Consumers Energy

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40 CFR 60 Subpart JJJJ Compliance Test Report

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AIR QUALITY DIVISION

EUEMERGGEN3

Ray Compressor Station
69333 Omo Road
Armada, Michigan 48005
State Registration Number (SRN) B6636

Test Date: April 26, 2017

Report Submitted:
June 13, 2017

Report Revision 0

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

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1.0 INTRODUCTION

Identification, location and dates of tests

Consumers Energy Company's (CEC) Regulatory Compliance Testing Section (RCTS) performed air emission testing on one (1) 4-stroke lean burn (4SLB) natural gas-fired, reciprocating internal combustion engine (RICE) identified as EUEMERGGEN3, installed and operating at CEC's Ray Compressor Station (RCS) on April 26, 2017 in Armada, Michigan. A Test Protocol dated March 8, 2017 was submitted and subsequently approved by the Michigan Department of Environmental Quality (MDEQ) in their letter dated March 23, 2017.

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 testing was performed to evaluate compliance with *Standards of Performance for Stationary Spark Ignition* (SI) *Internal Combustion Engines* (ICE), 40 CFR Part 60, Subpart JJJJ. Specific test parameters are described in Table 1 below and are also specified in the RCS Renewable Operating Permit (ROP) No. *MI-ROP-B6636-2015a*.

TABLE 1
Summary of EUEMERGGEN3 Test Parameters

Test Parameter	Measurement Unit	Test Location	Regulation
Nitrogen Oxides (NO_x), Carbon Monoxide (CO) & Volatile Organic Compounds[1] (VOCs), [as Non-Methane Organic Compound (NMOC)]	grams per horsepower hour (g/HP-hr)	Engine Exhaust	40 CFR Part 60 Subpart JJJJ

[1] Although 40 CFR Part 60 Subpart JJJJ refers to volatile organic compounds as defined in 40 CFR 51.100(s)(1), which specifies a VOC definition including *"any compound of carbon...other than the following, which have been determined to have negligible photochemical reactivity: methane, ethane..."*, for this test event, the Subpart JJJJ exhaust gas measurements of VOC include ethane.

Brief description of source

The Ray Compressor Station maintains EUEMERGGEN3 as an emergency generator when emergency power is needed. The RICE is not equipped with add-on controls.

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 testing was performed by CEC RCTS employees Joe Mason and Dillon King on April 26, 2017. There were no MDEQ representative's onsite to witness the test. Mr. Charles Kelley, Ray Field Leader, coordinated the test and collected operating data. Table 2 contains additional test program participant contact information.

TABLE 2
Ray Compressor Station RICE Test Program Participants

Responsible Party	Address	Contact
Test Facility Representative	Ray Compressor Station 69333 Omo Road Armada, Michigan 48005	Mr. Charles Kelly 586-784-2096 charles.kelley@cmsenergy.com
Corporate Air Quality Representative	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 231-720-4856 joe.mason@cmsenergy.com
State Representative	Michigan Department of Environmental Quality Technical Programs Unit 525 W. Allegan, Constitution Hall Lansing, Michigan 48909	Mr. Thomas Gasloli 517-284-678 gasloit@michigan.gov
		Mr. Robert Elmouchi 586-753-3736 elmouchir@michigan.gov

2.0 SUMMARY OF RESULTS

The NO_x, CO and VOC (as NMOC) results, presented in Table 3, indicate that EUEMERGGEN3 is in compliance with Subpart JJJJ and facility-specific ROP emission limits.

TABLE 3
Summary of Emission Results

Test Parameter	Emission Rate (g/HP-hr)	JJJJ/ROP Limit (g/HP-hr)
NO_x	0.42	2.0/0.5
CO	2.1	4.0
$VOC_{as\ NMOC}$	0.19	1.0/0.81

[1] Please note that the facility ROP does not have a CO g/HP-hr emission limit specific to EUEMERGGEN3, and the source is therefore subject only to the 4.0 g/HP-hr limit in 40 CFR 60 Subpart JJJJ.

Operating Data

A portable load bank, provided by Caterpillar, was connected to the engine during the performance testing so that an operating load could be achieved within 10% of full load, as Subpart JJJJ § 60.4244(a) states *each performance test must be conducted within 10 percent of 100 percent peak (or the highest achievable) load*. Operating data collected during each test run consisted of engine torque, rpm, fuel flow rate, and load (torque). Horsepower was calculated by multiplying the vendor supplied horsepower output of 1,818 by the logged percent load. Ambient temperature, barometric pressure and humidity data was also collected.

Applicable Permit Number

The Ray Compressor Station is currently operating 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 natural gas pressure to move it in and out of storage reservoirs and along the pipeline system. The natural gas-fired emergency generator engine was installed in 2013 to provide emergency power for the site.

The engine NO_x emissions are minimized through lean-burn combustion technology. Lean-burn combustion occurs when a high level of excess air (generally 50% to 100% relative to the stoichiometric amount) in the combustion chamber absorbs combustion process heat, thereby reducing combustion temperatures and pressure, resulting in lower NO_x emissions. Since original installation, significant maintenance has not been performed on the engine.

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

Table 4 contains pertinent vendor provided engine specifications.

TABLE 4

Summary of Manufacturer Specifications

Parameter [1]	**EUEMERGGEN3**
Make	Caterpillar
Model	G3516B LE
Output (brake-horsepower)	1,818
Heat Input, LHV (mmBtu/hour)	12.8
Exhaust Gas Temp. (ºF)	974

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

Description of Process Instrumentation Monitored During the Test

In addition to the engine operating data described earlier, electric generator amperage was logged and averaged for each test run.

4.0 SAMPLING AND ANALYTICAL PROCEDURES

Description of sampling train(s) and field procedures

Triplicate one-hour NO_X, CO, $VOC_{as\ NMOC}$ and O_2 runs were conducted at the engine exhaust with the unit operating within 10% of 100% peak (or the highest achievable) load using Reference Methods in 40 CFR Part 60, Appendix A.

All components of the extractive sample systems in contact with flue gas were constructed of Type 316 stainless steel and/or Teflon. The 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 instrument. The output signal from each analyzer was connected to a computerized data acquisition system (DAS).

The O_2, NO_X, and CO analyzers were calibrated with U.S. EPA Protocol calibration gases at a minimum of three points: zero (0-20% of calibration span), mid-level (40-60% of calibration span) and high-level gas (equal to the calibration span). 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.

After correcting the post-test analyzer data for drift and bias, the average NO_X, CO and $VOC_{as\ NMOC}$ g/HP-hr emission rates were calculated on a dry basis using Equations 1-3 and Table 2 in 40 CFR Part 60, Subpart JJJJ §60.4244. The conversion of wet $VOC_{as\ NMOC}$ concentrations to a dry basis was approximated in the field, however 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 as presented in this report. CO_2 and O_2 concentrations were measured as percent by volume, dry basis.

Detailed Discussion of Test Methods

4.1 Traverse Points

The engine exhaust traverse points were determined based on U.S. EPA Method 1 *Sample and Velocity Traverses for Stationary Sources* criteria. During run 1, gas concentrations were measured from twelve traverse points. After determining the duct was not stratified, one traverse point was selected for each run thereafter which most closely matched the average concentration measured. Figure 2 of this report illustrates the path of engine effluent.

4.2 Diluent/Molecular Weight

O_2 concentrations were measured at the outlet using a paramagnetic analyzer 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 exhaust gas moisture content was measured in the field using U.S. EPA Alternate Method 008, *Alternative Moisture Measurement Method Midget Impingers* during one 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. This measurement served as a surrogate moisture value in the field until moisture results from the natural gas fuel sample 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 5 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 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 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.

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.

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

The exhaust stack configuration for EUEMERGGEN3 is shown in Figure 2.

5.0 TEST RESULTS AND DISCUSSION

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

Table 1 following the text of this report contains a comprehensive summary of emission rates from the April 26th, 2017 test event. RICE operating data, calculation spreadsheets, field data sheets, calibration information, fuel analyses and analytical data are contained in Attachments 1 - 6.

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

The NO_x, CO and $VOC_{as\ NMOC}$ emission rates are within ROP *MI-ROP-B6636-2015a* and 40 CFR 60 Subpart JJJJ limits for the emergency 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 along with the Thermo 55I analyzer 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 5.

TABLE 5
SUMMARY OF CONCENTRATIONS AND EMISSIONS
RAY COMPRESSOR STATION
EUEMERGGEN3
APRIL 26, 2017

Time Period	Run 1	Run 2	Run 3	Averages
	1202-1302	**1328-1428**	**1450-1550**	
Process Conditions				
Engine Speed, Revolutions Per Minute:	1,799.2	1,800	1,798.5	**1,798**
Brake Horsepower:	1,676	1,681.4	1,681.1	**1,703**
Load, Percent:	92.2	92.5	92.5	**100.0**
Fuel Flow, SCFM:	213.89	214.14	214.74	**232.6**
Exhaust Gas Conditions				
Drift Corrected Oxygen Concentration, Dry (Percent):	9.58	9.48	9.45	**9.50**
Drift Corrected CO Concentration, Dry (ppmdv):	509.61	503.22	503.95	**505.6**
Drift Corrected CO Concentration, Dry (ppmdv @ 15% O_2):	265.64	259.92	259.57	**261.7**
CO Emission Rate, g/HP-Hour:	2.12	2.07	2.07	**2.08**
40 CFR Part 60, Subpart JJJJ Emission Limit g/HP-Hour:	4.0	4.0	4.0	**4.0**
Drift Corrected NOx Concentration, Dry (ppmdv):	67.8	59.6	60.1	**62.5**
NOx Emission Rate, g/HP-Hour:	0.46	0.40	0.41	**0.42**
ROP Emission Limit, g/HP-Hour [1]:	0.5	0.5	0.5	**0.5**
$VOC_{as\ NMOC}$ Concentration, Dry (ppmdv), as Propane:	53.5	54.9	56.6	**54.98**
$VOC_{as\ NMOC}$ Emission Rate, g/HP-Hour:	0.16	0.19	0.20	**0.19**
ROP Emission Limit, g/HP-Hour [1]:	0.81	0.81	0.81	**0.81**

[1] Note that the NO_x and VOC emission limits found in the facility ROP are more stringent than the applicable NO_x and VOC limits of 2.0 grams/HP-hour and 1.0 grams/HP-hour, respectively, as specified in 40 CFR Part 60, Subpart JJJJJ. Furthermore, the facility ROP does not state any CO emission limits for EUEMERGGEN3, so the unit is therefore subject to the Subpart JJJJ CO emission limit of 4.0 g/HP-hr only.

FIGURE 1

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

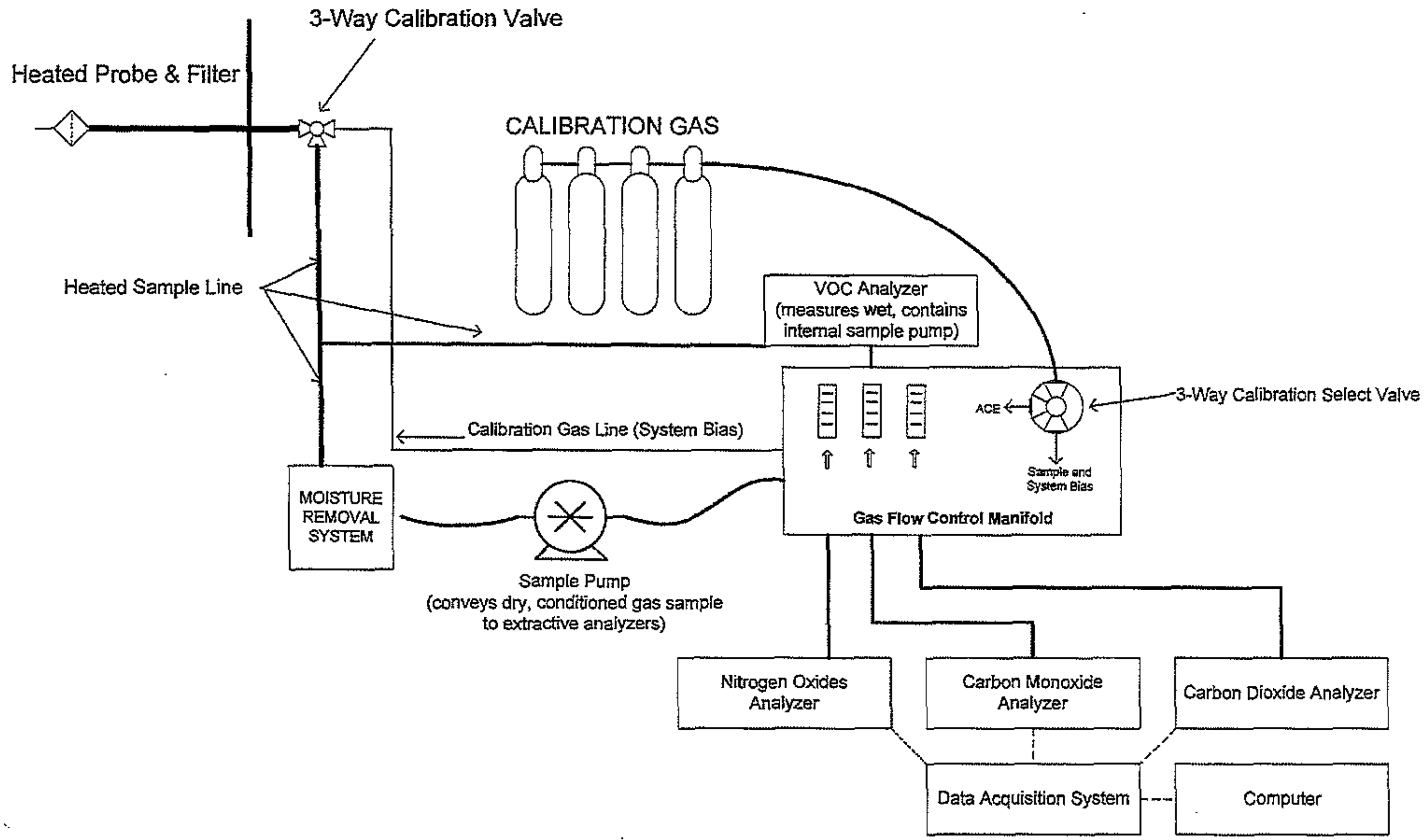
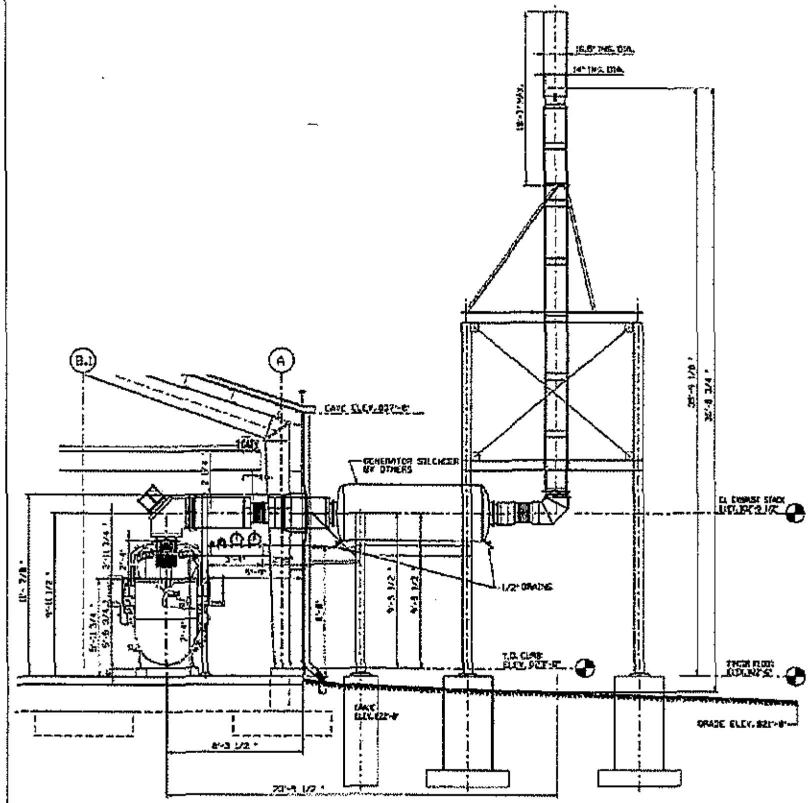


FIGURE 1

DRY AND WET EXTRACTIVE GASEOUS SAMPLE APPARATUS

FIGURE 2

Caterpillar Model G3516B LE Stack Schematic
(EUEMERGGEN3)



SECTION "E - E" - GENERATOR STACK

NOTE:

REFERENCE VENDOR DEAN BOILER DWGS:
- BOILER STACK INSTALLATION
- 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. MAXA
CHECKED J. MAXA
DESIGNED K. FIELD
APPROVED M. PEPLINSKI

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