Consumers Energy

Count on Us

Continuous Compliance Demonstration Test Report

40 CFR Part 60 Subpart JJJJ/
40 CFR Part 63 Subpart ZZZZ

EUENGINE1, EUENGINE2, EUENGINE3, EUENGINE4 & EUEMERGGEN

Located at:

White Pigeon Compressor Station
68536 A Road, Route 1
White Pigeon, Michigan 49099

Test Dates: March 28 - 30, 2017

Report Submitted:
May 19, 2017

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

On March 28-31, 2017 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 EUENGINE1, EUENGINE2, EUENGINE3, EUENGINE4 and EUEMERGGEN. The engines are located and operating at the White Pigeon Compressor Station (WPCS) in White Pigeon, Michigan.

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

The purpose of the testing was to evaluate compliance with both (a) the *National Emission Standards for Hazardous Air Pollutants* (NESHAP) for RICE, 40 CFR Part 63, Subpart ZZZZ, and (b) *Standards of Performance for Stationary Spark Ignition* (SI) *Internal Combustion Engines* (ICE), 40 CFR Part 60, Subpart JJJJ. A summary of specific test parameters is shown in Table 1.

TABLE 1

Summary of Engine Test Parameters

Test Parameter	Measurement Unit	Affected Source(s)	Test Location(s)	Regulation
Carbon Monoxide (CO) Reduction Efficiency (RE)	ppmvd (part per million by volume, dry basis), corrected to 15% Oxygen (O_2)	EUENGINE1 – 4	Pre/Post Oxidation Catalyst (Engine Exhaust)	40 CFR Part 63 Subpart ZZZZ
Nitrogen Oxides (NO_x), CO[1] & Volatile Organic Compounds (VOCs), as Non-Methane Organic Compounds (NMOC)	grams per horsepower hour (g/HP-hr)	EUENGINE1 – 4[1]; EUEMERGGEN	Engine Exhaust	40 CFR Part 60 Subpart JJJJ

[1] Please note that 40 CFR Part 60, Subpart JJJJ, Table 1, footnote (b), indicates RICE units that meet the CO requirements in 40 CFR Part 63, Subpart ZZZZ are not subject to CO standards in 40 CFR Part 60, Subpart JJJJ. With that being said, from this point onward, the CO results in this report will be shown in conjunction with the Subpart JJJJ NO_x and $VOC_{as\ NMOC}$ results.

Brief description of source

The White Pigeon Compressor Station is a natural gas compressor station. The purpose of the facility is to compress and maintain the pressure of natural gas in order to move it along the pipeline system. Each RICE tested is of a 4SLB design, exclusively fired with pipeline quality natural gas.

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

CEC RCTS employees Joe Mason and Dillon King conducted the emission test program with assistance from Rusty Richardson, CEC Laboratory Services Utility Technician. Mr. Timothy Wolf, WPCS Field Leader, coordinated the test in tandem with Ms. Janet Zondlak, CEC Gas Compression Environmental Coordinator. Mr. Craig Jaeger, CEC Gas Compression Senior Technician, collected engine operating data. MDEQ representatives Mr. Thomas Gasloli and Mr. Dennis Dunlap were onsite to witness portions of the testing. Table 2 contains additional test program participant contact information.

TABLE 2

White Pigeon Compressor Station RICE Test Program Participants

Responsible Party	Address	Contact
Test Facility Representative	White Pigeon Compressor Station 68536 A Road White Pigeon, Michigan 49099	Mr. Timothy Wolf 269-483-2902 timothy.wolf@cmsenergy.com
Gas Compression Representative	Consumers Energy Company Gas Compression/Storage Operations 17010 Croswell Road West Olive, Michigan 49460	Ms. Janet Zondlak 616-738-3702 janet.zondlak@cmsenergy.com
Performance Test Representative	Consumers Energy Company Regulatory Compliance Testing Section 17010 Croswell Street West Olive, Michigan 49460	Mr. Joe Mason, QSTI 231-720-4856 joe.mason@cmsenergy.com
State Representative	Michigan Department of Environmental Quality 525 W. Allegan, Constitution Hall Lansing, Michigan 48909	Mr. Dennis Dunlap 269-567-3553 dunlapd@michigan.gov
		Mr. David Patterson 517-284-6782 pattersond2@michigan.gov

2.0 SUMMARY OF RESULTS

40 CFR Part 63, Subpart ZZZZ

The percent CO reduction efficiency determined at each engine oxidation catalyst utilized dry-basis CO concentrations adjusted to 15% O_2 as measured before and after dedicated oxidation catalysts. The RE results in Table 3 confirm each engine oxidation catalyst is achieving the minimum 93 percent CO reduction efficiency required by 40 CFR Part 63, Subpart ZZZZ.

TABLE 3

Summary of 40 CFR 63 Subpart ZZZZ CO Reduction Efficiency Results

Source	CO Reduction Efficiency (%) [ZZZZ Limit = ≥93%]	Catalyst Inlet Temperature (°F) [ZZZZ Limit = ≥450°F and ≤1350°F]	Catalyst Pressure Drop (Inches Water Gauge) [ZZZZ Limit = ±2" from Initial Test]	Initial Catalyst Pressure Drop (Inches Water Gauge)
EUENGINE1	99.9	744	4.6	3.5
EUENGINE2	99.5	729	2.9	3.2
EUENGINE3	96.2	757	3.1	2.9
EUENGINE4	94.0	755	3.2	3.0

40 CFR Part 60, Subpart JJJJ

The NO_x, CO and $VOC_{as\ NMOC}$ g/HP-hr emission rates were determined at each engine exhaust utilizing measured dry-basis concentrations in conjunction with appropriate RICE operating data. As shown in Table 4 below, the g/HP-hr emission rates verify each engine satisfies the 40 CFR Part 60, Subpart JJJJ and facility ROP requirements.

TABLE 4

Summary of 40 CFR 60 Subpart JJJJ and ROP g/HP-hr Emission Results

Source	CO Emission Rate (g/hp-hr) [ROP Limit = 0.2[1]; JJJJ Limit = 4.0]	NO_x Emission Rate (g/hp-hr) [ROP Limit = 0.5; JJJJ Limit = 2.0]	VOC Emission Rate, Expressed as NMOC (g/hp-hr) [JJJJ Limit = 1.0]
EUENGINE1	0.001	0.4	0.2
EUENGINE2	0.01	0.4	0.5
EUENGINE3	0.1	0.5	0.3
EUENGINE4	0.1	0.5	0.3
EUEMERGGEN	2.3	0.4	0.2

[1] ROP limit does not apply to EUEMERGGEN

Operating Data

EUENGINE1 – 4 operating data collected included catalyst inlet temperature, catalyst pressure drop, engine torque, rpm, horsepower and fuel flow rate. EUEMERGGEN operating data included electrical output (amps), voltage, engine torque, fuel flow rate, horsepower and rpm.

The RICE horsepower data was used to verify engine load, fulfilling the requirement in Subpart ZZZZ § 63.6620 (b) which states *the test must be conducted at any load condition within plus or minus 10 percent of 100 percent load* and Subpart JJJJ § 60.4244(a) which states *each performance test must be conducted within 10 percent of 100 percent peak (or the highest achievable) load.*

Applicable Permit Number

The White Pigeon Compressor Station currently operates pursuant to the terms and conditions of ROP No. MI-ROP-N5573-2013.

3.0 SOURCE DESCRIPTION

Description of Process

The White Pigeon Compressor Station operates three Caterpillar Model 3616 4SLB engines (EUENGINE2 – 4) and one Caterpillar Model 3608 4SLB engine (EUENGINE1) for the purpose of maintaining natural gas pipeline system pressure. Each engine is fired with pipeline quality natural gas exclusively and equipped with modular oxidation catalysts designed to reduce CO and VOC emissions. EUEMERGGEN is a Caterpillar Model G3516B LE engine which turns an emergency generator for use during power outages. EUEMERGGEN is not equipped with add-on controls.

The NO_x emissions from each engine is 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.

The Caterpillar Model G3616 production engines (EUENGINE2 – 4) are each equipped with four modular oxidation catalysts, while the Caterpillar Model G3608 engine (EUENGINE1) is equipped with two. The catalysts are constructed of proprietary materials that allow lower oxidation process temperatures, such as the engine exhaust gas temperatures generated, to better oxidize CO and other organic compounds. The catalyst vendor guarantees a minimum CO reduction (destruction) efficiency of 93%, while estimating formaldehyde and non-methane, non-ethane hydrocarbon (NMNEHC) destruction efficiencies of 85% and 75%, respectively.

Process Flow Sheet or Diagram

The exhaust stacks serving EUENGINE1-4 are a non-typical design. Specifically, the bottom portion of each stack actually has an outer stack (the shape is like a doughnut looking down from the top of the stack) and an inner circular stack. The exhaust gases from the engines enter the outer stack via two horizontal exhaust ducts running from the engines to the free standing stacks. Once the gases enter the outer stack, they flow downwards through the oxidation catalysts placed at the bottom of the outer stacks. After passing through the catalysts, the gases enter the inner stacks through an opening located near the base of the stacks and travel upwards through the inner stacks to be discharged unobstructed to the ambient air. Figure 2 of this report depicts the Caterpillar Model G3608 (EUENGINE1) Stack Schematic. Figure 3 illustrates the Caterpillar Model G3616 (EUENGINE2-4) Stack Schematic.

Type and Quantity of Raw Material Processed During the Tests

NA

Maximum and Normal Rated Capacity of the Process

Table 5 contains pertinent engine specifications.

TABLE 5

Summary of RICE Specifications [1]

Parameter	EUENGINE1	EUENGINE2-4	EUEMERGGEN
Make	Caterpillar	Caterpillar	Caterpillar
Model	G3608	G3616	G3516B LE
Output (brake-horsepower)	2,370	4,735	1,818
Heat Input, LHV	16.1	32.0	12.8
Exhaust Gas Temp. (°F)	857	856	974

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

Description of Process Instrumentation Monitored During the Test

EUENGINE1 – 4 operating data collected included catalyst inlet temperature, catalyst pressure drop, engine torque, rpm, horsepower and fuel flow rate, suction and discharge pressure. EUEMERGGEN operating data included electrical output (amps), voltage, engine torque, fuel flow rate, horsepower and rpm. The preceding data was logged and averaged to determine the per-test run values.

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 in conjunction with measurements of CO, NO_x, $VOC_{as\ NMOC}$, O_2 and CO_2 at the engine (oxidation catalyst) exhaust. CO reduction efficiency calculations followed specifications in 40 CFR Part 63, Subpart ZZZZ §63.6620 Equation 1 and Table 4, and NO_x, CO and $VOC_{as\ NMOC}$ emission rates were based on Equations 1-3 and Table 2 in 40 CFR Part 60, Subpart JJJJ §60.4244.

All components of the CO_2, O_2, NO_x, CO and $VOC_{as\ NMOC}$ 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 $VOC_{as\ NMOC}$ 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 components in the engine exhaust gases were conveyed via a heated sample line to an electronic gas sample conditioner to remove moisture and any particulate matter prior to analyzer injection, as these parameters require dry-basis analysis. Conversely, the $VOC_{as\ NMOC}$ concentrations in the engine exhaust gas were measured as ppm by volume, wet-basis, so a separate heated sample system dedicated for that purpose was used.

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 $VOC_{as\ NMOC}$ g/HP-hr emission rates were also calculated on a dry basis. The conversion of wet $VOC_{as\ NMOC}$ concentrations to a dry basis was approximated in the field from daily exhaust gas moisture content measurements. Ultimately, the laboratory reported water content from natural gas fuel samples collected as required by 40 CFR Part 60 Subpart JJJJ was used for wet to dry-basis $VOC_{as\ NMOC}$ conversions and presented in this report. CO_2 and O_2 concentrations were measured as percent by volume, dry basis.

4.1 Traverse Points

The sample traverse points used at the EUENGINE1 oxidizer inlet and each of the engine exhaust outlets were determined using U.S. EPA Method 1, *Sample and Velocity Traverses for Stationary Sources* and U.S. EPA Method 7E, *Determination of Nitrogen Oxides from Stationary Sources (Instrumental Analyzer Procedure)* criteria in § 8.1.2 of the method.

Gas concentrations at the EUENGINE1 oxidizer inlet were measured from three traverse points located at 16.7, 50.0 and 83.3% of the duct diameter in a line through the centroidal area. The level of gas stratification at each each engine exhaust *outlet* was determined during the first run at each source from twelve traverse points located in the duct. The concentrations measured at each point, when compared to the 12-point concentration mean, revealed that each point concentration was within ±5.0 percent of the mean concentration, indicating the ducts were unstratified. Therefore, a single traverse point most closely matching the mean concentration was used for each subsequent test run thereafter.

Conversely, the physical area within the oxidizer *inlet* sample location at EUENGINE2, 3 and 4 is extremely limited and a-typical compared to U.S. EPA Method 1 criteria due to the proprietary nature and design of the installed modular catalyst equipment. Therefore, these area constraints limited the inlet sampling to just one traverse point at approximately 50% of the duct area or diameter.

Figure 2 of this report depicts the Caterpillar Model G3608 (EUENGINE1) Stack Schematic. Figure 3 illustrates the Caterpillar Model G3616 (EUENGINES2-4) Stack Schematic and Figure 4 illustrates the Caterpillar Model G3516B LE (EUEMERGGEN) Stack Schematic.

4.2 Diluent/Molecular Weight

CO_2 and O_2 concentrations were measured at each catalyst inlet and/or engine 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)*. The O_2 concentrations were used to adjust measured CO to 15% O_2, however if necessary, a CO_2 correction factor based on O_2 to CO_2 fuel factor ratios as described in §63.6620 (e)(2)(ii)(Eq.3) based on dry basis CO_2 concentrations described in Equation 4, § 63.6620 (e)(2)(iii) could also be used to adjust the CO. The F_c and F_d fuel factors used to derive the CO_2 correction factors are obtained from natural gas fuel sample analyses.

4.3 Moisture Content

In the field, an approximate determination of the RICE exhaust gas moisture content was obtained daily using U.S. EPA Alternate Method 008, *Alternative Moisture Measurement Method Midget Impingers.* Effluent gas was drawn through a series of four impingers immersed in an ice bath to achieve efficient moisture condensation, and collected water vapor was determined gravimetrically for calculating percent moisture. The first two impingers contained water, the third was empty and the fourth contained indicating silica gel. Upon receipt of laboratory results from the daily natural gas samples collected as required by

40 CFR Part 60 Subpart JJJJ, 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 (GC) column is used to separate methane from other organic compounds.

Upon injecting sample gas into the column, methane travels through the GC quicker than other existing organic compounds due to its low molecular weight and high volatility. Upon exiting the GC, methane is analyzed in the FID, after which any remaining non-methane organic compounds are analyzed while the column is flushed with inert carrier gas. This GC approach allows for separate, distinct methane and non-methane organic compound measurement via a single FID. Note that for the purposes of this test program, the methane channel on the Thermo Model 55i analyzer could not be quality assured.

4.7 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, 3 and 4 depict the affected Caterpillar RICE engines .

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 $VOC_{AS\ NMOC}$ emission rates from each RICE. RICE operating data, calculation spreadsheets, field data sheets, calibration information, fuel and NMNEOC analyses are contained in Attachments 1 - 7.

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

40 CFR 63 Subpart ZZZZ

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.

40 CFR 60 Subpart JJJJ

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.

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

No variations in sampling procedures or operating conditions occurred during this test program, however RCTS noted that measured $VOC_{AS\ NMOC}$ field concentrations and subsequent g/HP-hr emission rates were elevated slightly in comparison to previous test events. This observation may be supported by higher ethane concentrations in the daily natural gas fuel samples collected combined with the Thermo 55I analyzers design which combines the measured ethane fraction with other NMOC in the gas stream.

Finally, the $VOC_{AS\ NMOC}$ data in this report has been adjusted for analyzer drift using U.S. EPA Method 7E, *Determination of Nitrogen Oxides from Stationary Sources (Instrumental Analyzer Procedure)* specifications. While U.S. EPA Method 25A does not require VOC analyzer drift correction, this action is consistent with previous MDEQ requests.

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

EUENGINE1

WHITE PIGEON COMPRESSOR STATION

SUMMARY OF RICE EFFICIENCY AND EMISSIONS

March 31, 2017

Time Period	Run 1 0957-1057	Run 2 1112-1212	Run 3 1227-1327	**Average**
Engine Process Conditions				
Engine Speed, Revolutions Per Minute:	999	999	999	**999**
Brake Horsepower:	2330	2344	2354	**2343**
Torque (Load), Percent:	98	99	99	**99**
Fuel Flow, SCFM	278.38	279.3	280.0	**279.24**
Suction Pressure, PSIG	501.5	500.6	498.5	**500.2**
Discharge Pressure, PSIG	719.7	720.0	719.7	**719.8**
Catalyst Inlet Gas Conditions				
Drift Corrected Oxygen Concentration, Dry (Percent):	12.06	12.05	12.08	**12.07**
Drift Corrected CO Concentration, Dry (ppmvd):	407.55	420.89	429.87	**419.44**
Corrected CO Concentration (ppmvd @ 15% O2):	272.06	280.67	287.65	**280.13**
Catalyst Outlet Gas Conditions				
Drift Corrected Oxygen Concentration, Dry (percent):	11.88	12.09	12.07	**12.02**
Drift Corrected CO Concentration, Dry (ppmvd):	0.49	0.29	0.51	**0.43**
Corrected CO Concentration (ppmvd @ 15% O2):	0.32	0.19	0.34	**0.28**
CO Reduction Efficiency				
CO Reduction Efficiency (≥93%):	99.9	99.9	99.9	**99.9**
CO Emissions				
Emission Rate, g/bph-hr:	0.001	0.0004	0.001	**0.001**
ROP Emission Limit, g/bhp-hr[1]				**0.2**
Subpart JJJJ Emission Limit, g/bhp-hr:				**4.0**
NO_x Emissions				
Drift Corrected Nitrogen Oxides Concentration (ppmvd):	55.34	54.37	53.02	**54.24**
Emission Rate, g/bhp-hr:	0.4	0.4	0.4	**0.4**
ROP Emission Limit, g/bhp-hr[1]:				**0.5**
Subpart JJJJ Emission Limit, g/bhp-hr:				**2.0**
VOC (as NMOC) Emissions				
VOC (as NMOC) Concentration, Dry (ppmvd), Expressed as Propane:	19.92	26.72	22.44	**23.03**
VOC (as NMOC) Emission Rate, g/bhp-hr:	0.2	0.2	0.2	**0.2**
Subpart JJJJ Emission Limit, g/bhp-hr:				**1.0**

[1] The ROP emission limits for CO and NO_x are more stringent than the applicable limits in 40 CFR Part 60, Subpart JJJJ

TABLE 7
EUENGINE2
WHITE PIGEON COMPRESSOR STATION
SUMMARY OF RICE EFFICIENCY AND EMISSIONS
March 30, 2017

Time Period	Run 1 1005-1105	Run 2 1124-1224	Run 3 1242-1342	Average
Engine Process Conditions				
Engine Speed, Revolutions Per Minute:	999	998	1000	**999**
Brake Horsepower:	4697	4702	4687	**4695**
Torque (Load), Percent:	99	98	99	**99**
Fuel Flow, SCFM	574.46	575.43	574.18	**574.69**
Suction Pressure, PSIG	538.5	555.0	559.0	**550.8**
Discharge Pressure, PSIG	757.2	737.6	735.2	**743.3**
Catalyst Inlet Gas Conditions				
Drift Corrected Oxygen Concentration, Dry (Percent):	12.63	12.66	12.58	**12.62**
Drift Corrected CO Concentration, Dry (ppmvd):	297.14	296.49	299.50	**297.71**
Corrected CO Concentration (ppmvd @ 15% O2):	211.97	212.19	212.39	**212.18**
Catalyst Outlet Gas Conditions				
Drift Corrected Oxygen Concentration, Dry (percent):	12.57	12.53	12.51	**12.54**
Drift Corrected CO Concentration, Dry (ppmvd):	1.41	2.11	1.32	**1.61**
Corrected CO Concentration (ppmvd @ 15% O2):	1.00	1.48	0.93	**1.14**
CO Reduction Efficiency				
CO Reduction Efficiency (≥93%):	99.5	99.3	99.6	**99.5**
CO Emissions				
Emission Rate, g/bph-hr:	0.01	0.01	0.01	**0.01**
ROP Emission Limit, g/bhp-hr[1]:				**0.2**
Subpart JJJJ Emission Limit, g/bhp-hr:				**4.0**
NO_x Emissions				
Drift Corrected Nitrogen Oxides Concentration (ppmvd):	43.68	44.27	45.42	**44.45**
Emission Rate, g/bhp-hr:	0.4	0.4	0.4	**0.4**
ROP Emission Limit, g/bhp-hr[1]:				**0.5**
Subpart JJJJ Emission Limit, g/bhp-hr:				**2.0**
VOC (as NMOC) Emissions				
VOC (as NMOC) Concentration, Dry (ppmvd), Expressed as Propane:	61.61	62.53	47.79	**59.71**
VOC (as NMOC) Emission Rate, g/bhp-hr:	0.5	0.5	0.5	**0.50**
Subpart JJJJ Emission Limit, g/bhp-hr[1]:				**1.0**

[1] The ROP CO and NO_x emission limits are more stringent than the applicable limits in 40 CFR Part 60, Subpart JJJJ

TABLE 8
EUENGINE3
WHITE PIGEON COMPRESSOR STATION
SUMMARY OF RICE EFFICIENCY AND EMISSIONS
March 29, 2017

Time Period	Run 1 1541-1641	Run 2 1659-1759	Run 3 1813-1913	Average
Engine Process Conditions				
Engine Speed, Revolutions Per Minute:	997	996	998	**997**
Brake Horsepower:	4605	4737	4612	**4651**
Torque (Load), Percent:	97	100	97	**98**
Fuel Flow, SCFM	558.41	574.91	561.66	**564.99**
Suction Pressure, PSIG	579.1	579.0	579.0	**579.0**
Discharge Pressure, PSIG	767.5	768.9	769.1	**768.5**
Catalyst Inlet Gas Conditions				
Drift Corrected Oxygen Concentration, Dry (Percent):	12.16	12.04	11.99	**12.06**
Drift Corrected CO Concentration, Dry (ppmvd):	307.24	304.86	307.35	**306.48**
Corrected CO Concentration (ppmvd @ 15% O2):	207.47	202.92	200.44	**204.61**
Catalyst Outlet Gas Conditions				
Drift Corrected Oxygen Concentration, Dry (percent):	12.05	11.95	12.01	**12.00**
Drift Corrected CO Concentration, Dry (ppmvd):	11.56	11.99	11.70	**11.75**
Corrected CO Concentration (ppmvd @ 15% O2):	7.71	7.90	7.76	**7.79**
CO Reduction Efficiency				
CO Reduction Efficiency (≥93%):	96.3	96.1	96.2	**96.2**
CO Emissions				
Emission Rate, g/bph-hr:	0.1	0.1	0.1	**0.1**
ROP Emission Limit, g/bhp-hr[1]:				**0.2**
Subpart JJJJ Emission Limit, g/bhp-hr:				**4.0**
NO_x Emissions				
Drift Corrected Nitrogen Oxides Concentration (ppmvd):	53.49	55.05	54.6	**54.38**
Emission Rate, g/bhp-hr:	0.4	0.5	0.5	**0.5**
ROP Emission Limit, g/bhp-hr[1]:				**0.5**
Subpart JJJJ Emission Limit, g/bhp-hr:				**2.0**
VOC (as NMOC) Emissions				
VOC (as NMOC) Concentration, Dry (ppmvd), Expressed as Propane:	50.13	43.58	41.8	**45.17**
VOC (as NMOC) Emission Rate, g/bhp-hr:	0.4	0.3	0.3	**0.3**
Subpart JJJJ Emission Limit, g/bhp-hr[1]:				**1.0**

[1] The ROP CO and NO_x emission limits are more stringent than the applicable limits in 40 CFR Part 60, Subpart JJJJ

TABLE 9
EUENGINE4
WHITE PIGEON COMPRESSOR STATION
SUMMARY OF RICE EFFICIENCY AND EMISSIONS
March 29, 2017

Time Period	Run 1 1119-1219	Run 2 1300-1400	Run 3 1420-1520	Average
Engine Process Conditions				
Engine Speed, Revolutions Per Minute:	989	995	992	**992**
Brake Horsepower:	4719	4737	4735	**4730**
Torque (Load), Percent:	98	99	99	**99**
Fuel Flow, SCFM	572.48	574.76	574.59	**573.94**
Suction Pressure, PSIG	574.6	576.0	578.5	**576.4**
Discharge Pressure, PSIG	795.5	790.0	793.8	**793.1**
Catalyst Inlet Gas Conditions				
Drift Corrected Oxygen Concentration, Dry (Percent):	12.02	12.00	12.01	**12.01**
Drift Corrected CO Concentration, Dry (ppmvd):	319.07	317.11	316.63	**317.61**
Corrected CO Concentration (ppmvd @ 15% O2):	212.03	210.30	210.09	**210.81**
Catalyst Outlet Gas Conditions				
Drift Corrected Oxygen Concentration, Dry (percent):	11.86	11.96	11.94	**11.92**
Drift Corrected CO Concentration, Dry (ppmvd):	19.00	19.38	19.12	**19.17**
Corrected CO Concentration (ppmvd @ 15% O2):	12.41	12.80	12.59	**12.60**
CO Reduction Efficiency				
CO Reduction Efficiency (≥93%):	94.1	93.9	94.0	**94.0**
CO Emissions				
Emission Rate, g/bph-hr:	0.1	0.1	0.1	**0.1**
ROP Emission Limit, g/bhp-hr[1]:				**0.2**
Subpart JJJJ Emission Limit, g/bhp-hr:				**4.0**
NO_x Emissions				
Drift Corrected Nitrogen Oxides Concentration (ppmvd):	54.8	57.38	58.24	**56.81**
Emission Rate, g/bhp-hr:	0.4	0.5	0.5	**0.5**
ROP Emission Limit, g/bhp-hr[1]:				**0.5**
Subpart JJJJ Emission Limit, g/bhp-hr:				**2.0**
VOC Emissions				
VOC (as NMOC) Concentration, Dry (ppmvd), Expressed as Propane:	47.27	45.21	45.82	**46.10**
VOC (as NMOC) Emission Rate, g/bhp-hr:	0.3	0.4	0.4	**0.3**
Subpart JJJJ Emission Limit, g/bhp-hr[1]:				**1.0**

[1] The ROP CO and NO_x emission limits are more stringent than the applicable limits in 40 CFR Part 60, Subpart JJJJ

TABLE 10
EUEMERGGEN
WHITE PIGEON COMPRESSOR STATION
SUMMARY OF EMISSIONS
March 28, 2017

Time Period	Run 1	Run 2[2]	Run 3	Run 4	Average
	0935-1035	1102-1202	1336-1436	1455-1555	
Engine Process Conditions					
Engine Speed, Revolutions Per Minute:	1805	1806	1806	1805	**1806**
Brake Horsepower:	1621	1619	1619	1619	**1619**
Torque (Load), Percent:	93	93	93	93	**93**
Fuel Flow, SCFM	227.96	228.71	228.92	228.71	**228.58**
Current, Amps	1472	1471	1471	1471	**1471**
Volts	477	477	477	477	**477**
Outlet Gas Conditions					
Drift Corrected Oxygen Concentration, Dry (percent):	9.38	9.42	9.44		**9.41**
Drift Corrected CO Concentration, Dry (ppmvd):	501.93	500.83	514.40		**505.72**
Corrected CO Concentration (ppmvd @ 15% O2):	257.07	257.35	264.78		**259.73**
CO Emissions					
Emission Rate, g/bph-hr:	2.2	2.3	2.3		**2.3**
Subpart JJJJ Emission Limit, g/bhp-hr:					**4.0**
NO_x Emissions					
Drift Corrected Nitrogen Oxides Concentration (ppmvd):	56.19	54.22	52.49		**54.3**
Emission Rate, g/bhp-hr:	0.4	0.4	0.4		**0.4**
ROP Emission Limit, g/bhp-hr[1]:					**0.5**
Subpart JJJJ Emission Limit, g/bhp-hr:					**2.0**
VOC (as NMOC) Emissions					
VOC (as NMOC) Concentration, Dry (ppmvd), Expressed as Propane:	46.37		49.48	38.04	**44.63**
VOC (as NMOC) Emission Rate, g/bhp-hr:	0.2		0.2	0.1	**0.2**
Subpart JJJJ Emission Limit, g/bhp-hr[1]:					**1.0**

[1] The ROP NO_x emission limit is more stringent than the applicable limit in 40 CFR Part 60, Subpart JJJJ
[2] The Run 2 NMOC data is invalid due to the instrument drifting during the run, causing it to fail post calibration.

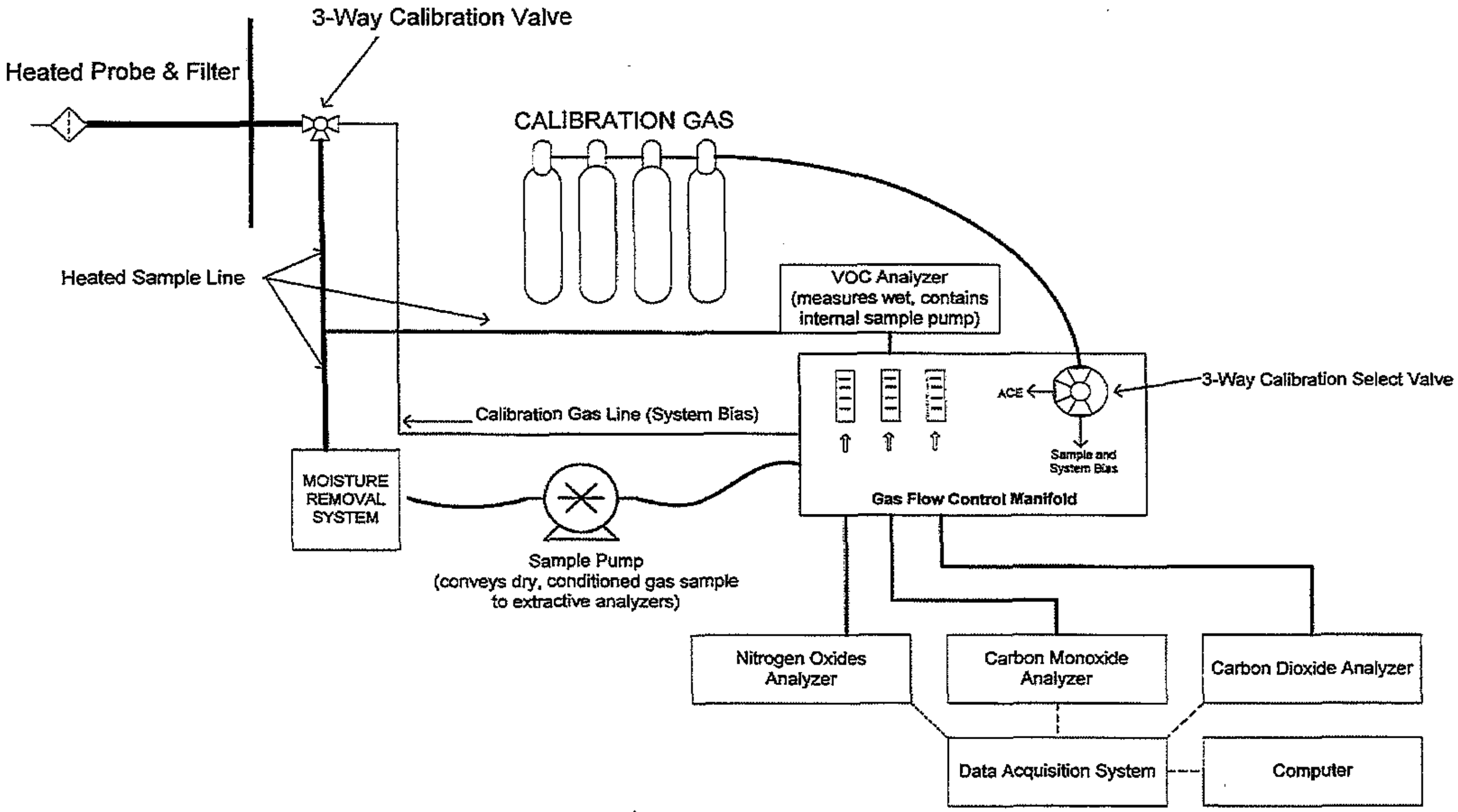
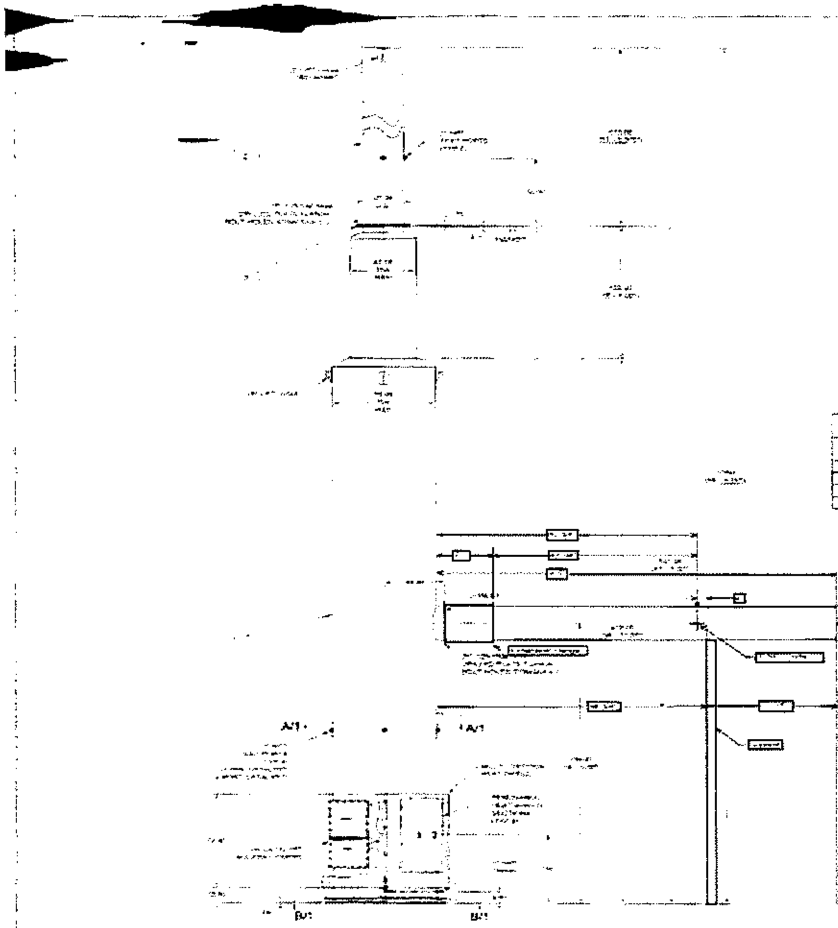


FIGURE 1

DRY AND WET EXTRACTIVE GASEOUS SAMPLE APPARATUS



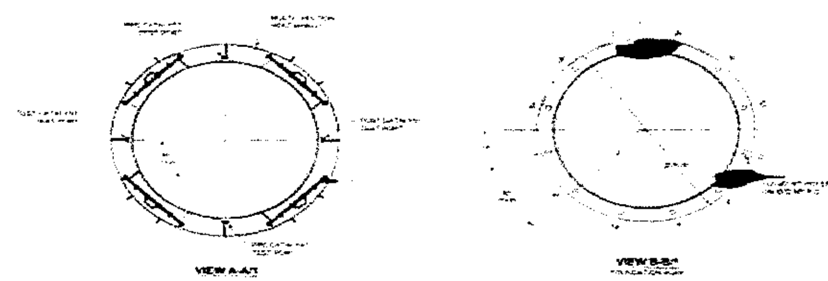


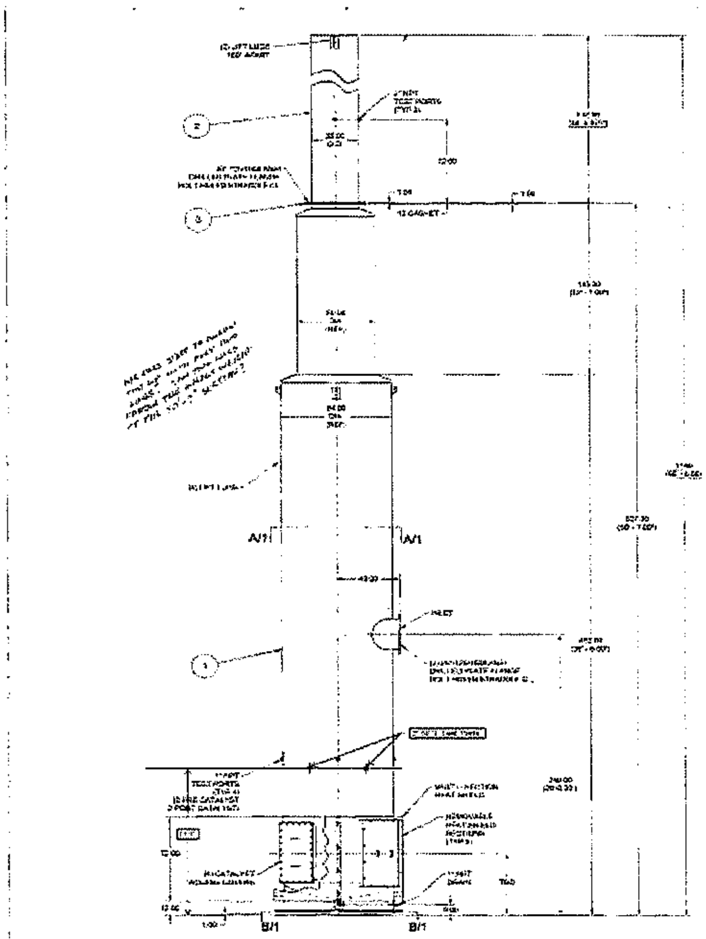
TABLE #1				
ITEM	QTY	DESCRIPTION	U.S. PART #	WEIGHT (LBS)
1	1	SILENCER / CATALYST	TBD	22,300
2	1	OUTLET STACK	TBD	6,400
3	1 PKG	LOOSE PARTS	TBD	300
		TOTAL SYSTEM WEIGHT =		29,300

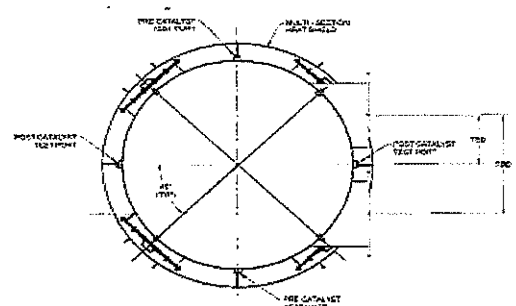
SUPPORT	DEAD LOAD	FORCE DIRECTION	WIND LOAD			SEISMIC LOAD		
A	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
B	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
C	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
D	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
E	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
F	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
G	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
H	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
I	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
J	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
K	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
L	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

COMMENTS

UNIVERSAL SILENCER

18-6000005 | 0 | 1 - 1





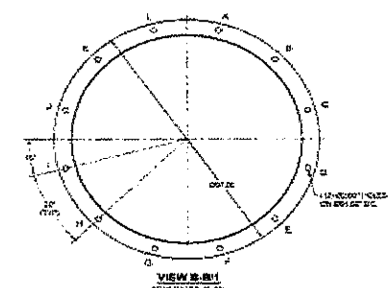


TABLE #1				
ITEM	QTY	DESCRIPTION	U.S. PART #	WEIGHT (LBS)
1	1	ELEMENT CATALYST	TBD	34,000
2	1	OUTLET STACK	TBD	7,000
3	1 PKG	LOOSE PARTS	TBD	300
		TOTAL SYSTEM WEIGHT =		41,300

SUPPORT	DEAD LOAD	FORCE DIRECTION	WIND LOAD X	WIND LOAD Y	WIND LOAD Z	SEISMIC LOAD X	SEISMIC LOAD Y	SEISMIC LOAD Z
A	-3.5	X	1.5	–	36.2	0.6	–	13.1
		Y	–	1.5	30.2	–	0.6	13.1
B	-3.5	X	1.6	–	36.2	0.6	–	13.1
		Y	–	1.5	30.2	–	0.6	13.1
C	-3.0	X	1.5	–	36.2	0.6	–	13.1
		Y	–	1.5	36.2	–	0.6	13.1
D	-4.5	X	1.5	–	36.2	0.6	–	13.1
		Y	–	1.5	30.2	–	0.6	13.1
E	-3.6	X	1.6	–	30.2	0.6	–	13.1
		Y	–	1.5	36.2	–	0.6	13.1
F	-3.5	X	1.5	–	[illegible]	0.6	–	13.1
		Y	–	1.5	36.2	–	0.6	13.1
G	-3.5	X	1.5	–	36.2	0.6	–	13.1
		Y	–	1.5	30.2	–	0.6	13.1
H	-3.5	X	1.6	–	30.2	0.6	–	13.1
		Y	–	1.5	36.2	–	0.6	13.1
I	-3.5	X	1.5	–	36.2	0.6	–	13.1
		Y	–	1.5	30.2	–	0.6	13.1
J	-3.6	X	1.5	–	30.2	0.6	–	13.1
		Y	–	1.5	36.2	–	0.6	13.1
K	-3.5	X	1.5	–	36.2	0.6	–	13.1
		Y	–	1.5	30.2	–	0.6	13.1
L	-3.5	X	1.5	–	36.2	0.6	–	13.1
		Y	–	1.5	36.2	–	0.6	13.1

System overturning moment = 800 kip ft
Horizontal shear force = 16.4 kips

NOTES

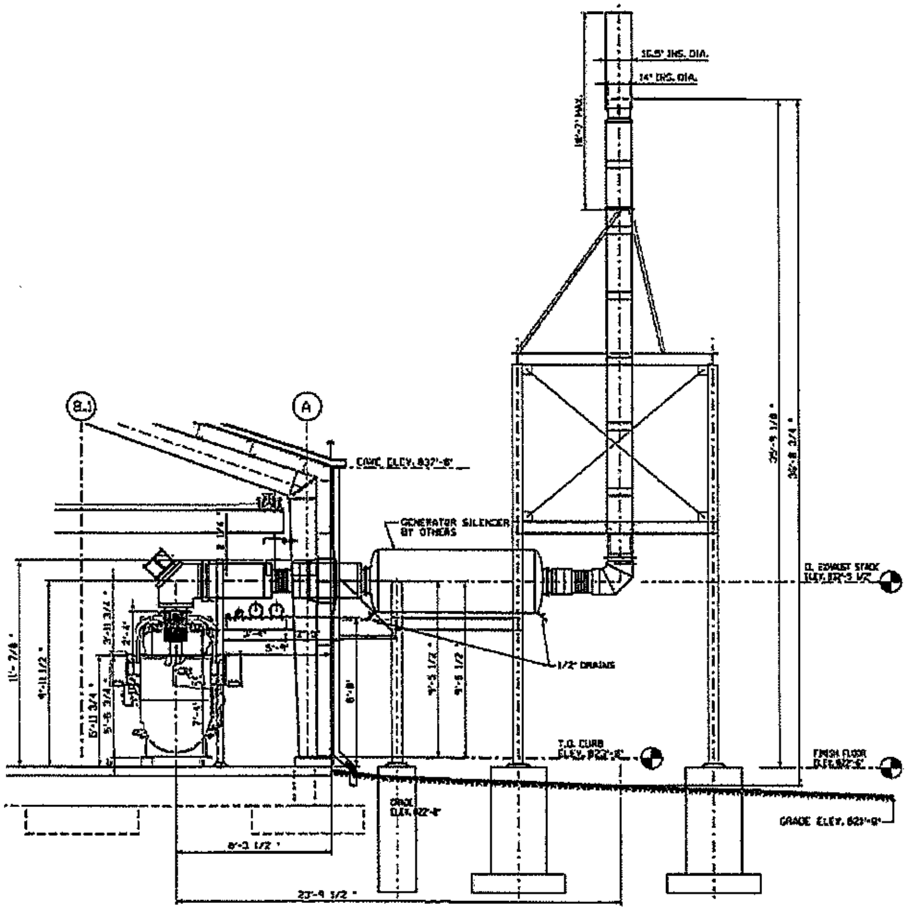
COMMENTS

UNIVERSAL SILENCER

18-6000004

0 1 of 1

42251 - 42253



SECTION 'E - E' - GENERATOR STACK

SCALE: 3/8"=1'-0"

NOTE:

REFERENCE VENDOR DEAN BOILER DWG'S:
E3689L872.5 - BOILER STACK INSTALLATION
E3689L2283 - GENERATOR STACK INSTALLATION

REVISED FOR RECORD

WHITE PIGEON COMPRESSOR STATION
FACILITY SET

PLANT 3 ADDITION, AUX. BLDG
GENERATOR & BOILER EXHAUST STACKS
ELEVATION & DETAILS

Consumers Energy
GAS T. & S. ENGINEERING
JACKSON, MICHIGAN

DRAWN J. MAYA
CHECKED J. MAYA
DESIGNED M. FIELD

M-3005 | 003 | G

DWG. NO. | REFERENCE DRAWINGS | REV. | DATE | DESCRIPTION

...\133M3005-004.003.dgn 7/12/2010 11:16:02 AM