grams/HP-hr; NO_x = 2.0 grams/HP-hr; VOC = 1.0 grams/HP-hr

TABLE 9
RAY COMPRESSOR STATION
SUMMARY OF RICE EFFICIENCY AND EMISSIONS, EUENGINE34
July 13, 2016

Time Period	Run 1 1501-1601	Run 2 1621-1721	Run 3 1743-1843	Average
Engine Process Conditions				
Engine Speed, Revolutions Per Minute:	943.36	943.08	943.03	**943.16**
Brake Horsepower:	4449	4452	4451	**4451**
Load, Percent:	100	100	100	**100**
Fuel Flow, SCFM	519.94	518.93	518.12	**519.00**
Suction Pressure, PSIG	588.22	582.93	579.17	**583.44**
Discharge Pressure, PSIG	1284.65	1285.36	1285.5	**1285.17**
Catalyst Inlet Gas Conditions				
Drift Corrected Oxygen Concentration, Dry (Percent):	11.30	11.38	11.37	**11.38**
Drift Corrected CO Concentration, Dry (ppmvd):	353.97	357.95	358.09	**356.67**
Corrected CO Concentration (ppmvd @ 15% O2):	217.50	221.79	221.76	**220.35**
Catalyst Outlet Gas Conditions				
Drift Corrected Oxygen Concentration, Dry (percent):	11.47	11.41	11.34	**11.41**
Drift Corrected CO Concentration, Dry (ppmvd):	4.72	4.90	4.74	**4.79**
Corrected CO Concentration (ppmvd @ 15% O2):	2.95	3.04	2.92	**2.97**
CO Reduction Efficiency				
CO Reduction Efficiency (≥93%):	98.64	98.63	98.68	**98.65**
CO Emissions				
Emission Rate, g/bph-hr:	0.022	0.007	0.006	**0.012**
ROP Emission Limit, g/bhp-hr[1]:	0.2	0.2	0.2	**0.2**
NO_x Emissions				
Drift Corrected Nitrogen Oxides Concentration (ppmvd):	63.56	63.57	64.46	**63.86**
Emission Rate, g/bhp-hr:	0.49	0.49	0.49	**0.49**
ROP Emission Limit, g/bhp-hr:	0.5	0.5	0.5	**0.5**
VOC Emissions				
VOC (as NMNEOC) Concentration, Dry (ppmvd), Expressed as Propane:	5.55	5.56	5.6	**5.6**
VOC (as NMNEOC) Emission Rate, g/bhp-hr:	0.041	0.041	0.041	**0.041**
ROP Emission Limit, g/bhp-hr[1]:	0.19	0.19	0.19	**0.19**
VOC (as NMOC) Concentration, Dry (ppmvd), Expressed as Propane:	64.78	64.21	63.62	**64.21**
VOC (as NMOC) Emission Rate, g/bhp-hr:	0.43	0.48	0.47	**0.46**
Subpart JJJJ Emission Limit, g/bhp-hr[1]:	1.0	1.0	1.0	**1.0**

[1] The PTI CO, NO_x and VOC emission limits are more stringent than the applicable limits in 40 CFR Part 60, Subpart JJJJ, which are as follows: CO = 4.0 grams/HP-hr; NO_x = 2.0 grams/HP-hr; VOC = 1.0 grams/HP-hr

TABLE 10

RAY COMPRESSOR STATION

SUMMARY OF RICE EFFICIENCY AND EMISSIONS, EUENGINE35

July 14, 2016

Time Period	Run 1	Run 2	Run 3	**Average**
	1441-1541	1602-1702	1720-1820	
Engine Process Conditions				
Engine Speed, Revolutions Per Minute:	965.0	963.57	963.80	**964.15**
Brake Horsepower:	4591	4585	4589	**4589**
Load, Percent:	100	100	101	**101**
Fuel Flow, SCFM	533.45	530.61	532.16	**532.07**
Suction Pressure, PSIG	590.19	587.27	584.31	**587.26**
Discharge Pressure, PSIG	1276.79	1276.79	1277.13	**1276.90**
Catalyst Inlet Gas Conditions				
Drift Corrected Oxygen Concentration, Dry (Percent):	11.40	11.53	11.57	**11.55**
Drift Corrected CO Concentration, Dry (ppmvd):	370.22	370.37	370.25	**370.28**
Corrected CO Concentration (ppmvd @ 15% O2):	229.82	233.14	234.18	**232.38**
Catalyst Outlet Gas Conditions				
Drift Corrected Oxygen Concentration, Dry (percent):	11.63	11.74	11.95	**11.78**
Drift Corrected CO Concentration, Dry (ppmvd):	3.05	3.41	3.43	**3.30**
Corrected CO Concentration (ppmvd @ 15% O2):	1.94	2.20	2.26	**2.13**
CO Reduction Efficiency				
CO Reduction Efficiency (≥93%):	99.16	99.06	99.03	**99.08**
CO Emissions				
Emission Rate, g/bph-hr:	0.014	0.005	0.005	**0.008**
ROP Emission Limit, g/bhp-hr[1]:	0.2	0.2	0.2	**0.2**
NO_x Emissions				
Drift Corrected Nitrogen Oxides Concentration (ppmvd):	49.25	48.75	48.46	**48.82**
Emission Rate, g/bhp-hr:	0.4	0.4	0.4	**0.4**
ROP Emission Limit, g/bhp-hr:	0.5	0.5	0.5	**0.5**
VOC Emissions				
VOC (as NMNEOC) Concentration, Dry (ppmvd), Expressed as Propane:	0.55*	4.09	4.08	**4.09**
VOC (as NMNEOC) Emission Rate, g/bhp-hr:	0.004*	0.031	0.031	**0.031**
ROP Emission Limit, g/bhp-hr[1]:	0.19	0.19	0.19	**0.19**
VOC (as NMOC) Concentration, Dry (ppmvd), Expressed as Propane:	63.37	65.62	63.07	**64.02**
VOC (as NMOC) Emission Rate, g/bhp-hr:	0.43	0.49	0.49	**0.47**
Subpart JJJJ Emission Limit, g/bhp-hr[1]:	1.0	1.0	1.0	**1.0**

[1] The PTI CO, NO_x and VOC emission limits are more stringent than the applicable limits in 40 CFR Part 60, Subpart JJJJ, which are as follows: CO = 4.0 grams/HP-hr; NO_x = 2.0 grams/HP-hr; VOC = 1.0 grams/HP-hr

FIGURE 1

Methods 3A, 7E, 10 & 25A Sampling Apparatus Schematic

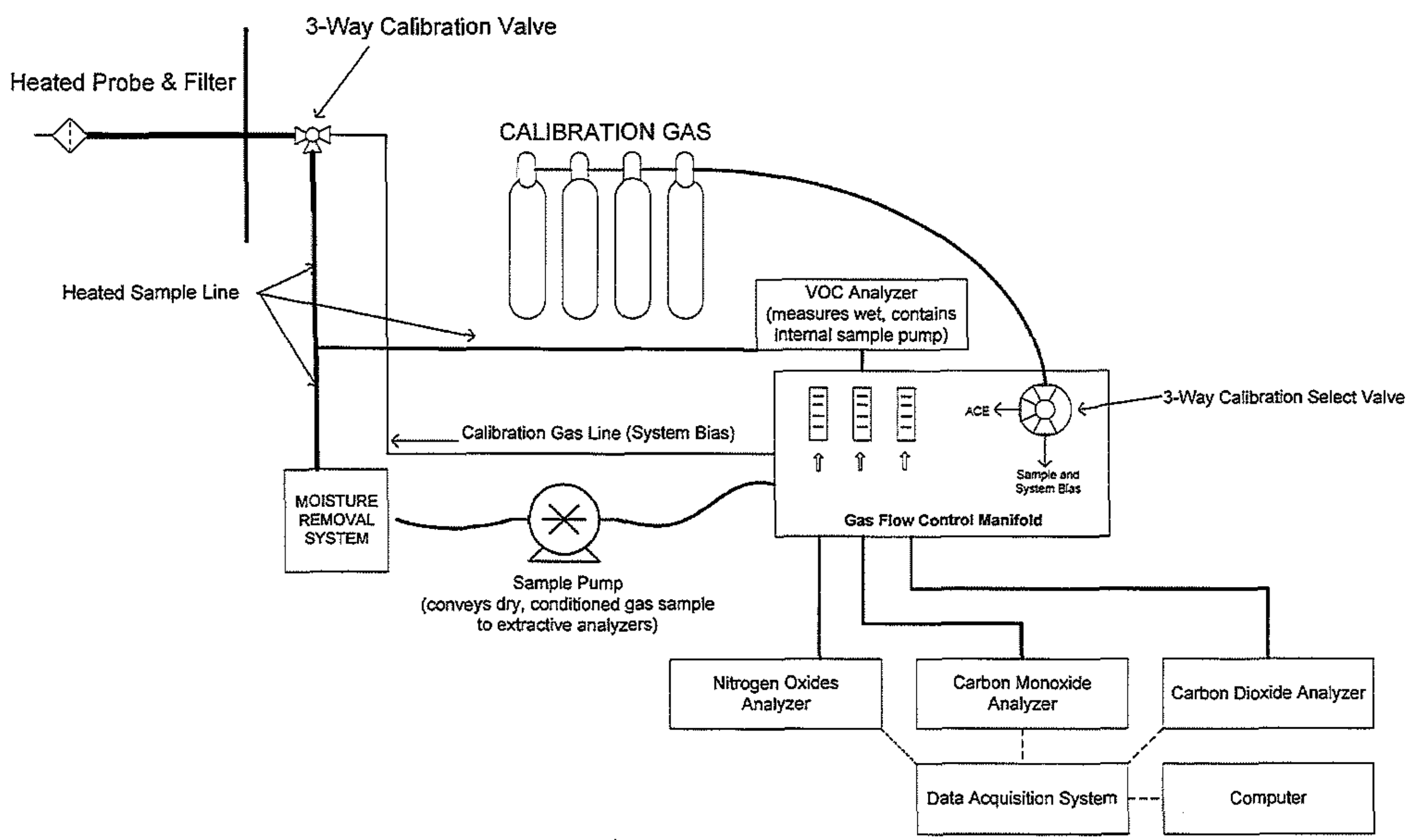


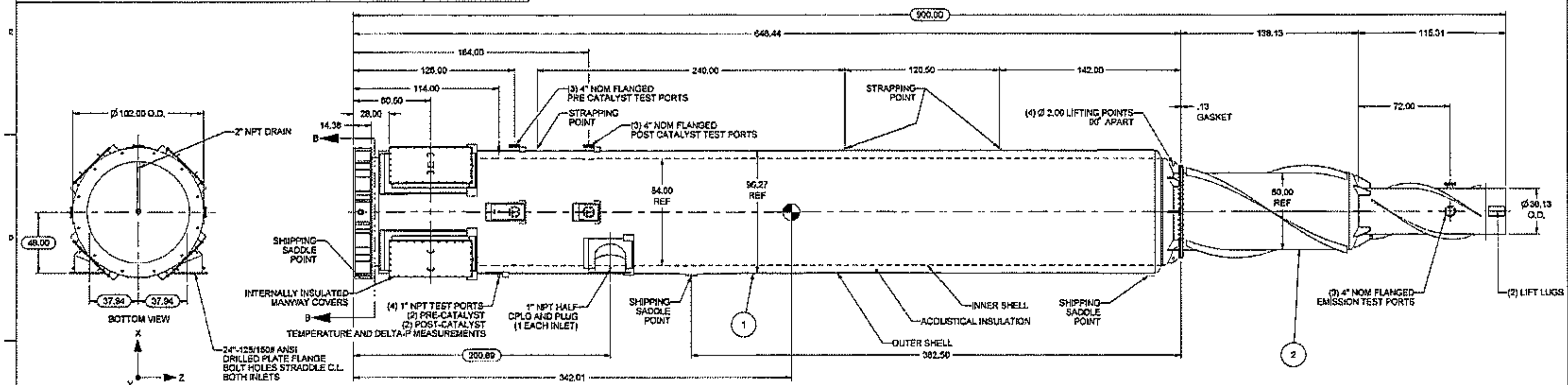
FIGURE 1

DRY AND WET EXTRACTIVE GASEOUS SAMPLE APPARATUS

FIGURE 2

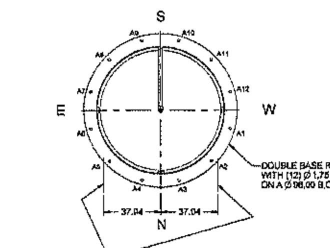
Caterpillar Model G3616 Stack Schematic – Catalyst Outlet Test Port Locations

TABLE #1				
ITEM	QTY	DESCRIPTION	U.S. PART #	APPROX. WEIGHT (LBS)
1	1	SILENCER/CATALYST	10000064840	53,000
2	1	ABSORPTIVE SILENCER/STACK	10000067210	6,150
3	1 PKG	LOOSE PARTS	10000066000	65
			TOTAL SYSTEM WEIGHT =	59,215

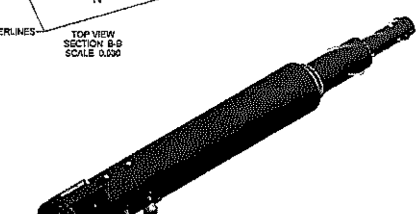


Supports	Dead (Gravity) Load	Force Direction	Wind Loads			Seismic Loads		
			X	Y	Z	X	Y	Z
A1	4.52	X-Direction	6.02	0.05	0.02	2.51	-0.01	0.00
		Z-Direction	0.03	-18.12	-6.04	0.00	-7.08	-3.51
A2	5.25	X-Direction	2.70	11.87	5.18	0.91	4.61	1.07
		Z-Direction	3.69	-18.36	-5.12	1.39	-7.15	-2.07
A3	5.29	X-Direction	-5.08	18.28	3.68	-2.06	7.15	1.40
		Z-Direction	5.18	-11.83	2.69	1.97	-4.62	0.89
A4	4.64	X-Direction	-8.87	18.04	0.00	-3.52	7.06	0.00
		Z-Direction	-0.02	0.08	6.91	0.00	0.00	2.49
A5	5.29	X-Direction	-5.08	18.28	-3.68	-2.06	7.16	-1.40
		Z-Direction	-5.19	11.90	2.67	-1.97	4.62	0.89
A6	5.25	X-Direction	2.70	11.87	-5.18	0.91	4.61	-1.97
		Z-Direction	-3.68	18.27	-5.09	-1.39	7.15	-2.07
A7	4.52	X-Direction	6.94	0.06	-0.02	2.51	-0.01	0.00
		Z-Direction	-0.02	18.01	-6.96	0.00	7.06	-3.51
A8	5.03	X-Direction	2.70	-11.82	5.17	0.90	-4.61	1.97
		Z-Direction	3.63	18.21	-5.06	1.39	7.13	-2.06
A9	5.00	X-Direction	-5.11	-18.33	3.67	-2.08	-7.14	1.39
		Z-Direction	5.16	11.84	2.71	1.97	4.60	0.92
A10	4.38	X-Direction	-8.04	-18.12	0.00	-3.51	-7.07	0.00
		Z-Direction	0.02	0.08	6.96	0.00	0.00	2.63
A11	5.00	X-Direction	-5.12	-18.33	-3.67	-2.08	-7.14	-1.39
		Z-Direction	-5.16	-11.77	2.74	-1.97	-4.60	0.92
A12	5.03	X-Direction	2.70	-11.82	-5.18	0.90	-4.62	-1.97
		Z-Direction	-3.65	-18.30	-5.09	-1.39	-7.13	-2.06

LOAD IN KIPS (1000 lb)
LOAD TABLE VALUES ARE SHOWN FOR LOADING CONDITIONS +X AND +Z.
Y-AXIS IS VERTICAL AXIS - POSITIVE DIRECTION IS ORIENTED UP.
SUPPORT VALUES ARE DEPENDENT ON THE DIRECTION OF WIND/SEISMIC LOADING. SUPPORTS ARE ASSUMED TO BE PINNED.
TOTAL MAX. BASE SHEAR (WIND LOADING) = 13.64 KIPS. THE AVERAGE SHEAR FORCE PER SUPPORT IS 1.13 KIPS.
WIND LOADS ARE PER ASCE 7-05, V_{3s} = 100 MPH, EXP. "C", I_w = 1.15, K_{zt} = 1.0
SEISMIC LOADS ARE PER ASCE 7-05, S_s = 0.105g, S_1 = 0.041g, I_e - 1.25



TOP VIEW
SECTION B-B
SCALE 0.030



ISO VIEW
FOR REFERENCE ONLY

NOTES:

1. ENGINE - CAT G3616

2. SYSTEM DESIGNED TO WITHSTAND 100 MPH WINDS, EXPOSURE C.

3. CATALYST SIZE: (4) 29 X 29 X 3.0, CATALYST MANWAYS: 35 X 60, CATALYST MANWAY COVERS: 40 X 65, 375 LBS.

4. LOCATION: ARMADA, MI.

5. ALL HARDWARE AND GASKETS FOR ATTACHING THE ABSORPTIVE SILENCER/STACK TO THE SILENCER/CATALYST ARE INCLUDED IN THE LOOSE PARTS KIT. ALL TEST PORT PLUGS/BLIND FANGES ARE INCLUDED.

6. FASTENERS:
MANWAY - GALVANIZED
FLANGED TEST PORTS - GALVANIZED
LOOSE PARTS KIT - STAINLESS STEEL

7. FINISH (EXTERNAL CARBON STEEL ONLY):
SURFACE PREP. - NEAR WHITE BLAST CLEAN PER SSPC-SP10, 1-3 MIL BLAST PROFILE.
PRIME - (1) COAT PPG DIMETCOTE 9H, 2-3 MILS DFT.
TOP COAT - (1) COAT PPG AMERCOAT 741, 2-3.5 DFT. COLOR - PEARL GRAY.
TOTAL MAX DFT: 6 MILS

8. (3) 4" NOMINAL VENT HOLES IN THE SKIRT.

9. THE DRAIN PIPE IS 304 S.S.

10. (4) 1/2" VENT HOLES BETWEEN EACH SILENCER CHAMBER.

11. CATALYST/SILENCER HOUSING WILL SHIP WITHOUT CATALYSTS INSTALLED. CATALYSTS & GASKETS PROVIDED BY OTHERS. CATALYSTS DESIGN & PERFORMANCE BY OTHERS.

12. EXPECTED ACOUSTICAL PERFORMANCE: SEE REPORT " CONSUMERS ENERGY PHASE 1B REPORT C3"

13. EXPECTED AERODYNAMIC PERFORMANCE: 7.2" W.G. (TP) @ 55,050 LBS/H & 855 F. ESTIMATE INCLUDES 2" W.G. TO ACCOUNT FOR CUSTOMER SUPPLIED CATALYST.

14. ANCHORING FOUNDATION DESIGN & HARDWARE BY OTHERS.

DIMENSIONS CERTIFIED FOR:
P.O. NO.
U.S. S.O. NO
BY
DATE

TOLERANCES UNLESS STATED - SEE FULL SPEC. 86-0073			
(mm)	US customary (")	(mm)	US customary (")
0-300	0-12	±1.5	±1/16
>300-600	>12-24	±3	±1/8
>600-900	>24-36	±5	±3/16
>900-6000	>36-240	±6	±1/4
>6000	>240	±12	±1/2

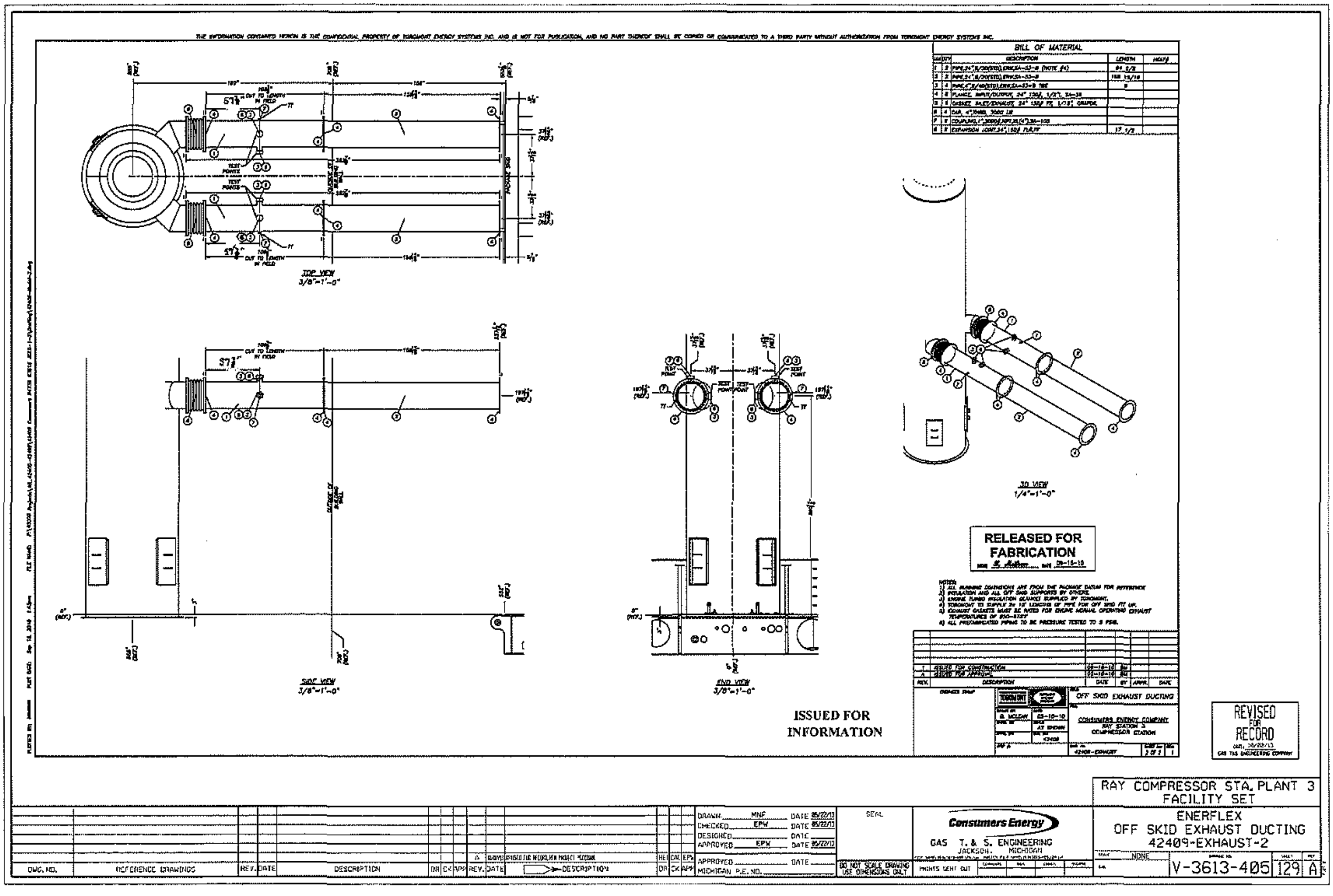
DO NOT SCALE DRAWING
APPROX. WT. SEE TABLE #1 MATERIAL C3
FINISH SEE NOTE 7

	NAME	DATE
DRAWN	WG	10/13/2015
CHECKED	JM	10/20/2015

UNIVERSAL
Acoustic & Emission Technologies
MM NO. 3000008585
DWL VERSION: 04
DESCRIPTION GENERAL ARRANGEMENT DRAWING
SPECIAL ENSSU5YX-36 CATALYST SILENCER
THIRD ANGLE PROJECTION
DIMENSIONAL DWG. NO 10000087372
SHEET 1 OF 1
REV. 3

FIGURE 3

Caterpillar Model G3616 Stack Schematic – Catalyst Inlet Test Port Locations



BILL OF MATERIAL
TOP VIEW
3/8"=1'-0"
SIDE VIEW
3/8"=1'-0"
END VIEW
3/8"=1'-0"
3D VIEW
1/4"=1'-0"
RELEASED FOR FABRICATION
ISSUED FOR INFORMATION
REVISED FOR RECORD
OFF SKID EXHAUST DUCTING
RAY COMPRESSOR STA. PLANT 3
FACILITY SET
Consumers Energy
GAS T. & S. ENGINEERING
JACKSON, MICHIGAN
ENERFLEX
OFF SKID EXHAUST DUCTING
42409-EXHAUST-2
DRAWN MNF
CHECKED EPW
DESIGNED
APPROVED EPW
APPROVED
MICHIGAN P.E. NO.
SEAL
DO NOT SCALE DRAWING USE DIMENSIONS ONLY
PRINTS SENT OUT
NONE
V-3613-405
129
A
DWG. NO.
REFERENCE DRAWINGS
REV.
DATE
DESCRIPTION