Derenzo and Associates, Inc.
Environmental Consultants

March 28, 2011

Mr. Jeffery F. Koerner, Administrator
STATE OF FLORIDA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
New Source Review Section
2600 Blair Stone Road
Tallahassee, Florida 32399-2400

Subject: Response to Request for Additional Information
Brevard Energy, LLC Proposed PM_{10} and CO Emissions Standards Increase
Project No. 0090069-009-AC (PSD-FL-378C)

Dear Mr. Koerner:

Derenzo and Associates, Inc. (Derenzo and Associates) has prepared this document on behalf of Brevard Energy, LLC (Brevard Energy) to respond to the Florida Department of Environmental Protection (FDEP) Request for Additional Information (RAI) correspondence dated December 27, 2010.

Brevard Energy has submitted a permit application that requests increases to the allowable (permitted) carbon monoxide (CO) and particulate matter (PM_{10}) emission rates for its landfill gas (LFG) fueled reciprocating internal combustion engines (RICE) operating at the Brevard County Central Disposal Facility.

This document was prepared under the direction and approval of Mr. Richard M. DiGia, President and CEO of Landfill Energy Systems/Brevard Energy LLC, and Secondary Responsible Official for the Brevard County Central Disposal Facility.

Comment 1 – Siloxane and Hydrogen Sulfide

What are the actual siloxane and hydrogen sulfide (H_2S) levels in the landfill gas being fired in these engines? What are the vendor's maximum landfill gas siloxane and H_2S specifications for the Model No. G3520C engine? See the attached 2006 Caterpillar white paper titled, "Dealing with Landfill Fuel: Evaluating Fuel Treatment Options", which discusses contaminants in low energy fuels such as landfill gas.

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Response 1

Brevard Energy has performed semi-annual sampling and analysis of the treated LFG fuel for sulfur content since commencement of operations in 2008. The laboratory results are submitted to the FDEP as a condition of the Brevard Energy air operations permit and were provided in Appendix E of the permit application document. The measured LFG sulfur content for the semi-annual samples ranges from 165 to 338 parts per million by volume (ppmv) as H_2S. Additionally, Brevard Energy measures the H_2S content of its treated LFG fuel using a continuous monitoring system (CMS). The monthly average treated LFG H_2S content for calendar year 2010 measured with the CMS ranged from 108 to 256 ppmv.

In February 2011, Brevard Energy performed sampling and analysis of the treated LFG fuel for silicon content using the JET-CARE SiTest method recommended by the engine manufacturer, Caterpillar. The average measured total silicon content (average of two samples) was 88.4 ppm or 5.98 micrograms per British thermal unit (μg/Btu).

The treated LFG fuel sulfur and silicon analytical results are summarized in the table below.

Table 1. Summary of treated LFG fuel analyses for sulfur and silicon

Month / Year	Sulfur Content (ppmv as H_2S)	Sulfur Content (μg/Btu)	Silicon Content (ppmv as Si)	Silicon Content (μg/Btu)
May 2008	288	21	--	--
November 2008	255	19	--	--
March 2009	338	25	--	--
November 2009	165	12	--	--
May 2010	252	19	--	--
February 2011	--	--	88.4	5.98

Caterpillar has published a *Gas Engine Applications and Installation Guide* (A&I Guide) for its G3600 through G3300 series engines. The A&I Guide presents fuel quality guidelines for Caterpillar gas engines with model number prefixes 33 through 36, which includes the model G3520C engines used at Brevard Energy.

The A&I Guide presents a table of recommended conditions for gas used in low energy fuel engines (e.g., landfill gas), which the FDEP reproduced in its RAI correspondence. The recommended fuel gas:

- Sulfur content is 60 µg/Btu or less.
- Silicon content is 0.6 µg/Btu or less.

The site-specific test results indicate that the sulfur content of the treated LFG fuel at Brevard Energy is within the recommended value and that the siloxane content (as total silicon) exceeds the recommended value. This indicates that more frequent preventative maintenance may be required to periodically remove deposits within the combustion cylinders.

Attachment A provides calculations for converting measured H_2S concentration values to µg/Btu.

Attachment B provides a copy of the JET-CARE SiTest Analytical Report.

Comment 2 – Operation and Maintenance

Please describe the operation and maintenance practices that operators have employed so far to minimize CO and PM10 emissions. Have the engines been tuned in accordance with the vendor's specifications to achieve the optimal air-to-fuel mixture that will promote good combustion? Has it been necessary to change the air-to-fuel ratio? Have periodic washes been performed to remove contaminant buildup?

Response 2

The engine/generator sets are not equipped with add-on emission control devices. Therefore, air pollutant emissions are minimized through proper operation and maintenance of the fuel treatment and combustion systems.

The incoming LFG is treated (filtered, compressed and dewatered) prior to combustion. The treatment system contains primary and polishing filter vessels that use coalescing filters designed to remove particulates greater than or equal to 0.3 microns in size (0.3 micron filter rating). This exceeds (is better than) the recommended particulate filtration of 1 micron specified in the Caterpillar A&I Guide. The treatment system is described in more detail in Response 3.

Air/fuel blending and ignition in the CAT® G3520C engine is controlled by the Caterpillar engine control module (ECM). The inlet gas methane content (i.e., heat value) is monitored and the fuel is blended with an appropriate amount of combustion air (air-fuel ratio) based on internal mapping within the ECM. The engine is equipped with numerous sensors that monitor critical operation parameters. The engine operating data are received by the ECM, which adjusts operating variables to maximize fuel combustion efficiency and engine output. Therefore, air-to-fuel ratio is constantly being adjusted by the ECM computer based on the fuel quality measurements and the process monitoring feedback control loop. The ECM mapping is setup and calibrated by Caterpillar; Brevard Energy has not changed these settings.

Since the treated LFG fuel contains sulfur and siloxanes that have the potential to create deposits within engine, Brevard Energy follows a preventative maintenance schedule that is significantly more aggressive than natural gas fired engines:

- Spark plugs are changed every 400 hours of operation (approximately twice per month);
- Lubricating oil is changed every 800 hours of operation (approximately once per month); and
- Intake and exhaust valves are reset every 800 hours of operation.

The recently-promulgated RICE National Emission Standard for Hazardous Air Pollutants (NESHAP, 40 CFR Part 63, Subpart ZZZZ) requires oil changes and spark plug inspections at 1,440-hour intervals, which presumably is based on USEPA's research of standard industry practices. The frequency of the preventative maintenance actions at Brevard Energy are considerably more stringent than those specified in the RICE NESHAP.

Whenever the lubricating oil in the engine is changed (i.e., once per month), a sample of the used oil is sent to the oil supplier for analysis. The supplier checks the used oil for levels of acids, particles, metals, silicon, coolant breakthrough and other performance indicators. The analytical results of the used oil at Brevard Energy verify that the oil change schedule is appropriate for the site-specific conditions.

Once operating hours or combustion deposits reach a certain level, an engine is scheduled for a top-end overhaul. The engine heads and pistons are replaced (or reused pistons are equipped with new rings) and deposits within the combustion cylinders are removed mechanically by chipping, grinding and polishing. Brevard Energy does not perform "washes" to remove contaminant build-up. Water does not effectively remove combustion system deposits. These deposits must be removed using mechanical methods. The FDEP may be referring to a procedure that Caterpillar has described in which deionized, reverse-osmosis water is injected into the combustion air intake during operation to loosen hardened engine deposits. This procedure has many disadvantages and can cause severe engine damage if not performed in a controlled environment. Caterpillar has since rescinded this recommendation based on its potential to cause component damage and/or engine failure.

Comment 3 – Gas Filtration and Drying

The figure in Appendix D, "Process Flow and Engineering Specifications", identifies two filters in the landfill gas treatment system prior to the engines: a two-stage 10-micron inlet filter; and a two-stage, 3-micron outlet filter. For low energy fuels, Caterpillar recommends limiting the particulate matter in the fuel to no more than 1 micron. Permit No. 0090069-004-AC specifies the installation and use of a one micron filter. What was installed in the existing system? Please provide the recommended vendor specifications regarding the vendor for cooling and drying gas.

Response 3

The information and diagram provided in the November 2010 permit application is from an earlier drawing and is not representative of actual operations. Brevard Energy uses two (2) two-stage filter towers in its LFG treatment system (primary and polishing filters) that are installed prior to and after the compressor. Each filter tower contains a coalescing filters rated at 0.3 micron.

The LFG treatment system consists of a(n):

1. Primary two-stage filter tower containing coalescing filters rated for 0.3 microns.

2. Positive displacement gas compressor.

3. Air-to-gas cooler designed to cool the gas to within 10°F of ambient temperature.

4. Polishing two-stage filter tower containing coalescing filters rated for 0.3 microns.

Attachment C provides a revised process flow diagram specifying the appropriate 0.3 micron filter rating for the gas treatment system.

The treated gas has a dew point of approximately 36°F and is delivered to the engines at a pressure of 2.2 pounds per square inch, gauge (psig). These treatment methods and fuel parameters satisfy the Caterpillar recommendations for low energy fuel engines.

Comment 4 – Fuel Properties and Delivery Pressure

The following table summarizes several critical parameters for low energy fuels identified by Caterpillar. How does the landfill gas being fired by Brevard Energy compare to these specifications? Is the landfill gas being provided at a relatively constant pressure (±0.25 psig)?

Is the supply pressure continuously monitored? For which contaminants does the facility typically analyze the landfill gas? What is the frequency of such sampling and analysis?

Response 4

Brevard Energy has installed a pressure transducer in the main fuel supply header between the treatment system and the CAT® G3520C engines to continuously monitor and record fuel supply pressure. Records for calendar year 2010 indicate that the fuel was delivered to the engines at an average pressure of 2.2 psig. Throughout the year, the fuel delivery pressure ranged between a minimum of 2.1 psig and a maximum of 2.3 psig (i.e., had a variation of less than $\pm$0.25 psig).

Thermocouples are installed to monitor the temperature of the fuel gas in the main fuel supply header between the treatment system and the CAT® G3520C engines. Daily readings are performed to record the gas temperature. The maximum observed temperature for calendar year 2010 was 108°F.

Brevard Energy has performed semi-annual sampling and analysis of the treated LFG fuel for chlorinated compound content since commencement of operations in 2008. The analytical results are submitted to the Florida DEP as a condition of the Brevard Energy air operations permit and were provided in Appendix E of the permit application documents. The maximum calculated chloride content of the treated LFG fuel is 0.85 µg/Btu for the semi-annual samples collected from May 2008 through October 2010. The manufacturer recommendation for fuel gas halide content is 20 µg/Btu or less.

Attachment D provides a summary of the chlorinated compound analytical results and calculations for converting measured concentration values to µg/Btu.

Based on information presented in this correspondence, the treated LFG fuel used at Brevard Energy satisfies the manufacturer's sulfur, halide, particulate, temperature, pressure and moisture recommendations. Total silicon content is addressed in Response 1 and 2 of this correspondence. The treated fuel has not been analyzed for ammonia and oil content.

Comment 5 – Stack Emission Analysis

Do the operators perform any stack emissions analysis with hand-held portable monitors? If available, please provide this representative information data.

Response 5

The operators at Brevard Energy do not perform stack emissions analysis with a hand-held portable monitor. An emission source test is performed for one RICE per year. These results are presented in the following response.

Comment 6 – Source Test Results and Test Methods

In Appendix H-1, "Summary of Compliance Test Results for CAT G3520C Engines", provides information regarding the performance stack tests for CO and PM_{10} emissions conducted on the 1600 kW Caterpillar Model G3520C engines at Ocean Energy, Brevard Energy, Seminole Energy and Trail Ridge Energy...

a. *The information appears to show compliant emission levels with little variation between engines. Provide additional information to support the claim that performance degradation of the engines over time has caused higher actual CO and PM_{10} emissions for installed engines.*

b. *Please identify which test methods were used to determine the PM_{10} emission rate from the Brevard Energy engines (and other engines if known).*

Response 6a

Emission source testing has been performed on one Brevard Energy CAT® G3520C RICE per year since commencement of operations.

Attachment E-1 provides a summary of the measured CO emission rate for each one hour test period and includes results from the most recent testing performed on March 14, 2011.

Attachment E-2 provides a summary of the measured PM_{10} emission rate for each one hour test period (the PM_{10} results from the March 14, 2011 test event are not yet available).

The measured CO emission rate for each of the twelve (12) one-hour test periods is between 80 and 97% of the allowable mass emission rate. The most recent test results are within one standard deviation of exceeding the permitted CO emission rate of 2.75 g/bhp-hr.

Based on the experience of Landfill Energy Systems (the parent company of Brevard Energy, LLC) with LFG-fueled RICE generators at similar facilities, the CO emission rate will likely increase with respect to operating hours and, at some point, may exceed the existing permitted value of 2.75 g/bhp-hr. Brevard Energy is proactively seeking this permit modification to provide compliance assurance and prevent unnecessary enforcement actions by the regulatory agency. The proposed allowable CO emission rate (3.30 g/bhp-hr) is 20% less than the manufacturer's specified not-to-exceed emission rate of 4.13 g/bhp-hr and 30% less than the limit specified in the federal New Source Performance Standard for Spark Ignition Internal Combustion Engines (40 CFR Part 60 Subpart JJJJ) for new LFG-fueled engines, which is 5.0 g/bhp-hr. The proposed CO emission rate results in ambient air impacts that are in compliance with all applicable ambient air quality standards (an air pollutant modeling and standards demonstration was submitted with the permit application).

Attachment F provides a copy of the Caterpillar Gas Engine Technical Data Sheet for the CAT® G3520C.

The measured emission rate for each of the nine (9) one-hour PM_{10} test periods is greater than 75% of the allowable mass emission rate (0.24 g/bhp-hr) , and in some cases, exceeds 0.24 g/bhp-hr for an individual one-hour test period (however, the three-test average for each test event is below the permitted emission rate). Additionally, the average of the nine (9) one-hour test results is within one standard deviation of exceeding the allowable emission rate.

Response 6b

The performance testing performed at all of the identified facilities (Ocean Energy, Brevard Energy, Seminole Energy, and Trail Ridge Energy) was performed using USEPA Method 5 (for filterable PM) and USEPA Method 202 (for condensable PM emissions). All collected particulate matter was assumed to be PM_{10}.

For the most recent test event at Brevard Energy in March 2011, particulate matter testing was performed according to the newly-promulgated Method 202 for condensable particulate matter. The revisions to Method 202 are designed to reduce the influence of artifact particulate formation within the sampling train. These test results are not available as of the date of this response document and will be forwarded to FDEP upon receipt of the laboratory data and completion of the test report.

Additional Information Regarding CO Emission Rates

The properties of the LFG collected at the Brevard County Central Disposal Facility are not notably different than the LFG collected at municipal solid waste landfills throughout the U.S. The LFG treatment methods used by Brevard Energy are typical of those used throughout the LFG-to-energy industry and result in a treated fuel gas that complies with the engine manufacturer's fuel parameter recommendations, with the exception of siloxane (total silicon) content. Brevard Energy (and other engine operators) has countered this by implementing an aggressive preventative maintenance schedule and oil monitoring program. These practices have resulted in measured CO emission rates that are well below the manufacturer's specified not-to-exceed emission value, which is 4.13 g/bhp-hr for CO.

The CO emission limit specified in the air operations permit issued to Brevard Energy (2.75 g/bhp-hr) is 33% less than the manufacturer's specified not-to-exceed emission value and does not take into account potential increases in emission rate throughout the maintenance cycle and operating life of the engine. Caterpillar has acknowledged the influence of operating hours on the engine CO emission rate in its Gas Engine Technical Data Sheet for the CAT® G3520C, which specifies that the "Nominal" CO emission value (2.5 g/bhp-hr) is representative of a new engine and is only valid for the first 100 hours of operation (see endnote 15 of the Attachment F Gas Engine Technical Data Sheet). Brevard Energy has proposed a more appropriate allowable CO emission rate that is based on periodic emission measurements performed on other LFG-fueled CAT® G3520C engines at similar facilities and is between the new engine "Nominal" emission value and the manufacturer's not-to-exceed emission value.

Derenzo and Associates, Inc./Brevard Energy, LLC appreciate the consideration of the FDEP of the information presented in this correspondence.

Please contact us at (517) 324-1880 or rharvey@derenzo.com if you have any questions or require additional information.

Sincerely,

DERENZO AND ASSOCIATES, INC.

Robert L. Harvey, P.E.
Engineering Services Manager

c: Ms. Heidi Coggins, FDEP New Source Review Section
Mr. Richard M. DiGia, Landfill Energy Systems/Brevard Energy, LLC

Attachment A

Brevard Energy, LLC
Hydrogen Sulfide Content Analyses

Month/Year	Sulfur Content (ppmv as H_2S)	Sulfur[1] Content (μg/Btu)
May-2008	288	21
Nov-2008	255	19
Mar-2009	338	25
Nov-2009	165	12
May-2010	252	19

Notes

1. Based on an average LFG heat value of 510 Btu/scf using the following equation:

Sulfur Content (μg/Btu) = $(Cs/10^6)$ (AWs) (453,600,000 μg/lb) / V_M / HVgas.

where: Cs = concentration sulfur (ppmv as H_2S)
AWs = atomic weight sulfur (32.06)
V_M = molar volume of ideal gas (387 scf/lb-mol)
HVgas = heat value of landfill gas (510 Btu/scf)

ATTACHMENT B

LFG SILICON ANALYTICAL RESULTS

JET-CARE

SiTest SILICON SAMPLE REPORT

JET-CARE INTERNATIONAL INC
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e. enquiries@jet-care.com
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~Attention: David Derenzo

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~Address: 39395 Schoolcraft Rd.
Livonia, MI 48150

~Email: dderenzo@derenzo.com
~Site: Brevard Energy
~Equipment Registration:
~Position:
~Hours:

Report Date: 02-17-11
Analysis Date: 02-17-11
Date Received: 02-16-11

~ indicates information supplied by customer

The tests are carried out in accordance with 'in house' documented methods. Wear Elements by Inductively Couple Plasma, carried out using M019 results quoted in ppm or wt %.
Results are issued under the authority of A. Hadowanetz, Laboratory Manager.

Summary issue no:	1	2				
~Sample Date:	02-11-11	02-11-11				
~Sample ref:	2911	2912				
~**Methane* %:	51.0%	51.0%				
Lab ref no: Lab result:	M11B329 15.86	M11B332 17.07				
Lab ref no: Lab result:	M11B330 21.96	M11B333 22.58				
Lab ref no: Lab result:	M11B331 38.35	M11B334 39.33				

NOTE: *As previously agreed, original silicon results are then sub-contracted to Bio-Engineering Services for* ***SiTest*** *result values using Methane Values* as supplied with submitted samples. µg/BTU conversion and* ***SiTest*** *values are provided under the authority of Mark Downing. This service is outside the scope of UKAS accreditation.*

SiTest Silicon (mg/Nm^3CH_4)	199.14	206.48				
Silicon (ppm)	86.79	89.99				
µg/Btu	5.87	6.08				

Comments:

Approved by: Ana Alvarez Elejalde
Laboratory Technician

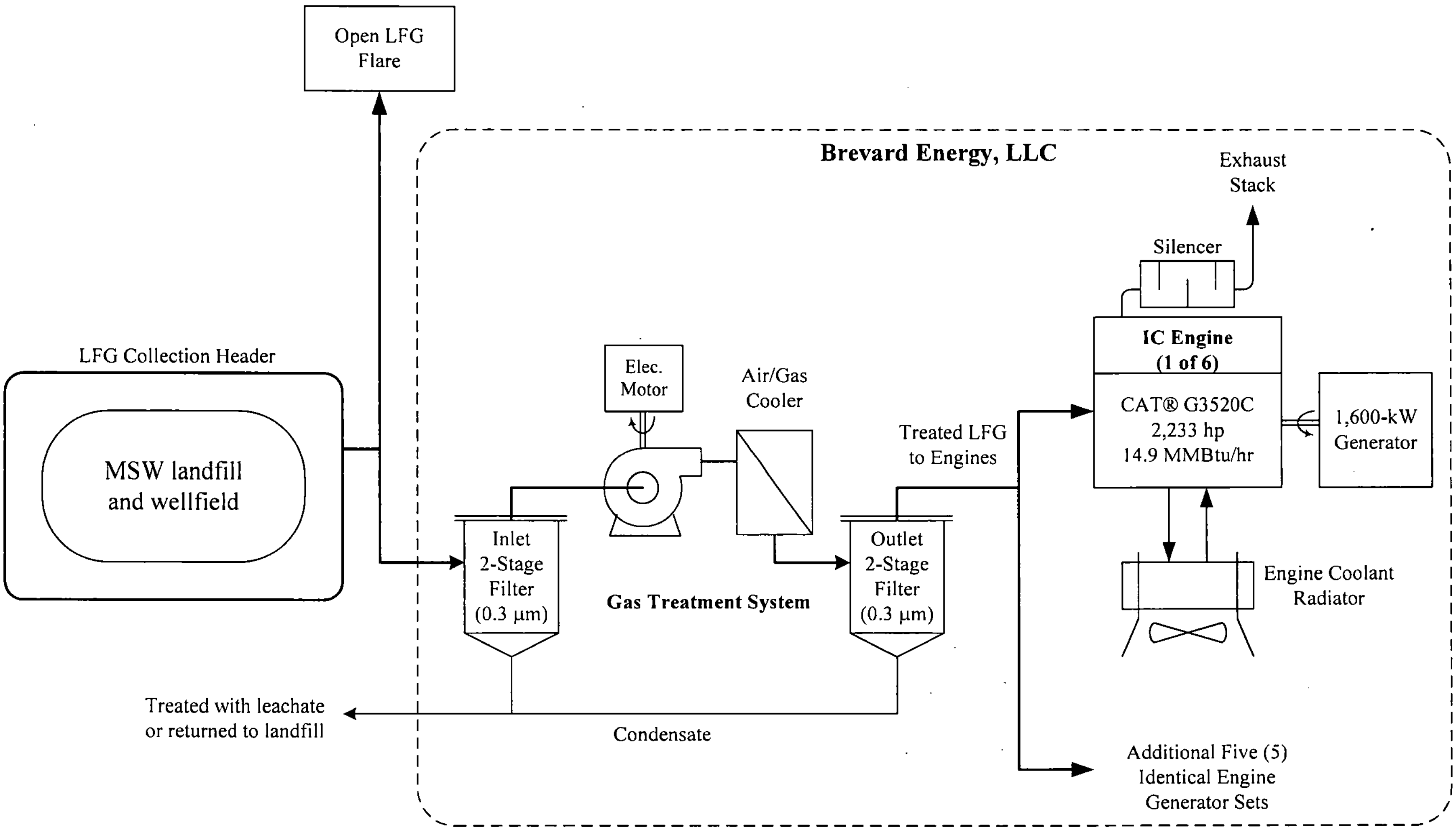
Issued under the authority of
Alison Hadowanetz
Laboratory Manager

Opinions and Interpretations herein are outside the scope of UKAS accreditation

Q/195A Issue 1
August 25 2010

ATTACHMENT C

REVISED PROCESS FLOW DIAGRAM



3/24/11	**Brevard Energy, L.L.C.** **LFG Electricity Generation Facility**		
	Scale None	Sheet 1 of 1	Derenzo and Associates Project No. 0804010

Attachment D

Brevard Energy, LLC
Chloride Content Analyses

Month/Year	Total Chlorine Content (ppmv)	Chlorine[1] Content (ug/Btu)
May-2008	7.80	0.64
Nov-2008	5.28	0.43
Mar-2009	3.54	0.29
Nov-2009	8.41	0.69
May-2010	10.40	0.85
Oct-2010	6.40	0.52

Notes

1. Based on an average LFG heat value of 510 Btu/scf using the following equation:

Chlorine Content (μg/Btu) = $(C_{Cl}/10^6)$ (AW_{Cl}) (453,600,000 μg/lb) / V_M / HVgas

where: C_{Cl} = chlorine concentration (ppmv as HCl)
AW_{Cl} = atomic weight chlorine (35.45)
V_M = molar volume of ideal gas (387 scf/lb-mol)
HVgas = heat value of landfill gas (510 Btu/scf)

Attachment E-1
Summary of Brevard Energy CO Source Test Results

Date	Unit	CO (lb/hr)	CO (g/bhp-hr)	% of Limit
9/24/2008	Engine #5	11.7	2.38	87%
9/24/2008	Engine #5	11.7	2.38	87%
9/24/2008	Engine #5	11.7	2.40	87%
3/19/2009	Engine #3	11.69	2.37	86%
3/19/2009	Engine #3	12.02	2.44	89%
3/19/2009	Engine #3	11.83	2.40	87%
5/3/2010	Engine #6	10.76	2.21	80%
5/3/2010	Engine #6	10.84	2.22	81%
5/3/2010	Engine #6	11.05	2.27	83%
3/14/2011	Engine #4	13.17	2.68	97%
3/14/2011	Engine #4	12.78	2.60	95%
3/14/2011	Engine #4	12.86	2.61	95%
	Average		**2.41**	
	Min		**2.21**	
	Max		**2.68**	
	Standard Deviation		**0.15**	

Attachment E-2
Summary of Brevard Energy PM-10 Source Test Results

Date	Unit	PM-10 (lb/hr)	PM-10 (g/bhp-hr)	% of Limit
9/24/2008	Engine #5	1.11	0.225	94%
9/24/2008	Engine #5	1.23	0.249	104%
9/24/2008	Engine #5	1.18	0.240	100%
3/19/2009	Engine #3	1.38	0.28	117%
3/19/2009	Engine #3	0.86	0.18	75%
3/19/2009	Engine #3	0.96	0.19	79%
5/3/2010	Engine #6	1.16	0.24	100%
5/3/2010	Engine #6	1.04	0.21	88%
5/3/2010	Engine #6	0.99	0.20	83%
	Average		**0.22**	
	Min		**0.18**	
	Max		**0.28**	
	Standard Deviation		**0.03**	

ATTACHMENT F

CAT® G3520C GAS ENGINE TECHNICAL DATA

G3520C GAS ENGINE TECHNICAL DATA CATERPILLAR®

ENGINE SPEED:	1200	FUEL:	LOW ENERGY (1.43 CH4:CO2 RATIO)
COMPRESSION RATIO:	11.3:1	FUEL SYSTEM:	CAT LOW PRESSURE WITH AIR FUEL RATIO CONTROL
AFTERCOOLER - STAGE 1 MAX. INLET (°F):	218		
AFTERCOOLER - STAGE 2 MAX. INLET (°F):	130	FUEL PRESS. RANGE (PSIG):	1.5 - 5.0
JACKET WATER - MAX. OUTLET (°F):	230	MIN. METHANE NUMBER:	135
COOLING SYSTEM:	JW+1AC, OC+2AC	RATED ALTITUDE (FT):	1378
IGNITION SYSTEM:	ADEM3	AT AIR TO TURBO. TEMP. (°F):	77
SPARK PLUG TYPE:	J-GAP	NOx EMISSION LEVEL:	0.5 g/bhp-hr
EXHAUST MANIFOLD:	DRY	FUEL LHV (BTU/SCF):	456
COMBUSTION:	LOW EMISSION	APPLICATION:	GENSET

RATING AND EFFICIENCY		NOTES	LOAD	100%	75%	50%
ENGINE POWER	(WITHOUT FAN)	(1)	BHP	2233	1675	1116
GENERATOR POWER	(WITHOUT FAN)	(2)	EKW	1600	1200	800
ENGINE EFFICIENCY	**(ISO 3046/1)**	**(3)**	**%**	**40.1**	**38.6**	**36.1**
ENGINE EFFICIENCY	(NOMINAL)	(3)	%	39.1	37.7	35.2
THERMAL EFFICIENCY	(NOMINAL)	(4)	%	41.3	40.6	42.2
TOTAL EFFICIENCY	(NOMINAL)	(5)	%	80.4	78.3	77.4

ENGINE DATA						
FUEL CONSUMPTION	**(ISO 3046/1)**	**(6)**	**BTU/bhp-hr**	**6354**	**6592**	**7047**
FUEL CONSUMPTION	(NOMINAL)	(6)	BTU/bhp-hr	6509	6753	7219
AIR FLOW (77 °F, 14.7 psi)		(7)	SCFM	4512	3415	2286
AIR FLOW		(7)	lb/hr	20006	15141	10136
COMPRESSOR OUT PRESSURE			in. HG (abs)	105.8	80.8	55.5
COMPRESSOR OUT TEMPERATURE			°F	375	306	220
AFTERCOOLER AIR OUT TEMPERATURE			°F	142	138	135
INLET MAN. PRESSURE		(8)	in. HG (abs)	94.4	71.5	48.9
INLET MAN. TEMPERATURE	(MEASURED IN PLENUM)	(9)	°F	142	138	135
TIMING		(10)	°BTDC	27	27	27
EXHAUST STACK TEMPERATURE		(11)	°F	898	943	984
EXHAUST GAS FLOW (@ stack temp.)		(12)	CFM	12476	9780	6770
EXHAUST MASS FLOW		(12)	lb/hr	22318	16940	11418

EMISSIONS DATA					
NOx (as NO2)	(13)	g/bhp-hr	0.5	0.5	0.5
NTE CO	(14)	g/bhp-hr	4.13	4.25	4.4
NOMINAL CO	(15)	g/bhp-hr	2.5	2.5	2.5
THC (molecular weight of 15.84)	(14)	g/bhp-hr	5.84	6.49	7.51
NMHC (molecular weight of 15.84)	(14)	g/bhp-hr	0.88	0.98	1.13
EXHAUST O2	(16)	% DRY	9.0	8.8	8.6
LAMBDA	(16)		1.71	1.67	1.57

HEAT BALANCE DATA					
LHV INPUT	(17)	BTU/min	242216	188451	134313
HEAT REJECTION TO JACKET	(18)	BTU/min	28738	23806	21929
HEAT REJECTION TO ATMOSPHERE	(19)	BTU/min	7210	6034	4857
HEAT REJECTION TO LUBE OIL	(20)	BTU/min	10108	9524	8917
HEAT REJECTION TO EXHAUST (LHV to 77° F)	(21)	BTU/min	76779	65253	45101
HEAT REJECTION TO EXHAUST (LHV to 350° F)	(21)	BTU/min	57574	47602	34587
HEAT REJECTION TO A/C - STAGE 1	(22)	BTU/min	13823	5157	102
HEAT REJECTION TO A/C - STAGE 2	(23)	BTU/min	8895	5684	4086

CONDITIONS AND DEFINITIONS

ENGINE RATING OBTAINED AND PRESENTED IN ACCORDANCE WITH ISO 3046/1. DATA REPRESENTS CONDITIONS OF 77°F, 29.6 IN HG BAROMETRIC PRESSURE, 30% RELATIVE HUMIDITY, 10 IN H2O AIR FILTER RESTRICTION, AND 20 IN H2O EXHAUST STACK PRESSURE. ENGINE EFFICIENCY AND FUEL CONSUMPTION SPECIFICALLY NOTED AS ISO 3046/1 ARE REPRESENTED WITH 5 IN H2O AIR FILTER RESTRICTION AND 0 IN H2O EXHAUST STACK PRESSURE. CONSULT ALTITUDE CURVES FOR APPLICATIONS ABOVE MAXIMUM RATED ALTITUDE AND/OR TEMPERATURE. NO OVERLOAD PERMITTED AT RATING SHOWN.

EMISSION LEVELS ARE BASED ON THE ENGINE OPERATING AT STEADY STATE CONDITIONS AND ADJUSTED TO THE SPECIFIED NOx LEVEL AT 100% LOAD. EMISSION TOLERANCES SPECIFIED ARE DEPENDENT UPON FUEL QUALITY. METHANE NUMBER CANNOT VARY MORE THAN ± 3. PUBLISHED PART LOAD DATA IS WITH AIR FUEL RATIO CONTROL.

ENGINE RATING IS WITH 2 ENGINE DRIVEN WATER PUMPS. PUMP POWER IS NOT INCLUDED IN HEAT BALANCE DATA.

FOR NOTES INFORMATION CONSULT PAGE THREE.

FUEL USAGE GUIDE

CAT METHANE NUMBER	40	50	60	70	80	90	100	110	120	130	140	150
IGNITION TIMING	-	-	-	-	-	-	-	-	24	26	28	30
DERATION FACTOR	0	0	0	0	0	0	0	0	1.00	1.00	1.00	1.00

ALTITUDE DERATION FACTORS

AIR TO TURBO (°F)	0	1000	2000	3000	4000	5000	6000	7000	8000	9000	10000	11000	12000
130	0.96	0.93	0.89	0.86	0.83	0.79	0.76	0.74	0.71	0.68	0.65	0.63	0.60
120	0.98	0.94	0.91	0.87	0.84	0.81	0.78	0.75	0.72	0.69	0.66	0.64	0.61
110	0.99	0.96	0.92	0.89	0.86	0.82	0.79	0.76	0.73	0.70	0.68	0.65	0.62
100	1.00	0.97	0.94	0.90	0.87	0.84	0.81	0.77	0.74	0.72	0.69	0.66	0.63
90	1.00	0.99	0.96	0.92	0.89	0.85	0.82	0.79	0.76	0.73	0.70	0.67	0.65
80	1.00	1.00	0.97	0.94	0.90	0.87	0.84	0.80	0.77	0.74	0.71	0.68	0.66
70	1.00	1.00	0.99	0.96	0.92	0.89	0.85	0.82	0.79	0.76	0.73	0.70	0.67
60	1.00	1.00	1.00	0.97	0.94	0.90	0.87	0.83	0.80	0.77	0.74	0.71	0.68
50	1.00	1.00	1.00	0.99	0.96	0.92	0.88	0.85	0.82	0.79	0.76	0.73	0.70

ALTITUDE (FEET ABOVE SEA LEVEL)

AFTERCOOLER HEAT REJECTION FACTORS

AIR TO TURBO (°F)	0	1000	2000	3000	4000	5000	6000	7000	8000	9000	10000	11000	12000
130	1.33	1.37	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40
120	1.26	1.31	1.33	1.33	1.33	1.33	1.33	1.33	1.33	1.33	1.33	1.33	1.33
110	1.19	1.24	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26
100	1.13	1.17	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20
90	1.06	1.11	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13
80	1.00	1.04	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06
70	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
60	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
50	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

ALTITUDE (FEET ABOVE SEA LEVEL)

FREE FIELD MECHANICAL & EXHAUST NOISE

100% Load Data			dB(A)	(dB)							
Free Field Mechanical	DISTANCE FROM THE ENGINE (FEET)	3.2	108.5	51.5	78.7	88.2	92.9	99.9	97.3	93.2	99.2
		22.9	91.6	34.6	59.0	68.1	74.0	83.0	79.4	75.1	85.2
		49.2	85.0	28.0	55.2	64.7	69.4	76.4	73.8	69.7	75.7
Free Field Exhaust	DISTANCE FROM THE ENGINE (FEET)	4.9	106.1	67.5	86.5	96.0	88.5	88.7	90.1	95.6	92.7
		22.9	92.7	54.1	73.1	82.6	75.1	75.3	76.7	82.2	79.3
		49.2	86.1	47.5	66.5	76.0	68.5	68.7	70.1	75.6	72.7
			Overal SPL	63 Hz	125 Hz	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz	8 khz

Octave Band Center Frequency (OBCF)

FUEL USAGE GUIDE:

This table shows the derate factor required for a given fuel. Note that deration occurs as the methane number decreases. Methane number is a scale to measure detonation characteristics of various fuels. The methane number of a fuel is determined by using the Caterpillar Methane Number Calculation program.

ALTITUDE DERATION FACTORS:

This table shows the deration required for various air inlet temperatures and altitudes. Use this information along with the fuel usage guide chart to help determine actual engine power for your site.

INLET AND EXHAUST RESTRICTION CORRECTIONS FOR ALTITUDE CAPABILITY:

To determine the appropriate altitude derate factor to be applied to this engine for inlet or exhaust restrictions differing from the standard conditions listed on page 1, a correction to the site altitude can be made to adjust for this difference. Add 141 feet to the site altitude for each additional inch of H_2O of exhaust stack pressure greater than spec sheet conditions. Add 282 feet to the site altitude for each additional inch of H_2O of inlet restriction greater than spec sheet conditions. If site inlet restriction or exhaust stack pressure are less than spec sheet conditions, the same trends apply to lower the site altitude.

ACTUAL ENGINE RATING:

It is important to note that the Altitude/Temperature deration and the Fuel Usage Guide deration are not cumulative. They are not to be added together. The same is true for the Low Energy Fuel deration (reference the Caterpillar Methane Number Program) and the Fuel Usage Guide deration. However, the Altitude/Temperature deration and Low Energy Fuel deration are cumulative; and they must be added together in the method shown below. To determine the actual power available, take the lowest rating between 1) and 2).

1) (Altitude/Temperature Deration) + (Low Energy Fuel Deration)
2) Fuel Usage Guide Deration

Note: For NA's always add the Low Energy Fuel deration to the Altitude/Temperature deration. For TA engines only add the Low Energy Fuel deration to the Altitude/Temperature deration whenever the Altitude/Temperature deration is less than 1.0 (100%). This will give the actual rating for the engine at the conditions specified.

AFTERCOOLER HEAT REJECTION FACTORS:

Aftercooler heat rejection is given for standard conditions of 77°F and 500 ft altitude. To maintain a constant air inlet manifold temperature, as the air to turbo temperature goes up, so must the heat rejection. As altitude increases, the turbocharger must work harder to overcome the lower atmospheric pressure. This increases the amount of heat that must be removed from the inlet air by the aftercooler. Use the aftercooler heat rejection factor to adjust for ambient and altitude conditions. Multiply this factor by the standard aftercooler heat rejection. Failure to properly account for these factors could result in detonation and cause the engine to shutdown or fail. For 2 Stage Aftercoolers with separate circuits, the 1st stage will collect 90% of the additional heat.

SOUND DATA:

Data determined by methods similar to ISO Standard DIS-8528-10. Accuracy Grade 3. SPL = Sound Pressure Level.

NOTES

1 ENGINE RATING IS WITH 2 ENGINE DRIVEN WATER PUMPS. TOLERANCE IS ± 3% OF FULL LOAD.

2 GENERATOR POWER DETERMINED WITH AN ASSUMED GENERATOR EFFICIENCY OF 96.1% AND POWER FACTOR OF 0.8 [GENERATOR POWER = ENGINE POWER x GENERATOR EFFICIENCY].

3 ISO 3046/1 ENGINE EFFICIENCY TOLERANCE IS (+)0, (-)5% OF FULL LOAD % EFFICIENCY VALUE. NOMINAL ENGINE EFFICIENCY TOLERANCE IS ± 2.5% OF FULL LOAD % EFFICIENCY VALUE.

4 THERMAL EFFICIENCY: JACKET HEAT + STAGE 1 A/C HEAT + EXH. HEAT TO 350°F.

5 TOTAL EFFICIENCY = ENGINE EFF. + THERMAL EFF. TOLERANCE IS ± 10% OF FULL LOAD DATA.

6 ISO 3046/1 FUEL CONSUMPTION TOLERANCE IS (+)5, (-)0% OF FULL LOAD DATA. NOMINAL FUEL CONSUMPTION TOLERANCE IS ± 2.5 % OF FULL LOAD DATA.

7 UNDRIED AIR. FLOW TOLERANCE IS ± 5 %

8 INLET MANIFOLD PRESSURE TOLERANCE IS ± 5 %

9 INLET MANIFOLD TEMPERATURE TOLERANCE IS ± 9°F.

10 TIMING INDICATED IS FOR USE WITH THE MINIMUM FUEL METHANE NUMBER SPECIFIED. CONSULT THE APPROPRIATE FUEL USAGE GUIDE FOR TIMING AT OTHER METHANE NUMBERS.

11 EXHAUST STACK TEMPERATURE TOLERANCE IS (+)63°F, (-)54°F.

12 WET EXHAUST. FLOW TOLERANCE IS ± 6 %

13 NOX TOLERANCES ARE ± 18 % OF SPECIFIED VALUE.

14 NTE CO, CO2, THC, and NMHC VALUES ARE "NOT TO EXCEED".

15 NOMINAL CO IS A NOMINAL VALUE AND IS REPRESENTATIVE OF A NEW ENGINE DURING THE FIRST 100 HOURS OF ENGINE OPERATION.

16 O2% TOLERANCE IS ± 0.5; LAMBDA TOLERANCE IS ± 0.05. LAMBDA AND O2 LEVEL ARE THE RESULT OF ADJUSTING THE ENGINE TO OPERATE AT THE SPECIFIED NOX LEVEL.

17 LHV RATE TOLERANCE IS ± 2.5%.

18 TOTAL JW HEAT (based on treated water) = JACKET HEAT + STAGE 1 A/C HEAT + 0.90 x (STAGE 1 + STAGE 2) x (ACHRF-1). TOLERANCE IS ± 10 % OF FULL LOAD DATA.

19 RADIATION HEAT RATE BASED ON TREATED WATER. TOLERANCE IS ± 50% OF FULL LOAD DATA.

20 LUBE OIL HEAT RATE BASED ON TREATED WATER. TOLERANCE IS ± 20% OF FULL LOAD DATA.

21 EXHAUST HEAT RATE BASED ON TREATED WATER. TOLERANCE IS ± 10% OF FULL LOAD DATA.

22 STAGE 1 A/C HEAT (based on treated water) = STAGE 1 A/C HEAT + 0.90 x (STAGE 1 + STAGE 2) x (ACHRF-1). TOLERANCE IS ± 5 % OF FULL LOAD DATA.

23 STAGE 2 A/C HEAT (based on treated water) = (STAGE 2 A/C HEAT + (STAGE1 + STAGE 2) x 0.10 x (ACHRF - 1)) + LUBE OIL HEAT. TOLERANCE IS ± 5 % OF FULL LOAD DATA.