PRELIMINARY DESIGN REPORT (PDR) – FINAL

Jacob A. Hands WWTP

Combined Heat and Power Project

JOEL CAPPER RIFE
NEW MEXICO
12040
REGISTERED PROFESSIONAL ENGINEER
1/7/2013

City of Las Cruces, NM

January 2013

CDM Smith

Table of Contents

Appendices

List of Tables

List of Figures

Acronyms

CHP	Combined Heat Power
EPEC	El Paso Electric Company
HVAC	Heating, Ventilation, Air Conditioning
JAHWWTP	Jacob A. Hands Wastewater Treatment Plant
ICE	Existing Engine Generator
NSR	New Source Review
AQB	Air Quality Bureau
PTE	Potential to Emit
CAAA	Clean Air Act Amendments

Executive Summary

The Jacob A. Hands Wastewater Treatment Plant (JAHWWTP) utilizes an anaerobic digestion process to stabilize primary sludge, trickling filter humus, and waste activated sludge. Stabilized sludge after anaerobic digestion is dewatered and disposed of offsite. Biogas is produced as a byproduct during digestion of the wastewater sludge. The biogas can be currently utilized as fuel to produce electricity using an engine/generator set. The existing engine/generator set is rated at 342 kW when fueled with biogas. This engine/generator set can also be run on natural gas. This system has approached its end-of-life, and the addition of a new cogeneration system for Combined Heat and Power (CHP) is the primary objective of the City of Las Cruces under this project.

The intent is to provide a new cogeneration system with the ability to produce the power required for full plant operation at the City's discretion. The existing generator electrical system has limited medium voltage interface capacity and would need to be modified to facilitate a broader supply capability. The available biogas will be utilized to the extent of its daily production, supplemented with natural gas in order to meet the plant power requirements. The City of Las Cruces has retained CDM Smith to perform a series of pre-design evaluations that will cumulatively form the basis for subsequent detailed design and construction services. This pre-design report will serve as the basis for design and summarizes the findings, recommendations, and action items associated with the following:

- Biogas Production and Treatment
- Engine, Generator, and Switchgear
- Balance of Plant
- Opinion of Construction Cost, Schedule, and Sequencing
- Air Permitting

Major recommendations and findings of this pre-design report include the following:

- Perform detailed biogas sampling during final design that includes the full family of siloxane compounds.
- Two new engines are recommended for JAHWWTP, each sized to generate 330 kWe of power utilizing a blend of biogas and natural gas. Preferred engine manufacturers include Cummins and GE Jenbacher.
- As an alternate to the installation of two engines, provisions could be made for a single engine installation with provisions for future engine(s). The number of future engines will be confirmed during detailed design. Decommissioning of the existing cogeneration engine is recommended concurrently with the installation of the new cogeneration engines.

- It's recommended that a single engine manufacturer/supplier provide the engine, generator, and switchgear components, all heat recovery system components on the engine side of the digester heating water system (including heat exchangers and radiators), and a cogeneration heat recovery heat exchanger (HEX) that interfaces with the digester heating water system.

- A non-traditional procurement approach is recommended that will allow for the City of Las Cruces to evaluate and award/select an engine manufacturer in advance of the completion of the balance of plant design.

- The total opinion of the cost of construction of a complete system with two engine generator sets, switchgear, enclosures and all ancillary items and equipment to achieve close to full system capacity of powering the wastewater treatment plant is $2,720,133 if the total project were to be completed today.

  A single engine approach with full co-generatoncapacity infrastructure constructed today as Phase 1 was viewed by the City of Las Cruces as the most favorable option at $2,200,773. This approach requires a future Phase 2 that would essentially include a second engine generator set, enclosure, switchgear, tie-ins and electrical terminations. The second engine generator set with tie-ins and electrical interface has an opinion of the cost of construction in today's dollars at $519,360.

  However; by completing Phase 2 as a future project, there is a possibility that this work may be performed by a different contractor. Based on our experience, the overhead cost for separating the improvements into two separate contracts is typically higher than one contract. Additional engineering effort may also be required to manage a second contract. To account for this potentially additional expense to implement the second engine generator set and associated equipment and tie-ins at a later date, the estimated cost is increased to $649,200, which includes 10% for contractor's overhead and 15% to cover additional engineering and contingency. See the breakdown below that provides total project costs as a single project today and as two separate projets.

Both Phases as a single project today (Includes Phase 1 & Phase 2): Total Cost	Phase 1 in today's dollars	Phase 2 in today's dollars
$2,720,133	$2,200,773	$519,360
Phase 1 constructed today & Phase 2 constructed at a future date (Phase 1 & Future Phase 2 as separate projects): Total Cost	Phase 1 in today's dollars	Phase 2 in today's dollars
$2,849,973	$2,200,773	$649,200

Full system recommendations are provided at the conclusion of each section of this report. The following Table 1-0 Project Cost Recap includes the cost breakdown taken from Appendix I. Note, the future Phase 2 cost is adjusted per the discussion above.

Table 1-0 Project Cost Recap

TOTAL COST	DESCRIPTION	PHASE 1 COST	FUTURE PHASE 2 COST
	Engine gen-set w/ switchgear &	$766,511	$506,828
	Biogas treatment system	$275,000	
	Compressor system	$550,000	
	Electrical	$407,384	$12,532
	Piping / mech	175,495	
	Miscellaneous	$26,383	
			$51,936 (OH)
			$77,904 (Cont & Eng)
TOTAL COST		**$2,200,773**	**$649,200**

Section 1

Biogas Production and Treatment for JAHWWTP Cogeneration Upgrades

1.1 Introduction

The JAHWWTP treats both primary and secondary solids. Primary solids and waste activated sludge (WAS) solids are thickened using centrifuges and sent to one of four anaerobic digesters, namely Digester Nos. 1 through 4.

This section presents the evaluation of solids produced at the JAHWWTP and the amount the biogas generated. This section also provides an overview of the biogas treatment required. An evaluation of the existing biogas treatment system is also presented in this section.

1.2 Solids Production

The JAHWWTP flow and loading data from March 2010 through March 2012 was compiled and evaluated. Based on the data, the JAHWWTP treats an average flow of 9.4 MGD and produces 22,175 lbs/day of solids (Primary and WAS). At the permitted flow of 13.5 MGD, it is estimated that the JAHWWTP will produce 31,850 lbs/day of solids. The target solids retention time (SRT) in the anaerobic digesters is 15 days in order to achieve volatile solids and pathogen reduction criteria, and reduce vector attraction, so this SRT is assumed in the evaluation of biogas production. A solids concentration of 5 percent is used in the evaluation. At current plant flow, two digesters provide a SRT of 15 days while three digesters are required at maximum permitted flow condition.

The current volatile solids loading rate based on solids produced at the JAHWWTP is 0.05 pounds/day/ft^3. The volatile solids loading rate at permit flow condition is 0.08 pounds/day/ft^3. Digesters can handle a volatile solids loading rate of 0.14 pounds/day/ft^3 at HRT of 15-20 days. Even though digesters can handle higher solids loading rate, the total volume of digester available is approximately equal to the digester volume required to handle the sludge production at permitted flow and HRT of 15 days.

The JAHWWTP is permitted to treat 13.5 MGD of wastewater. Future flows to the plant are anticipated to increase and thus the potential for increased sludge production at the JAHWWTP is anticipated. **Table 1-1** presents the solids produced at the current average flow conditions and estimated future solids production at permitted flow conditions. Detailed calculations are included in **Appendix A**.

Table 1-1 JAHWWTP Solids Production

Flow (MGD)	Solids Produced (lbs/day)

Flow (MGD)	Solids Produced (lbs/day)
9.4 (Current Average Flow)	22,175
13.5 (Permit Flow)	31,750

1.3 Design Biogas Production Rate

As a byproduct from the anaerobic digestion process, biogas contains methane and carbon dioxide, as well as trace amounts of nitrogen, hydrogen, hydrogen sulfide, water vapor and other gases. The actual volume and quality of biogas produced during the digestion process will vary depending on the volatile content of the solids going to the digester and the biological activity within the digester.

In determining the total energy value of the biogas, the percentage of the volatile solids in the biosolids, the percent volatile solids destroyed in the anaerobic digestion process, the biogas production rate and the calorific value of the biogas must be taken into account. Typical values for each of these variables are shown in **Table 1-2**.

Table 1-2 Typical Biogas Production Characteristics

Fraction of Total Biosolids Fed to Digesters that are Volatile (%)	Fraction of Volatile Biosolids Concentration Destroyed through Digestion (%)	Biogas Production Rate (ft^3 gas / lb Volatile Solids Destroyed)
60 – 80	45 - 60	12 - 18

For this study, a 75% volatile solids (VS) concentration and 55% VS destruction with a biogas production rate of 15 ft3 /lb VS destroyed, is assumed in computing the amount of biogas produced. The biogas produced at the JAHWWTP was sampled on January 19, 2012 and analyzed and tested for gas characteristics. A copy of this analysis is included in **Appendix B**. The results of the analysis indicated that the calorific value of the biogas ranged from 366 Btu/ft3 to 508 Btu/ft3, with an average calorific value of 435 Btu/ft3. Using the data above and assumptions listed, **Table 1-3** is developed, showing the biogas volume and heat value produced. Detailed calculations are included in **Appendix A**.

Table 1-3 Biogas Production

Flow Condition	Volume of Biogas (ft^3/day)	Heat Value of Biogas (BTU/day)	Heat Value of Biogas (MMBTU/day)
9.4 (Current Average Flow)	137,000	60,00,000	60
13.5 (Permit Flow)	196,400	85,000,000	85

CDM Smith

1.4 Beneficial Use of Biogas

JAHWWTP currently uses biogas to fuel its single unit, existing cogeneration engine and also uses natural gas to fuel its boilers. The existing cogeneration system is also equipped to run on natural gas. The existing boilers can also run on biogas. Excess biogas that cannot be utilized by the cogeneration engine and boiler is burned off at the two waste gas burners. The heat recovered from the existing cogeneration engine is used for heating digesters.

The JAHWWTP is considering a replacement of the existing cogeneration system with a new cogeneration system that is to be designed and operated using a blend of natural gas and biogas to meet the JAHWWTP's overall electrical load requirements. The new cogeneration system and electrical load requirements are discussed in detail in Section 2. As discussed in Section 2, the heat value required for generation of power to meet the JAHWWTP's electrical demand is approximately 170 MMBtu/day. This is in excess of the total heat value of the biogas being generated at the JAHWWTP, so all biogas produced at JAHWWTP could be beneficially used to generate electricity and/or heat.

1.5 Biogas Treatment

Biogas contains levels of contaminants that can degrade structures and equipment and require gas treatment/cleaning to reduce or eliminate contaminants from the biogas. Biogas treatment is the conditioning of biogas to upgrade its quality prior to utilization, specifically by the proposed new engines. Without proper biogas treatment, the engines will experience increased wear, deterioration, and maintenance issues.

The overall biogas treatment process is described by **Figure 1-1** and involves removing the majority of hydrogen sulfide, moisture, particulate, and siloxane contaminants common to biogas.

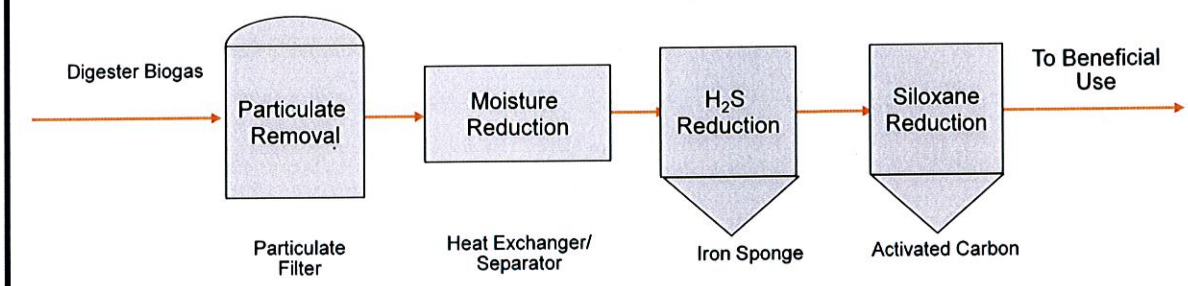


Figure 1-1
:nt Process

The existing gas purification system at JAHWWTP includes particulate removal, moisture reduction and hydrogen sulfide removal. JAHWWTP currently maintains four gas purifiers with iron sponge cleaning media to remove hydrogen sulfide from the biogas, refrigerated dryer to remove moisture and eight sediment traps to remove particulates from the biogas. The following paragraphs briefly describe various components of a typical biogas treatment system and present evaluation of the existing system.

1.5.1 H_2S Removal

An iron sponge system uses a wood chip media that has been impregnated with ferric oxide to reduce the gaseous hydrogen sulfide to a solid form. The chemical reaction is shown by the following equation:

$$Fe_2O_3(s) + H_2O(l) + 3H_2S(g) \longrightarrow Fe_2S_3(s) + 4H_2O(l)$$

As the reaction consumes the iron sponge media, the media must be regenerated and/or replaced periodically. Regeneration typically occurs once every six months to a year depending on the design and operating conditions. Media that has been regenerated two or three times is often replaced. During regeneration, oxygen is diffused through the system with a continuous flow of water. Water is required to regulate the temperature of the reaction and to wash away any solids that may have accumulated. The oxygen reverses the chemical reaction and generates fresh ferric oxide. Iron sponge systems typically use two vessels in parallel, so that overall biogas treatment can be maintained during regeneration events.

Two gas purifiers manufactured by Varec Division are currently being used for removal of H_2S from the biogas. Each purifier consists of two purifying compartments filled with iron oxide sponge. These purifiers were installed in 1984 and are in good condition and can continue to be used for biogas purification. Each purifier has a design capacity of handling 48,000 to 80,000 ft^3/day of biogas with a combined capacity of at least 192,000 ft^3/day of biogas and will be able to handle current and future biogas production. Based on the input from the City, the existing units are fairly new and appear to be in good condition. Their use for future biogas cleaning will be confirmed during design.

1.5.2 Particulate Removal

Particulates can carry over from the digestion process or can be introduced by the media used in other biogas treatment processes. Removing particulates is important to preserve engine life and to prevent their discharge in the exhaust stream. Eight sediment traps manufactured by Varec Division are currently being used to remove excess moisture and inert particles from the biogas. Each existing sediment traps have 12 gallon capacity and can handle up to 240,000 scfm of biogas at a pressure drop of 1 inch. These units have sufficient capacity to handle biogas produced at the Plant. Based on input from the City and CDM Smith's observations, the existing particulate removal system is in good condition.

1.5.3 Moisture Removal

Latent moisture reduces combustion efficiency of engines and can cause corrosion by forming an acidic condensate or rust. To limit required maintenance, moisture is removed prior to utilization.

Drip traps, coalescing filters, and condensate knockout tanks are simple, low technology methods of removing the condensable water fraction from the biogas. However, they alone do not sufficiently dry the biogas. A refrigerated dryer system is recommended for this purpose.

A refrigerated dryer produces chilled water that is passed through a gas-to-water heat exchanger to cool the biogas to 40 degrees Fahrenheit or below. Once cooled, water more readily partitions out of the gas-phase and is removed via a coalescing filter or similar equipment. Following moisture removal, the biogas is reheated to between 55 and 75 degrees Fahrenheit to prevent additional moisture from condensing.

JAHWWTP has one refrigerated dryer system to remove moisture from the biogas. The existing refrigerated dryer system is manufactured by PSB Industries Inc. The existing refrigerated dryer is in good condition and is rated for 115 scfm at 100^0F and 4 psig. The future gas production rate is higher than the existing dryer capacity and will have to be replaced or a second unit added.

1.5.4 Siloxane Removal

Siloxanes are carbon and silica based chemical compounds that are frequently used in cosmetics and foods to create a creamy consistency. In biogas, siloxanes are a contaminant that create an abrasive and glassy solid similar to sand when combusted. This abrasive material can "pit out" the components of process equipment such as the proposed engines, and can collect on surfaces leading to reduced equipment efficiency.

Biogas was collected on May 16, 2012 and tested for siloxanes. The Biogas test result data was provided to potential engine generator providers, Jenbacher and Cummins. Based on the input from the engine manufactures, the siloxane levels in the biogas are in an acceptable range. However, the detailed biogas sampling, including identification of the entire chemical family of siloxane compounds, shall be performed to determine if siloxane removal is required prior to installation of engine generators.

1.5.5 Biogas Pressure and Booster Blowers/Compressors

Increasing the biogas pressure is an integral part of the biogas treatment process and is needed to:

- Overcome the head losses associated with each of the other components of the biogas treatment system.
- Overcome minor losses in biogas piping leading to the proposed engine location.
- Deliver the treated biogas to the engine fuel train assembly at or above the minimum required inlet pressure for the selected engine.

JAHWWTP currently has two compressors to compress biogas. The existing compressors are positive displacement gas compressors, Model 55XA manufactured by Roots. The existing compressors can compress biogas to a maximum outlet pressure of 4 psi. The minimum fuel pressure required for engine generators between 1.2 (minimum per proposed Jenbacher Engine Generator) to 4 psi (per proposed Cummins Generator). New compressors rated for a maximum of 4 psi are recommended to be utilized for gas compression. The existing compressors are not deemed reliable due to their age and maintenance record.

1.6 Biogas Treatment System Location

The current hydrogen sulfide removal system, sediment traps, and compressors at the JAHWWTP are located in the Gas Metering Building. The new siloxane removal system, if required can be located outdoors next to the Gas Metering Building or can be located inside the proposed generator building. The spacing requirements for additional siloxane removal system will be evaluated during design. Preliminary dimensions of the siloxane removal system and compressor system are as follows:

- Siloxane Removal System: 8-ft by 6-ft

The areas immediately surrounding digesters such as the ones at JAHWWTP are classified per NFPA code. Figure 1-2 is an excerpt from the NFPA 820 regulation, describing the level of electrical classification as a function of distance from the digester/biogas piping/etc. The existing generator building could be subjected to NFPA 820 Table 6.2, Row 18 "Digester Gas-Processing Rooms". In this case, the area is referred to as a hazardous location and subjected to Class I Division I installation requirements. The final design will address the area classifications.

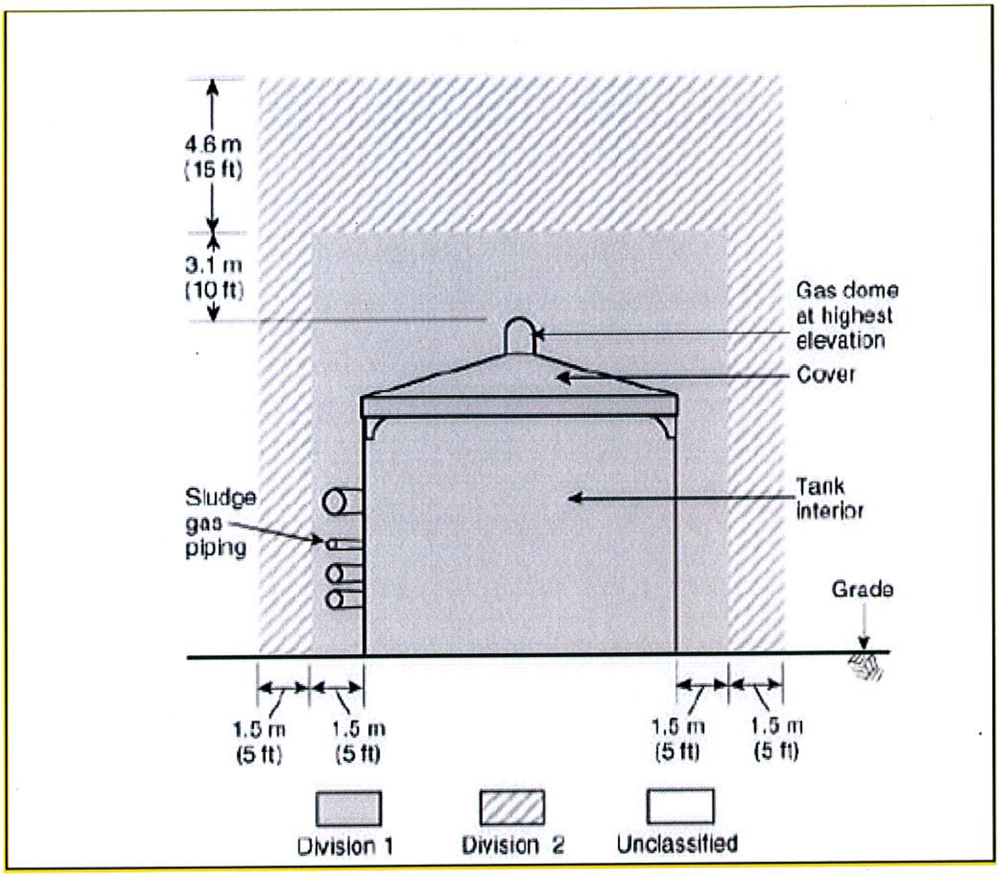


Figure 1-2
NFPA 820 Figure A.6.2(a) Anaerobic Digester with Fixed or Floating Cover above Grade Not Enclosed in a Building

1.7 Recommendations

CDM Smith is recommending adopting the following pre-design decisions and/or actions:

- Perform detailed biogas sampling during final design that includes the full family of siloxane compounds recommended by engine generator manufactures.
- Evaluate the existing refrigerated dryer system.
- Ensure the final configuration of the biogas treatment system modifications is compliant with NFPA 820 requirements.
- Evaluate the gas purifiers capability.
- Replace the gas fuel compressors.
- Identify a new gas metering system.

Section 2

Engine, Generator, and Power Distribution for JAHWWTP Cogeneration Upgrades

2.1 Introduction

In cogeneration applications, the generator sets are typically designed to operate in parallel with the electric utility provider. Electric power for the JAHWWTP is supplied by El Paso Electric Company (EPEC). One of the purposes of this section is to evaluate connecting the new generator(s) to the power grid to allow the power grid to supplement the power generated on-site. Power will be imported from EPEC for any motor starting transients and peak loading conditions. The amount of power imported from the power grid is user defined and will be discussed in more detail below. This allows for optimum reliability and performance and is the most cost effective approach. The system will not be allowed to export power under any circumstance. Exporting power typically changes the utility company's position towards the installation and will increase the cost of the overall installation.

The economic benefits for cogeneration systems are proportional to the unit run times assuming the waste heat being rejected by the engines is utilized. The fuel savings gained by operating with on-site generation, increases with an increase in the number of hours of cogeneration use. Also, these types of systems inherently save electrical demand charges which add back to the earnings of the fuel saving.

2.2 Possible Engine Manufacturers

The following internal combustion engine (ICE) manufacturers have been contacted to discuss their interest in ultimately bidding on this project:

- Caterpillar – no comprehensive information provided at this time
- Cummins – very responsive
- Deutz/MWM – no comprehensive information provided at this time
- Fairbanks Morse – no comprehensive information provided at this time
- GE Jenbacher – very responsive
- Guascor – responsive but are not able to provide UL listed electrical equipment
- Liebherr – no comprehensive information provided at this time
- MAN – no comprehensive information provided at this time
- Mitsubishi – no comprehensive information provided at this time
- Waukesha – no comprehensive information provided at this time

Fairbanks Morse (FM) does not offer engines that are capable of producing less than 1,750 kilowatts (kW); FM engines are slow-speed, high-capacity units. Liebherr does not offer engines that produce in excess of 300 kW. MAN has previously indicated to CDM Smith that it does not offer engines that produce in excess of 300 kW. Mitsubishi has previously indicated to CDM Smith that it does not yet have a U.S. installation operating with biogas. Waukesha does not offer continuous, online fuel blending and has indicated that it will not warrant its equipment if control modifications are included to allow such a provision. Therefore, Fairbanks Morse, Liebherr, MAN, Mitsubishi, Gausor, and Waukesha will not be carried forward as preferred manufacturers through detailed design.

The following budgetary information, provided by Cummins, shows typical unit costs associated with engines suitable for Biogas consumption:

- 334 kWe Generator Set with fuel system and heat recovery equipment costs approximately $410,000 each (refer to Section 2.4 for kWe unit explanation)
- 1000 kWe Generator Set without fuel system and heat recovery equipment costs approximately $800,000 each
- 1750 kWe Generator Set without fuel system and heat recovery equipment costs approximately $1,150,000 each
- 2000 kWe Generator Set without fuel system and heat recovery equipment costs approximately $1,200,000 each

The budgetary quote given to JAHWWTP by Cummins in March of 2011 for two machines rated at 334 kWe was $650,000. This price does not seem to take in to account the installation nor the necessary modifications to export power to the existing medium voltage network currently serving the plant. The budgetary price given to CDM Smith in March of 2012 for a single machine rated at 334 kWe was $410,000. Additionally, a weatherproof sound attenuated enclosure would add $125,000 to the unit cost.

2.3 Preferred Engine Manufacturers and Corporate Ownership

For reasons cited above, the following ICE manufacturers are being considered as preferred manufacturers and should form the basis of detailed design:

- Cummins
- GE Jenbacher

Caterpillar will more than likely be added once information becomes available during detailed design. Two major acquisitions transpired in the ICE industry. GE Jenbacher acquired Waukesha and Caterpillar acquired MWM. In both instances, manufacturer's representatives from all parties have indicated that all product lines will continue to be available for the foreseeable future; therefore, these manufacturers continue to operate as independent competitors regardless of their corporate ownership.

2.4 Engine Sizing Considerations and Basis of Recommendation

The engine/generator unit for this project will be certified with a continuous rating. With this rating, the unit is able to provide power to a non-varying load for an unlimited number of hours per year. Conversely, generator sets utilized for providing emergency backup power typically fall under the standby rating. A standby rated generator set can run for a maximum of 500 hours per year at recommended levels of no more than 70% of its nameplate rating. The disadvantages of improperly rating a generator set are increased capital expenditures from increased capacity (larger machines for transient motor starting and peak load conditions), shorter life to overhauls, increased repairs, and increased downtime. According to the National Electrical Manufacturers Association (NEMA), "gas fuel without an alternate on-site supply is usually not acceptable for emergency or standby use".

Last year the average electrical demand for the JAHWWTP was approximately 536 kW. The kilowatt-hour (kWh) values per month were obtained from JAHWWTP and corroborated with values provided by EPEC. Table 2-1 shows the plants Kilowatt hours and average Kilowatt usage per month.

Based upon this information, three alternatives were identified:

- Two identically sized engine generator sets are proposed for JAHWWTP. This recommendation is considered the first alternate and forms the basis of this section.
- The second alternate would be to provide a single engine system with provisions to add identical units in the future to ultimately achieve the capacity to power the plant demand.
- The last alternate would be to replace the existing generator system in kind. The system would be constrained to operate as currently configured and would not be able to power the plant (see Section 2.7 below for further discussions on the existing electrical system).

The proposed on-site generator capacity will not equal the plants total connected load. Instead, the two generators will be sized for an electrical output to meet the average electrical demand. The expected electrical output per engine when fully loaded is approximately 330 kW. During low demand periods, a single engine in conjunction with the utility grid can potentially sustain the plant demand. Additionally, the proposed system will potentially avert EPEC requests to shed power from their grid during heavily loaded periods.

Table 2-1 JAHWWTP 2011 Kilowatt hours E(kWh) and Kilowatt P(kW) per Month

Month	E(kWh)	P(kW) = E(kWH)/ t(hr)
January	445,376	598.62
February	268,700	386.06
March	394,618	530.40
April	422,631	586.99
May	389,577	523.63
June	400,600	556.39
July	451,176	606.42
August	362,899	487.77
September	401,552	557.71

For a rated output of 330 kW, each engine requires a fuel source of approximately 90 MMBtu/day. Therefore, each engine will be designed for a fuel consumption rate of 3.57 MMBTU/hr. As discussed in Section 1, the design biogas production rate of 196,400 cubic-feet per day (cfd) provides fuel source of approximately 85 MMBtu/day. This source is inadequate to meet the fuel requirements of the engines to generate power to meet the electrical demand. Therefore, the predominant fuel source will be natural gas blended with biogas as the supplemental fuel source. **Appendix G** contains a drawing of a typical fuel train used for blending fuels.

The proposed design may change due to further evaluation as information is attained from the utility company during detailed design. This section summarizes the possible and preferred engine manufacturers, appropriate engine models, technical considerations, controls, site plan, and enclosure types.

For identifying appropriate engine selections from the preferred manufacturers, and to create a more complete energy/power understanding of the cogeneration upgrades, it is useful to adopt a common convention for describing the content of both the fuel and the products. In this case, representing the power available in the fuel (biogas) in terms of kilowatts (kW) allows a clear comparison of the beneficial uses of biogas by the various engine selections. Through direct unit conversions, 196,400 cfd of biogas equates to 1,044 kW of fuel assuming a 435 BTU/ft^3 heating value for biogas. The fuel source required for each engine is approximately 1,000 – 1045kW. Table 2-2 depicts the fraction of available fuel that will be converted or used for the following functions for each of the preferred manufacturers:

- Electrical output (see kWe in Table 2-2): this represents the electrical output of each engine when supplied with energy input shown. These values are derived from electrical efficiency data provided by each engine manufacturer for the appropriate engine loading.

- Recoverable heat (see kWthermal in Table 2-2): this represents the combined thermal efficiency of the entire engine, assuming that significant heat is recovered from both the jacket water circuit and the engine exhaust, along with a minor contribution from the lube oil system. Note that it must be possible for a percentage of the recoverable heat to be wasted by other means (see Section 3) if the heating demands are satisfied before all recoverable heat is utilized.

Given the altitude of the project location, it may be necessary to propose larger engines which can be "de-rated" to meet the requirements without sacrificing overall production of electricity and recoverable heat. The altitude of Las Cruces is 3,908 feet above sea level.

Table 2-2 Energy Input, Electrical Output, and Recoverable Heat

Manufacturer	Energy Input/ Fuel Consumption	Electrical Output (kWe)	Recoverable Heat (kWthermal)
Cummins	1045	334	374
GE Jenbacher	930	335	401

2.5 Technical Comparison of Selected Engines

Tables 2-3A and Table 2-3B show a comparison of pertinent technical information for the selected engine make/models. A discussion of the relative benefit/disadvantage of each category follows:

- Number of cylinders, number of strokes and compression ratio: These are physical characteristics of the engines only and exhibit no particular benefit or disadvantage.
- Required gas (fuel) pressure: The pressure at which biogas must be delivered to the fuel train is a critical parameter in sizing the biogas blowers/compressors for the biogas treatment skid, which will deliver the conditioned biogas to the cogeneration engines. In this case, 7 psi is the highest of the operating pressures. Typically, biogas is boosted to a slightly higher pressure than is needed and subsequently lowered through the use of a pressure reducing valve (PRV) at the engine to ensure that sufficient pressures will continue to be available even if slight pressure fluctuations are observed over time.
- Speed (rpm): New engines of today are designed to allow for lower operating speeds that may provide some long-term maintenance benefits, though typically result in lower efficiencies.
- Electrical Efficiency: This provides a percentage of the energy content of the fuel that is converted to electricity.
- Thermal Efficiency: This provides a percentage of the energy content of the fuel that is converted to thermal energy, which can also be beneficially used (i.e., partially recovered). This is typically a less impactful parameter than the electrical efficiency, as not all of this heat can be easily recovered and beneficially used year-round.
- Total Efficiency: This is a direct sum of the electrical and thermal efficiencies; the Cummins engine has a lower total efficiency, while the GE Jenbacher engine has the highest total efficiency.

- NOx Emissions: Both engines are capable of meeting 0.6 g/bHP-hr of NOx emissions in the engine exhaust, which is within the acceptable range of the permit application at the time of this writing (1.0 g/bHP-hr; see Section 5).
- CO Emissions: Both engines exhibit similar carbon monoxide (CO) emissions in the engine exhaust; both are within the acceptable range of the permit application at the time of this writing (2.0 g/bHP-hr; see Section 5).
- PM Emissions: Estimated emissions of particulate matter (PM) in the engine exhaust for GE Jenbacher are based on a sulfur-rich fuel; however GE Jenbacher also indicated that the corresponding PM emissions for natural gas (a sulfur-free fuel) would be 0.02 g/bHP-hr.
- Exhaust Temperature: The temperature of the exhaust stream is provided for informational purposes; all cases include proper insulation of the exhaust piping that will be required to protect JAHWWTP staff.
- Net Heat Output (MMBtuh): Expressed in MMBtuh, this parameter indicates the total heat generated by the engine, which is also the theoretical maximum heat that could be recovered (although not all heat can be efficiently and economically recovered as discussed in Section 3)
- Net Electricity Generated (kWe): This represents the electrical output of each engine at the design biogas (fuel) flow rate of 200,000 cfd. Both the Cummins and GE Jenbacher engines can be expected to generate approximately 80 kWe.

Table 2-3A Summary of Technical Engine Information

Engine Make	Engine Model	Cylinders/Strokes	Compression Ratio	Required Gas Pressure	RPM
Cummins	334GFBA	6/4	11.0:1	7 psi	1800
GE Jenbacher	J208	8/4	12.0:1	1.2-2.9 psi	1800

Table 2-3B Summary of Technical Engine Information (continued)

Engine Make	Efficiency (%)			Emissions (g/bHP-hr)		
	Electrical	Thermal	Total	NOx	CO	PM
Cummins	32%	33.4%	65.4%	1.0	2.0	N/A
GE Jenbacher	36.3%	43.5%	79.8%	0.6	2.0	0.02

Emission limits are discussed in Section 5. The requirement for catalytic converters would be determined during detailed design. The engines investigated at this point meet the emissions standards set forth in EPA Subpart J.J.J.J. of 40 CFR 60; therefore, an additional exhaust after-treatment system such as a catalytic converter is not required.

2.6 Engine Manufacturer Scope of Supply

Each generator set and its associated controls will be specified to be furnished by the engine supplier or engineer approved equal as one complete integrated package along with associated electric starter, batteries, battery racks, and battery charger. Similarly, the engine supplier or engineer approved equal will be responsible for supplying all heat recovery equipment that will interface with the engine and/or engine systems. Refer to **Appendix C** for a typical combined heat power (CHP) system manufacturer scope of supply.

2.7 Existing Electrical Distribution System

The plant has two main EPEC electrical services. The services distribute power throughout the plant via two medium voltage network loops and respective JAHWWTP 23,900 V: 480Y/277 V step-down pad-mounted transformers. The preferred primary service is referred to as the Salapec 20 circuit. The nominal voltage is 23,900 Volts (V), three-phase and is metered at a riser pole located west of the Administration Building: EPEC meter number 104 935 835. This service transitions from the riser pole to a pad-mounted primary disconnect switch. The emergency primary service is referred to as the Las Cruces 20 circuit. The nominal voltage is 23,900 V, three-phase and is metered at a pole located east of the secondary digesters: EPEC meter number 104 935 860. This utility service also transitions to a pad-mounted primary disconnect switch. The primary disconnect switches are connected to a series of pad-mounted transformers located throughout the plant. The Salapec 20 and Las Cruces 20 circuits are electrically isolated and cannot serve any pad-mounted transformer concurrently.

An additional EPEC service provides 480 V, three-phase power to the existing generator building. This service originates from an EPEC owned pad-mounted step-down transformer. The transformer is located at the north side of the plant: EPEC meter number L08 227 570. This transformer is fed from either the Salapec 20 or Las Cruces 20 circuits via an EPEC owned transfer switch.

The transformers connected to the Salapec 20 circuit via the primary disconnect switch are designated as 'RN1', 'N3', 'N4', 'N5', and 'N6'. The transformers connected to the Las Cruces 20 circuit via the primary disconnect switch are designated as 'E1', 'E3', 'E4', 'E5', and 'E6'. These transformers provide the power required for the plant process equipment. Selection between the 'N' and 'E' transformer series is accomplished via transfer switches located throughout the plant.

Table 2-4 shows the approximate connected power of the plant. The power is listed in KVA and is based upon Record Drawings furnished by JAHWWTP.

Table 2-4 JAHWWTP Connected Plant KVA

Area	Approximate Connected KVA	Transformer Serving Area
Generator Building	600 KVA	XFMR N5 – 150 KVA or XFMR E5 – 225 KVA
Plant Water Pump Building, Secondary Sludge Pump Building, Admin. And Storage Buildings	645 KVA	XFMR RN1 – 500 KVA or XFMR E1 – 150 KVA
Entrance Works	100 KVA	XFMR N4– 300 KVA or XFMR E4 – 150 KVA
Entrance Works	45 KVA Connected strictly to XFMR E4	XFMR E4 – 150 KVA
EQ Basins	1150 KVA	XFMR N6– 750 KVA or XFMR E6 – 750 KVA
Centrifuge Building, Lift Station	605 KVA	XFMR N3– 1000 KVA or XFMR E3 – 750 KVA
Generator Building	600 KVA	EPEC Transformer – 300 KVA

Figure 2-1 in **Appendix D** shows a one-line diagram of the overall existing system and **Appendix E** shows a detailed site layout of the JAHWWTP.

2.8 Existing Electrical Distribution System Modifications

The existing electrical distribution system configuration has limited back-feed capacity. The only transformer currently connected in the existing system that can back-feed the medium voltage network thus providing power to the plant from the existing generator system is 'E5'. If 'E5' is utilized in back-feeding the plant, certain precautions must be made in order not to connect concurrently to the Las Cruces 20 circuit. The Las Cruces 20 primary manual transfer switch provides that necessary isolation. Switching the transfer switch manually isolates transformers 'E1', 'E3', 'E4', and 'E6' from the utility feed and provides an electrical path to 'E5'. At this point, the total KVA rating of the 'E' series transformers isolated from the Las Cruces 20 circuit and pathed to 'E5' is 1800 KVA. The capacity of transformer 'E5' is 150 KVA, which cannot support the plant load. Conversely, if transformer 'N5' was considered to back-feed the network, the pathed capacity of the 'N' series transformers would be 2550 KVA. The rated capacity of transformer 'N5' is 225 KVA and also cannot support the plant load. In the above discussions, the electrical requirements of the generator building loads are neglected given the direction of power flow back into the plant from this location.

Back-feeding the plant network loop via the existing electrical system is not an option, given the lack of capacity. Modifications would have to occur to facilitate an electrical tie-in to the existing medium voltage network. The best solution would only minimize required modifications to the existing infrastructure. It is therefore proposed to establish a new point.

The existing north side EPEC transformer is a logical node location. The EPEC transformer is rated at 300 KVA and does not have sufficient capacity to power the plant.

CDM Smith

Therefore, the existing north side EPEC transformer, metering, and associated circuitry are recommended to be removed in their entirety. The primary manual transfer switch will need to be replaced with a pad-mounted cable termination enclosure (cable switching station). The existing generator, switchboard, and associated circuitry will need to be removed in their entirety. Figure 2-2 in **Appendix D** shows a one-line diagram denoting the demolition of the major components.

CDM Smith proposes that EPEC supply a new pad-mounted 23,900 V: 480Y/277 V step-down transformer and associated metering. As an alternate, JAHWWTP could elect to own the transformer. The new transformer capacity will be sized for the entire plant load. The transformer is proposed to be located in the near proximity to the new generator system to minimize installation costs. The installation costs of any upgrade to the utility system are anticipated to be borne by JAHWWTP. The recommendation would be to carry this cost as an allowance in the final contract documents. This new transformer is the front-end of the tie-in connection point to the existing distribution system.

The EPEC transformer secondary will connect to a 4000 ampere (A), 480 V, 3-phase, service entrance rated UL 1558 switchgear. The switchgear will be sized per total connected load. This paralleling switchgear will be furnished under the generator manufacturer's scope of work and will contain the required controls for protecting and paralleling multiple power sources. Figure 2-3 in **Appendix D** shows the proposed one-line diagram of the overall CHP electrical system, with lighter line weights depicting existing equipment that will be reused.

The switchgear allows for several modes of operation:

- Power entire plant with the generators offline (circuit breaker 52U and 52N1 closed; circuit breakers 52T, 52G1, and 52G2 opened)
- Power entire plant with the generators online (circuit breakers 52U, 52N1, 52T, 52G1, and 52G2 all closed)
  - Power plant with one generator online (circuit breakers 52U, 52N1, 52T, 52G1 or 52G2 all closed)
- Parallel operation of the generators – without the power grid
  - Island mode (circuit breaker 52U opened; circuit breakers 52N1, 52G1 and or 52G2 closed)

To complete the interconnection to the existing electrical distribution system, an additional 2500 KVA; 23,900 V: 480Y/277 V pad-mounted transformer and pad-mounted medium voltage overcurrent (OC) device is required. The transformer will be connected to the load side of the paralleling switchgear. The OC device will be connected on the secondary of this additional transformer. This affords the required protection of equipment and allows the utility and or generator power to back-feed the existing medium voltage network. The final locations will be determined during detailed design.

The preferred Salapec and Las Cruces lines would remain as currently installed with the exception of the following:

- Salapec 20 Primary Switch would be fitted with a mechanical interlock system preventing operation of the switch simultaneously with the paralleling switchgear

- Las Cruces 20 Primary Manual Transfer Switch would be replaced with a cable switching station; this existing switch cannot be reused for any proposed modifications to the system

Different system configurations were investigated but were deemed overly complicated and cost prohibitive. The electrical distribution system described above without sustained paralleling with the utility would still be applicable as proposed regardless of the desired method of operation (i.e. cogeneration system synchronized with utility or a standalone standby system). The major differences would be in the size of the generator set(s) and the protective devices integral to the switchgear. The leading manufacturers have stated that there will be an increase in overall maintenance costs if the larger machines are operating under-loaded.

The new cogeneration system will be subject to an approval process as required by EPEC regardless of operational methods discussed. Some utilities have specific interconnection guidelines while others have general guidelines or none at all. Although EPEC does have an "Electric Service Requirements" manual, they have stated that there are no specific guidelines for cogeneration systems. Acceptances of designs depend upon their confidence of the proposed design and are reviewed on a case-by-case basis. Institute of Electrical and Electronics Engineers (IEEE) – "Standard for Interconnecting Distributed Resources with Electric Power Systems" and NEMA- "Guide to Preparing a Design Proposal for Paralleling Customer Generation with an Electric Utility" outline the interconnections, operational and metering requirements for generating facilities of this nature and will form the foundation of the overall design. The approval process normally consists of the following:

1. EPEC will have to complete a feasibility study for the proposed design. Any time there is a major system change, the utility company should be advised. Primary concerns for the utility company range from safety to providing continuous and reliable power to their customer base.

2. During detailed design, CDM Smith will complete and submit supporting documents detailing the proposed system. Supporting documents will include a basic One-Line Diagram, information regarding the location of the facility and anticipated construction schedule.

3. A submittal to EPEC from the installation contractor should be prepared following approval by the Owner's construction representative of shop drawings from the engine supplier.

4. Pre-Paralleling inspection – when the system is installed, but prior to energization, EPEC will perform an inspection on the system for completeness and compliance with all applicable provisions.

EPEC currently does not project a timeline for this process, but typically the timeline would be between three and seven months from the time of application depending on the project energy needs, location, and impacts on the EPEC grid. These activities will occur in parallel with the design and construction activities and typically do not protract the overall schedule. CDM Smith has requested the following information from EPEC:

- Peak Demand for each metered location

- Average load for each metered location

CDM Smith

- Minimum load for each metered location
- Short circuit capacity of the Salapec 20 and Las Cruces 20 circuits
- Rate structures
- Utility incentive programs
- Interconnection guidelines
- Interlocking requirements
- Utility grade protective device preferences

CDM Smith has received limited information from EPEC and will coordinate as required during detailed design.

2.9 Generator

Each generator set will be a skid-mounted synchronous machine, 480Y/277 V, three-phase, four-wire, 60 Hz with an output rating matching or exceeding the engine capacity. The generator sets proposed for this project are not offered in a medium voltage class. The generators will be provided by the engine manufacturer as an integral part of the engine-generator set. The generator, commonly referred to as the alternator, contains two separate sets of windings. The first set is the power generating three-phase windings in the stator. The second set is the field windings in the rotor. Precise DC control of the field windings gives complete control over the output of the synchronous alternator. A voltage regular senses the output voltage and adjusts the excitation level to the field windings to hold the voltage at a preset level.

A governing system controls the fuel setting of the prime mover (i.e., the engine). The control of the fuel system will be performed by an isochronous governor. This allows the fuel setting of the engine to become a function of the electrical load. Each governor will require the addition of a load-sharing module. This unit provides a corrective signal to the governor input such that each machine evenly shares the load. When operating as an isolated system, the generator set frequency is controlled by the governor and the load is independent of any action taken by the governor. When paralleled with an infinite source such as the utility grid, the line frequency is dictated by the utility.

Kilowatt load control is typically designed for cogeneration applications. This type of algorithm enables a soft loading to or from the utility. Additional features required will be import control and VAR/Power Factor control. The control system will regulate electricity imported from the utility grid. This system senses the desired user defined import power reference signal and sends the appropriate biasing signals to the electronic governing control through the load-sharing modules thereby controlling the engine output. Desired average imported power range average would fall between 50 kW to 100 kW. The VAR/Power Factor control the reactive power component and power factor due to fluctuating utility voltages.

The alternator outputs will be connected directly to paralleling switchgear circuit breakers, respectively. Each circuit breaker will be electrically operated. The circuit breakers will close automatically when the engine-generator sets are synchronized with the reference voltage. The reference point will be either the utility voltage or in island mode the first generator to reach synchronous speed.

2.10 Controls

Engine controls, synchronizing equipment, protective relays, and a communication interface package will be housed in a control panel integral to the paralleling switchgear. The control panel will have displays to control, monitor, and alarm the cogeneration unit operation. In addition, the control panel will have the capability of interfacing with the plant SCADA system on an Ethernet communication network for remote control and monitoring of the cogeneration units.

The type of control typically provided by manufacturers varies, and is likely to include proprietary systems. However, the interface and communication to plant SCADA will be specified in the contract documents. The operator will be able to see all monitoring and alarm points and will be able to send commands remotely; these items will be addressed during detailed design. All other parameters should be controlled automatically by the manufacturer's control system.

2.11 Cogeneration System Location and Enclosure

Appendix E shows the site location. The preferred location for the cogeneration system will be based upon JAHWWTP directions during detailed design.

The proposed engine location could be in an undeveloped area adjacent to the existing generator building, and thus a number of options exist for enclosing the new engine(s). Table 2-5 summarizes the major advantages and disadvantages for several options:

- An open-air metal weather canopy
- A pre-fabricated metal enclosure furnished specifically to house the cogeneration upgrades equipment
- A permanent concrete masonry unit (CMU) building
- Soundproof/weatherproof Engine Enclosure
- Existing Generator Building

CDM Smith

Table 2-5 Summary of Benefits and Disadvantages of Engine Enclosure Types

Criteria	Metal Canopy	Pre-Mfg. Metal Bldg.	Concrete Masonry Bldg.	Existing Generator Bldg.	Soundproof/Weatherproof Enclosure
Staff Protection from the Elements	Minimal protection; overhead precipitation only	Protection from elements	Protection from elements	Protection from elements	Protection from elements
Electrical Gear Protection from the Elements	Electrical gear requires NEMA 3R enclosure	Electrical gear located indoors; NEMA 1 enclosure sufficient	Electrical gear located indoors; NEMA 1 enclosure sufficient	Electrical gear located indoors, NEMA 1 enclosure sufficient; if space is not sufficient in existing building NEMA 3R enclosure required	Electrical gear located indoors; NEMA 1 enclosure sufficient; if space is not sufficient in existing generator building NEMA 3R enclosure required
Noise	No sound attenuation provided; engine would require separate acoustical treatment	Some engine sound attenuation achieved with acoustical insulation	Most sound attenuation	Some engine sound attenuation achieved	Most sound attenuation
Security	Least secure installation	Controlled access can be provided	Most secure installation	Secure installation	Controlled access can be provided
Ventilation Requirements	No mechanical ventilation required	Requires mechanical ventilation/heat removal	Requires mechanical ventilation/heat removal	Requires mechanical ventilation/heat removal system; Current system may not be sufficient; Area classification may dictate removal of biogas processing equipment	Requires mechanical ventilation/heat removal
Accessibility	Open from all sides	Fixed/limited access; may require larger floor area for forklift access	Fixed/limited access; may require larger floor area for forklift access	Fixed/limited access; If future engine provisions are required, majority of existing equipment will have to be removed	Fixed/limited access
Supplemental Lighting	No supplemental lighting required	May require supplemental lighting	May require supplemental lighting	May require supplemental lighting	No supplemental lighting required; Lighting part of Enclosure package
Ancillary Piping/Ductwork Concerns	Maximum flexibility in locating ancillary equipment	Must isolate pipe penetrations and provide fixed piping/ductwork routings	Must isolate pipe penetrations and provide fixed piping/ductwork routings	Must isolate pipe penetrations and provide fixed piping/ductwork routings	Maximum flexibility in locating ancillary equipment
Approx. Unit Cost	$75-$100/sf	$175/sf	$300/sf	$300/sf	$125,000/ per Enclosure

Figures 2-5 through 2-8 provide renderings of the new types of enclosures being proposed.

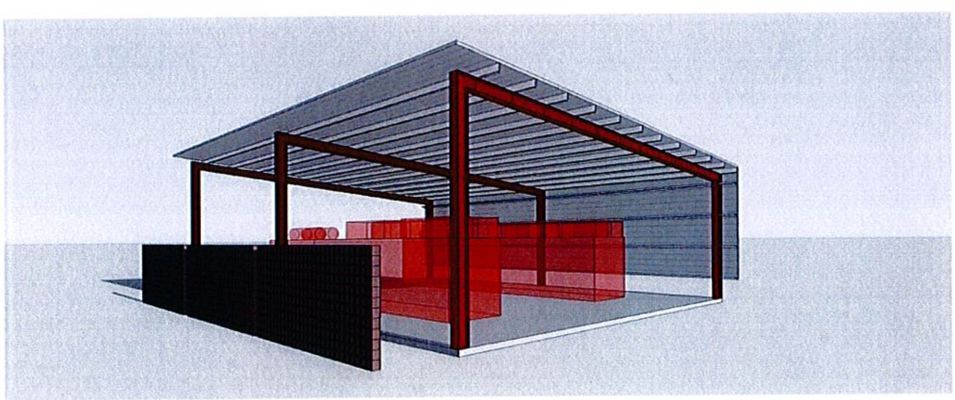


Figure 2-5
Architectural Rendering of Open Air Metal Canopy Enclosure

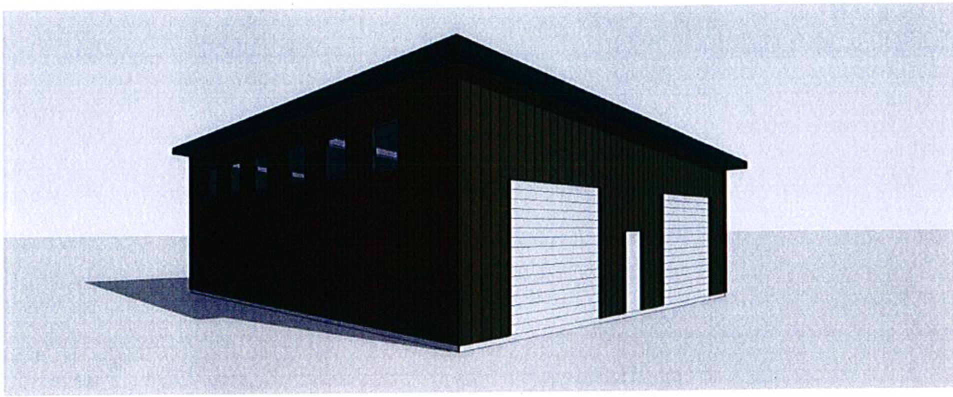


Figure 2-6
Architectural Rendering of Pre-Fabricated Metal Building Enclosure

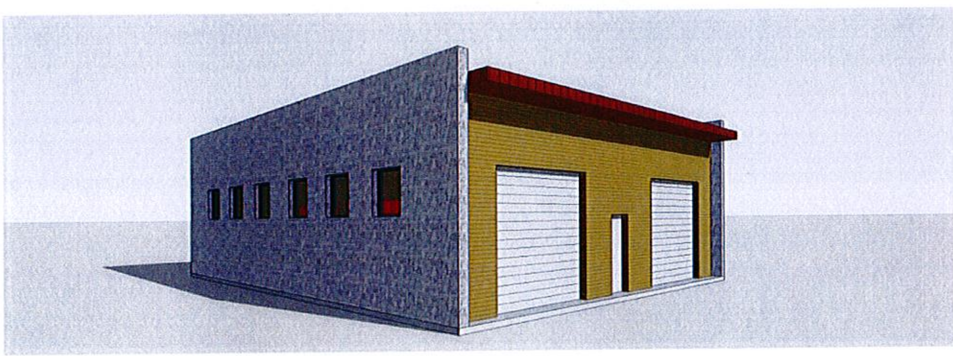


Figure 2-7
Architectural Rendering of Permanent CMU Building

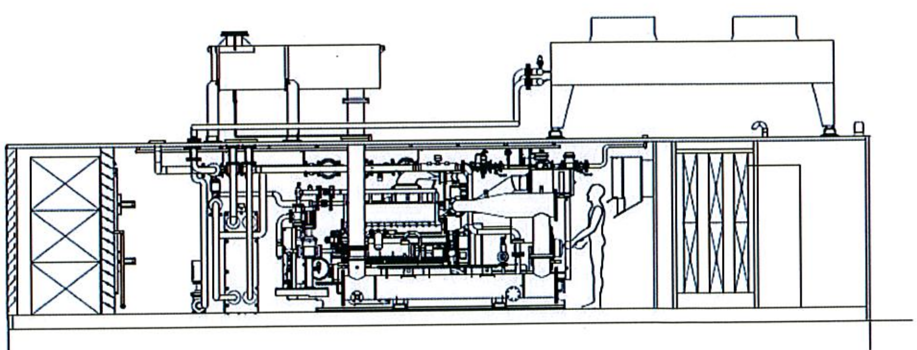


Figure 2-8
Soundproof/ Weatherproof Generator Enclosure

In all cases, it is recommended that the foundations provided for the engines themselves be deeper and structurally isolated from any foundation provided for the building and balance of the equipment.

The more robust foundations associated with the engines themselves are a result of the significant vibratory loads associated with internal combustion engines.

If the preferred option is utilizing the existing generator building, the following modifications would be necessary:

- Existing generator and ancillary systems such as but not limited to the external radiator, heat recovery heat exchanger and heat recovery silencer would have to be removed prior to any new installation.
- Digester heating water boiler, digester heating water pumps, and related piping systems would have to be relocated to a different location.
- Existing HVAC system would have to be evaluated and replaced with a new system if determined to be inadequate.
- Possible foundation modifications to support engine(s). Additionally, the utility trench may have to be modified to support new equipment.
- Reconfiguration of the existing electrical system to accommodate interconnection to the existing medium voltage system.

The pre-fabricated metal enclosure/building is perhaps the best solution but given budget constraints alternate solutions may be recommended during detailed design discussions with JAHWWTP. Because the cogeneration system will be paralleled with the utility (EPEC), main power for plant processes will not rely exclusively on the cogeneration system and thus the overall system need not be installed above the "critical equipment" protective flood elevation as is often the case with equipment such as emergency generators. The desired elevations and flood protection elements of any new enclosures will be reviewed with JAHWWTP during detailed design and the need for a more permanent building will be assessed at the time.

2.12 Recommendations

CDM Smith is recommending adopting the following pre-design decisions and/or actions:

- Two, identical internal combustion engines (ICEs) should be provided along with all heat recovery/cooling and electrical equipment. Alternative installation would consist of one generator with provisions for a second engine addition in the future.
- The following preferred manufacturers and associated engine selections should be carried forward as the basis of detailed design:
  - Cummins Model 334GFBA
  - GE Jenbacher Model J208
- The new cogeneration engine system should interface with the power grid (as shown in the one-line diagram for the cogeneration upgrades).
- Engine foundations should be isolated from one another and from the engine enclosure to address excessive vibratory loads.

Section 3

Ancillary System

3.1 Introduction

The purpose of this Section is to evaluate the major support and ancillary systems required for the cogeneration upgrades and address manufacturers/suppliers of the system components, construction materials, and appropriate sizes/capacities. The following systems are discussed:

- Heat Recovery
- Waste Heat
- Lube Oil
- Piping
  - Jacket Water
  - Hot Water Supply & Return
  - Engine Exhaust
  - Biogas
  - Natural Gas
  - Lube Oil

3.2 Existing Digester Heating Water System

The existing digester heating water system is located in the Generator Building and includes digester heating water boiler, heating water recirculation pumps, chemical addition tank, associated accessories and piping. The boiler can be operated on natural gas or biogas. The primary source of fuel to the boiler is biogas. However, the boiler is provided with automatic fuel switchover capability to change boiler fuel to natural gas when the biogas pressure is too low. Blending of heating water from the generator heat exchange system and the heating water from the boiler is facilitated by a mixing valve. If adequate heating is provided by the generator heat exchanger, automatic temperature controlled pneumatic valves isolate the boiler from the digester heating water system and the boiler is automatically shutdown. If adequate heat is not provided by the generator heat exchanger, the boiler is automatically started to heat water to the required temperature.

3.3 Heat Recovery

Table 3-1 summarizes the amount of recoverable heat that is generated from each engine generator at the design load of 330 kWe. A majority of the engine heat is transferred to one of three process streams: the high temperature jacket water circuit, the low temperature jacket water circuit and the exhaust.

Table 3-1 Energy Input and Recoverable Heat for Each Engine Generator

Manufacturer	Energy Input/ Fuel Consumption (MMBtu/day)	Recoverable Heat (MMBtu/day)
Cummins	86	31
GE Jenbacher	76	33

Based on the sludge production data and digester date presented in Appendix A, the amount of heat required to heat sludge and maintain digester temperature at average flow conditions is 26 MMBtu/day and at permitted flow conditions is 37 MMBtu/day. The amount of heat required to heat sludge is based on solids concentration of 5%. If the solids concentration of 5% cannot be achieved, the amount of heat required to heat solids will increase. As shown in Table 3-1, the heat recovered from the engine generator is sufficient to maintain temperature in the digesters. In the event one engine is out of service, the digester heating boiler will provide additional heat required.

3.3.1 High Temperature Jacket Water Circuit

Each engine manufacturer designs the high temperature jacket water circuit to remove heat from different components in the engine. This typically includes a first stage of an intercooler and the engine itself. It may also contain other sources such as lube oil. In either case, the temperature of the water in the high temperature jacket water circuit is usually in excess of 200°F. Heat can be recovered from this circuit by routing it through a plate and frame heat exchanger, referred to in this case as a Cogeneration Heat Recovery Heat Exchanger, capable of being connected to the JAHWWTP digester heating water system (Plant hot water loop). The high temperature jacket water circuit commences within the engine components, circulates through the Cogeneration Heat Recovery Heat Exchanger, and is returned to the engine. Digester heating water is circulated on the other side of the Cogeneration Heat Recovery Heat Exchanger, resulting in recovery of the heat from cogeneration. This recovered heat can be connected to the existing digester heating water system for heating digesters.

The high temperature jacket water will be a mix of water and glycol. The digester heating water system will continue to be a water loop only. The digester heating water system side of the Cogeneration Heat Recovery Heat Exchanger should be provided with carbon steel plates.

3.3.2 Low Temperature Jacket Water Circuit

Depending on the specific engine manufacturer, the low temperature jacket water circuit may remove intercooler heat and oil heat from the engine and is typically less than 150°F. Because of its low temperature, it is difficult to efficiently recover heat from this circuit and this heat is typically not included in the heat recovery system for digester heating.

3.3.3 Engine Exhaust

Engine exhaust temperatures will likely be in excess of 900°F, making engine exhaust a readily available source of heat for recovery. Exhaust Heat Recovery Heat Exchangers are water-to-gas heat exchangers where the exhaust is routed through heat exchanger tubes while water passes on the outside of the tubes. They are single pass units and should be installed in a manner that allows condensed exhaust to drain from the tubes when the system shuts down. The standard design for Jenbacher and Cummins is to install the Exhaust Heat Recovery Heat Exchanger on the digester heating water system, downstream of the Cogeneration Heat Recovery Heat Exchanger. Due to the potential for corrosion in the Exhaust Heat Recovery Heat Exchanger, heat exchanger tubes should be specified as 316L stainless steel.

3.3.4 Heat Recovery Scope of Supply

Almost all the main components of the heat recovery system should be provided by the engine manufacturer. Each engine manufacturer will have a separate, standardized design to remove and recover heat from its specific engine. Therefore the Contract Documents should not specify preferred makes and models for individual heat recovery components, but instead should be performance-based. Items that should be prescriptively included in the specifications as constraints include:

- Temperature Requirements
- Allowable Flows and Pressure Drops
- Materials of Construction

Both the Cogeneration Heat Recovery Heat Exchangers and the Exhaust Heat Recovery Heat Exchangers should be provided by the engine manufacturer. A schematic drawing of all components of the recommended heat recovery system to be included in the engine manufacturer's scope of supply is shown in Figure 3-1.

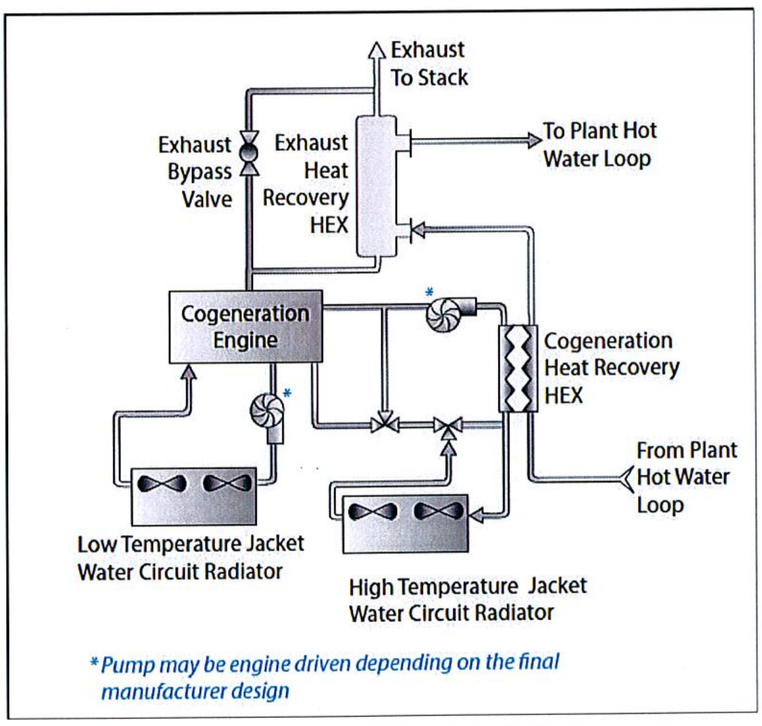


Figure 3-1
Schematic of Engine Manufacturer's Scope of Supply

3.4 Waste Heat Systems

In the event that any portion of the heat recovery system is not operational, an effective waste heat system must be provided to remove engine heat close to the source and protect the engine from tripping off due to high temperatures. For cogeneration systems located at wastewater treatment plants, there are two major sinks used to dump heat: the atmosphere or the plant effluent.

Heat from the exhaust should always be wasted to atmosphere. In the event that heat from the exhaust is not needed, an exhaust bypass valve could change position and divert exhaust around the Exhaust Heat Recovery Heat Exchanger, allowing all exhaust heat to be vented to atmosphere. The exhaust bypass valve should be provided by the engine manufacturer and controls for the valve should be built into the engine manufacturers control system – these items will be addressed in the Contract Documents.

Both high temperature and low temperature jacket water circuits can be wasted to the air by means of a radiator. Dual core radiators can be provided to keep the two jacket water circuits separate and maintain the correct cooling. Since radiators waste to the air, their location does not need to be tied to any other service other than electrical. Because radiators are sized to waste heat under all weather conditions, including hot summer days, and due to the low relative density of air, radiators need to move significant volumes of air. As a result, radiators have large fans with moderate motors and produce ambient noise on the order of 80 dB.

Generally, wasting jacket water heat to the plant effluent system would have a lower equipment cost and power cost compared to radiators. A plant effluent waste heat system is generally also quieter and smaller than a radiator system. However, a plant effluent system requires that the heat can be easily transported to a source of plant effluent, or that the plant effluent can be easily transported to the cogeneration system. Further, the NPDES permit must not have a temperature limit.

The existing JAHWWTP cogeneration engine currently wastes excess heat to the atmosphere. The new cogeneration engines can be provided with radiators to waste excess heat to the atmosphere as well. The radiator(s) could be situated on a concrete pad adjacent to the new cogeneration facility. Noise screening can be included as a requirement for the General Contractor if lower operating noise levels are desired.

3.5 Lube Oil

A lube oil system or protocol is needed to accommodate engine oil changes. Each GE Jenbacher and Cummins engine contains approximately 35 gallons of lube oil, respectively. For this study, it is assumed that the lube oil system protocol currently being used by the City will be carried out in similar fashion to the new generator system. The selected manufacturer will provide a recommended protocol to adhere to.

3.6 Piping Systems

The anticipated piping associated with this project includes the following services and/or systems:

- Jacket Water
- Hot Water Supply & Return
- Engine Exhaust

- Biogas
- Natural Gas
- Lube Oil

3.6.1 Jacket Water Piping

Both the low temperature and the high temperature jacket water circuits will contain a glycol-water mixture, with the only difference being their operating temperatures. Both systems should be ASTM A53, Grade B, steel and should incorporate butterfly valves. CDM Smith recommends that flanged or butt weld connections be allowed. All piping should be above grade. Piping should be insulated, mainly as a protection to personnel working adjacent to the piping.

Jacket water piping will be a closed system. Jacket water pumps should be provided as part of the engine manufacturer's scope of supply, as should expansion tanks. Each engine manufacturer will recommend the size (diameter) of the appropriate jacket water piping system for its engine. The General Contractor should be required to supply, install, and insulate the jacket water piping.

In many remote cogeneration facilities, and even in some centrally located facilities, the jacket water system is filled initially at startup. Because jacket water is a closed system, there is limited leakage during normal operations. Thus, a makeup system consisting of a potable or protected water connection and a glycol filling station is not necessary. However, the inclusion of these provisions reduces maintenance issues as these systems do not need to be manually recharged with a premixed glycol solution in the event that the system is opened for pump or other maintenance activities.

Potable or protected water is available at the location of the new cogeneration system, therefore, JAHWWTP should consider bringing that service into the building and delivering it to the jacket water system for make-up water as part of the scope of these improvements. In addition to the water connection, a make-up system would require a glycol feed station. Glycol addition could be done manually, based on periodic sampling of the jacket water.

3.6.2 Hot Water Supply and Return Piping

Hot water supply and return piping will need to be routed to the new cogeneration facility. Due to the distance between the existing digester heating water system located in the Generator Building and the new cogeneration facility, the existing hot water recirculation system pumps will require evaluation to make sure they can be used with the new engine generator system. To obtain the flow split between the two cogeneration units, CDM Smith recommends using balancing valves.

The proposed routing for the hot water piping will be evaluated after finalizing the location of the new engine generator location during design. The piping can generally be either buried or installed on a pipe bridge. Exposed hot water piping should be ASTM A53, Grade B, carbon steel. Butterfly valves are recommended. CDM Smith recommends that the General Contractor be allowed to use butt weld, grooved mechanical joints, or flanged connections. Piping should be insulated to reduce heat losses. CDM Smith further recommends that pre-insulated carbon steel piping be used for the buried pipe lines. The cost of this pipe is significantly higher than typical piping. Pre-insulated pipes, however, have lower installation costs as they reduce the need to apply insulation continuously over the pipe length (the insulation is only required at joints). Additional cost savings can be realized as trenches only need to be shored at pipe connections rather than configured to provide personnel access throughout to apply insulation. The pre-insulated piping systems are designed to be water tight at the factory, thus there is less opportunity for installation error that could allow moisture through the insulation and potentially causing corrosion of the buried pipe. Additional protections of buried pipe will be explored during detailed design.

3.6.3 Engine Exhaust Piping

Engine exhaust piping will vent the engine exhaust from the engine, through the Exhaust Heat Recovery Heat Exchanger, an exhaust silencer and out the exhaust stack. The Exhaust Heat Recovery Heat Exchanger and the exhaust silencer should be provided by the engine manufacturer. Engine exhaust piping should be stainless steel and insulated for personnel protection. Engine exhaust piping should be butt-welded. Exhaust piping should be sized to match the corresponding connection sizes for the equipment provided by the engine manufacturer.

3.6.4 Biogas Piping

Biogas piping must connect the digesters to the new biogas siloxane treatment system and also the biogas treatment system to the new cogeneration engines.

Biogas on the cogeneration-side of the biogas treatment system will be scrubbed of hydrogen sulfide, siloxanes, and moisture. As such, the biogas will no longer be corrosive. Butt-welded ASTM A53 carbon steel pipe should be used for all exposed biogas piping on the discharge of the biogas treatment system. Buried piping should be HDPE. Although most of the moisture in the biogas will be removed by the biogas treatment system, a means of condensate collection and manual removal should be provided at any low points in the piping.

3.6.5 Natural Gas Piping

Natural gas is provided to the existing digester heating water system and the digester gas utilization system through a 2" natural gas pipe. This natural gas piping will have to be rerouted from the digester gas utilization system to the new engine generators. The engines will need 7 psig of natural gas pressure as an input to the fuel blending equipment. The natural gas pipe size will be based on the engine natural gas demand and the pressure losses in the gas piping. Natural gas pressure from the utility shall be evaluated in sizing the natural gas pipe. Natural gas piping should be butt-welded ASTM A53 carbon steel. Valves should be lubricated plug valves.

3.7 Recommendations

CDM Smith is recommending adopting the following pre-design decisions and/or actions:

- Heat will be recovered from the following streams:
  - High temperature jacket water
  - Engine exhaust
- Excess jacket water heat not used for process and space heating needs will be wasted to a radiator.
- Excess exhaust heat not used for process and space heating needs will be wasted in the exhaust (and ultimately to atmosphere) through an exhaust bypass valve.
- A 55-gallon waste oil tank to hold the waste oil contents will be provided for each engine/generator set.

CDM Smith

- Overall piping recommendations are summarized in Table 3-3 below.

Table 3-3 Summary of Piping Recommendations

Piping System	Size	Materials	Connections	Valve Type
Jacket Water	Per manufacturer	ASTM A53 Carbon Steel	Flanged or butt welded	Butterfly
Plant Hot Water	Per manufacturer	ASTM A53 Carbon Steel	Flanged or butt welded	Butterfly
Engine Exhaust	Per manufacturer	316L SS	Butt welded	None
Biogas Piping – medium pressure (to cogeneration engines, exposed)	6-inch	ASTM A53 Carbon Steel	Butt welded	Lubricated plug
Biogas Piping – medium pressure (to cogeneration engines, buried)	6-inch	HDPE	Butt welded	Lubricated plug
Natural Gas	2-inch	ASTM A53 Carbon Steel	Butt welded	Lubricated plug

Section 4

Construction Cost, Schedule, and Sequencing for JAHWWTP Cogeneration Upgrades

4.1 Introduction

This section summarizes the major cost and schedule considerations associated with the JAHWWTP cogeneration upgrades. A preliminary project schedule outlining the two major options discussed herein will be provided after the workshop with the city, where the primary milestones of the project schedule will be finalized. The project schedule will be fully developed based upon the primary milestone dates developed in the workshop and will be provided in **Appendix H.** A preliminary opinion of probable construction cost for the project as currently constituted is provided in **Appendix I.**

4.2 Design & Construction Approaches - Traditional Procurement vs. Owner-Furnished Equipment with Assignment

The following two major design and construction procurement options were considered:

- Traditional procurement
- Owner-furnished equipment with assignment

A 'traditional procurement' approach includes a single, conservative design that can accommodate all preferred engine manufacturers.

Using an 'owner-furnished equipment with assignment' approach allows JAHWWTP to pre-purchase major equipment and improves the overall efficiency of the design process. Generally, an initial 100 percent 'owner-furnished equipment' design package is prepared along with approximately 30 percent of the 'balance of plant' design. Design work does not proceed further until the Contract for 'owner-furnished equipment' is advertised, evaluated, awarded and shop drawings are developed, reviewed, and approved. One hundred percent 'balance of plant' design then commences, using approved shop drawings for the selected owner furnished equipment as a basis.

Appendix H is reserved for a comparative project schedule for each of the above options. **Tables 4-1 and 4-2** summarize the various benefits and drawbacks for these two approaches.

Table 4-1 Benefits and Drawbacks of Traditional Procurement Approach

Benefits	Drawbacks
▪ Simplifies contracting. ▪ Shortest timeframe to 100% design drawings (may be a permit condition). ▪ Shortest overall design & construction period.	▪ Inefficient design (compounds 'worst-case' assumptions across all engine manufacturers). ▪ Higher overall design effort and requires re-design period during construction to translate 'worst-case assumptions' to final selection. ▪ Final engine selection is ultimately decided by Contractor. ▪ Longest timeframe to approved engine shop drawings (may be a permit condition).

Table 4-2 Benefits and Drawbacks of Owner Furnished Equipment with Assignment Approach

Benefits	Drawbacks
▪ Final engine selection is decided by JAHWWTP. ▪ Shortest timeframe to approved engine shop drawings (may be a permit condition). ▪ Most efficient design (lower effort spread over longer duration). ▪ Lowers capital cost by eliminating Contractor's mark-up on major equipment (partially off-set by 'assignment' costs).	▪ Longest overall design & construction period. ▪ Longest timeframe to 100% design drawings (may be a permit condition). ▪ Multiple contracts required with coordinated scheduling.

4.3 Recommended Design and Construction Approach

It is recommended that the JAHWWTP cogeneration upgrades project proceeds with an 'owner-furnished equipment with assignment' approach. The benefits described in Table 4-2 are significant and include a higher quality design and potentially lower overall project costs to JAHWWTP. One of the significant drawbacks of this approach is a longer overall design and construction schedule; the negative impact of the longer overall period in this case is as follows:

- Obtaining the permit to operate for these upgrades is the primary schedule driver as New Mexico Administrative Code may be enacting more stringent (and costly) requirements for similar installations in the near future.

Under the recommended approach, evaluation criteria for selecting the preferred engine equipment would be formalized, and should include both capital cost and the O&M cost of a fixed-duration (e.g., 5-year) maintenance contract from the bidders at a minimum. As a slight alteration to the recommended approach, pre-selection of the engines could also be achieved through a similar process that would culminate with the Contractor purchasing the pre-selected units for a pre-negotiated price. Logistics of such a modified approach will be discussed with JAHWWTP during detailed design.

4.4 Planned Shutdowns/Tie-Ins

At least two shutdowns may be required, as follows:

- Rehabilitation of the existing H_2S removal system and tie-in of biogas piping to the new biogas treatment system. This portion of the work is anticipated to last between four and five calendar weeks.
- Electrical check-out and tie-ins to the equipment being installed under this power reliability improvements project. The duration of this portion of the work will be largely dependent on requirements imposed by EPEC.

4.5 Cost Considerations

Appendix I includes an opinion of probable construction cost. In this case, a traditional procurement approach was assumed to result in a more conservative figure.

If the engine-generator sets are procured directly by JAHWWTP, a savings in Contractor's overhead and profit would be realized at approximately $150,000.00 of direct equipment cost if both engines are purchased. Should JAHWWTP choose to "pre-select" rather than fully "pre-purchase" the engines, the savings in Contractor's overhead and profit would be diminished. It would remain in JAHWWTP's best interest to advance the engine manufacturer's shop drawing production, review, and approval process before the General Contract is fully designed and awarded.

4.6 Recommendations

CDM Smith recommends adopting the following pre-design decisions and/or actions:

- Detailed design should proceed using an 'owner-furnished equipment with assignment' approach.
- Award of the owner furnished equipment contract should include both capital and a fixed-duration (e.g., 5-year) maintenance costs as part of the financial/economic evaluation.

Section 5

Emissions Standards and Air Permitting for JAHWWTP Cogeneration Upgrades

5.1 Introduction

The purpose of this section is to summarize the applicable federal and state emissions regulations pertaining to the proposed cogeneration engines and discuss potential permitting issues based on a review of the existing permit and current emissions regulations. Recommendations are included at the end of the section.

5.2 Existing Permit Review

The existing engine generator (ICE) and other stationary emission sources at the JAHWWTP, including blower engines and flares are regulated by a New Source Review (NSR) Air Quality Permit. The Permit (Permit No. 1865-M2) was issued by the Air Quality Bureau (AQB) in November 2002. An NSR permit is required for all sources with the potential emission rate greater than 10 pounds per hour, or 25 tons per year, of any of the following criteria pollutants:

- Nitrogen Oxides (NO_x)
- Carbon Monoxide (CO)
- Sulfur Oxides (SO_x)
- Ozone (O_3)
- Lead (Pb)
- Particulate Matter (PM)

The existing permit authorizes the operation of the JAHWWTP facility and imposes various conditions to assure continued compliance with applicable federal regulations and regulations issued by the State of New Mexico (Environmental Improvement Board). Potential and allowable emissions from the facility are included in the permit. Table 5-1 summarizes the allowable criteria pollutant emissions established by the permit and the total potential criteria pollutant emissions from the entire facility.

- *Title V Applicability*: For a facility to be considered a major source, it must have a potential to emit (PTE) 100 tons per year or more of any single air pollutant. In addition, a major source also includes facilities that have the potential to emit 10 tons per year or more of a single Hazardous Air Pollutant, or 25 tons per year or more of any combination of Hazardous Air Pollutants (HAP). A facility that is a major source is subject to the Clean Air Act Amendments (CAAA) Title V Operating Permit program and is required to obtain a Title V operating permit. Based on the total potential emissions listed in Table 5-1, and since the facility is not regulated by a Title V permit, it appears that the JAHWWTP is currently not classified as a major source.

Table 5-1 Allowable Emissions

Emission Unit no.	Type Of Unit	NOx[a]		CO		VOC		HP	Fuel Type
		pph[d]	tpy[d]	pph	tpy	pph	tpy	Max/Site	
1	Generator	19	63.7	4.4	14.7	1.0	3.4	616/572	Digester Gas or Natural Gas
2[b]	Blower Engine	7.1	30.9	6.4	28.0	0.4	1.8	307/286	Natural Gas
3[b]	Blower Engine	7.1	30.9	6.4	28.0	0.4	1.8	307/286	Natural Gas
4[b]	Blower Engine	7.1	30.9	6.4	28.0	0.4	1.8	307/286	Natural Gas
5[b]	Blower Engine	7.1	30.9	6.4	28.0	0.4	1.8	307/286	Natural Gas
6	Flare	0.1	0.5	0.6	2.7	0.2	0.8	(600BTU/ft^3)	Digester Gas
7	Flare	0.1	0.5	0.6	2.7	0.2	0.8	(600BTU/ft^3)	Digester Gas
Total Potential Criteria Pollutant Emissions			**95.1**		**45.4**		**6.0**		

a. Nitrogen dioxide emissions include all oxides of nitrogen expressed as NO_2

b. Only one (1) engine of units 2 through 5 may operate at any one time

c. Only one (1) flare of units 6 through 7 may operate at any one time

d. pph – pounds per hour; tpy – tons per year

- *Revisions and Modifications*: The existing permit states that any physical changes may constitute a modification as defined by 20 NMAC 2.72, Construction Permits.
- *Other Permit Conditions*: The following additional conditions included in the existing permit need to be considered during design. These conditions would continue to apply to the facility, or similar conditions could potentially be imposed (in case a modification is required) by the Air Quality Bureau for the proposed cogeneration upgrades.
  - The existing engine generator may not operate between 12:00 AM (midnight) and 8:00 AM during the months of March, April, and May.
  - The fuel for the existing generator shall be either pipeline quality natural gas or digester gas. Also, a limit of 5 ppmv has been set for the total sulfur (dry) content in the digester gas.

5.3 Applicable Federal and State Regulations

The proposed cogeneration upgrades include the installation of two spark-ignition lean-burn type internal combustion engines, or a single engine with the capabilities for future expansion. These engine generator systems will be used to power the plant using biogas gas with natural gas as a supplemental source. The system design will allow for blending natural gas and digester gas at approximately an 80/20 ratio with natural gas being the predominant fuel source. Based on initial engine selections from manufacturers, the proposed engines will be approximately 470 HP each.

The above criteria were used to identify and review federal (EPA) and New Mexico air quality regulations that could impact construction and operation of the proposed engine generators.

- *New Source Performance Standards (NSPS) for spark ignition reciprocating engines* ***(40 CFR Part 60, Subpart J.J.J.J.)***: These regulations establish emission standards applicable to the engines based on year of manufacture, fuel-to-air ratio, and type of fuel used. Table 5-2 presents emissions criteria pertinent to the proposed engines for this project. Detailed requirements for operation, performance testing, monitoring, recordkeeping, and compliance are contained in this regulation. These requirements need to be further evaluated during the permitting stage of the project to ensure compliance with this Subpart.

Table 5-2 Subpart JJJJ Stationary Spark Ignition Internal Combustion Engine Emission Standards

Engine Type and Fuel	Maximum Engine Power	Manufacture Date (On or After)	Emission Standards					
			g/HP-hr			ppmvd at 15% O2		
			NO_X	CO	VOC[b]	NO_X	CO	VOC[b]
Non-Emergency SI Natural Gas[a] and Non-Emergency SI Lean Burn LPG[a]	100≤HP<500	7/1/2008	2.0	4.0	1.0	160	540	86
		1/1/2011	1.0	2.0	0.7	82	270	60
Landfill/Digester Gas Lean Burn	HP<500	7/1/2008	3.0	5.0	1.0	220	610	80
		1/1/2011	2.0	5.0	1.0	150	610	80

a. Owners and operators of stationary non-certified SI engines may choose to comply with the emission standards in units of either g/HP-hr or ppmvd at 15 percent O2.

b. For purposes of this subpart, when calculating emissions of volatile organic compounds, emissions of formaldehyde should not be included.

- *National Emissions Standards for Hazardous Air Pollutants (NESHAP) for Stationary Reciprocating Internal Combustion Engines* ***(40 CFR Part 63, Subpart Z.Z.Z.Z.)***: This regulation establishes national emission limitations and operating limitations for hazardous air pollutants emitted from stationary reciprocating internal combustion engines located at major and area sources of HAP emissions. For a new engine, compliance with 40 CFR 60 Subpart J.J.J.J. is considered compliance with this regulation.

- *Mandatory Greenhouse Gas Reporting* ***(40 CFR Part 98)***: The Mandatory Reporting of Greenhouse Gases Rule, issued by the EPA, requires reporting of greenhouse gas (GHG) data and other relevant information from large sources and suppliers. A facility would be subject to the Rule if it has a PTE of 100,000 TPY CO2e, and undertakes a modification that is projected to increase emissions by at least 75,000 TPY CO2e.

In addition to the above Federal regulations, the proposed engine generators at the JAHWWTP will also be subject to applicable requirements of the following State regulations issued by the New Mexico Environmental Improvement Board. Table 5-3 provides a summary of applicable emissions regulations contained in the New Mexico Administrative Code (NMAC).

Table 5-3 NMAC Title 20 Chapter 2 (Air Quality) Emission Standards

Title	Citatation	Contaminant	Maximum Allowable Concentration
Ambient Air Quality Standards	20 NMAC 2.3	Total Suspended Particulates	24-hour average: **150 ug/m3;** 7-day average: **110 ug/m3;** 30-day average: **90 ug/m3;** Annual geometric mean: **60 ug/m3.**
		Sulfur Compounds	24-hour average: **0.10 ppm;** Annual arithmetic average: **0.02 ppm;**
		Hydrogen Sulfide	1-hour average (not to be exceeded more than once per year): **0.010 ppm**
		Total Reduced Sulfur	1/2 hour average: **0.003 ppm**
		Carbon Monoxide	8-hour average: **8.7 ppm** 1-hour average: **13.1 ppm**
		Nitrogen Dioxide	24-hour average: **0.10 ppm;** Annual arithmetic average: **0.05 ppm;**
Smoke and Visible Emissions	20 NMAC 2.61	Emissions from the stationary combustion equipment shall not equal or exceed an opacity of **20 percent**	

5.4 General Permitting Factors

The following factors were identified that could potentially influence permitting of new engine(s) at JAHWWTP, including:

- *Title V Reporting Thresholds and Potential to Emit*: Addition of new cogeneration engine capacity with no change in the existing operational configuration will increase the PTE and probably cause the total NO_x emissions to exceed 100 tpy. This would result in a change in the status of the facility from minor to major source.

- *Continued operation as a minor source (by decommissioning the existing ICE):* Installation of new lean-burn engines while decommissioning the existing ICE allows for a clear demonstration to the AQB that there is both a decrease in the emissions of pollutants that are currently permitted, and a significant decrease in the PTE thus moving JAHWWTP further below the Title V classification thresholds that are nearly exceeded by the existing system.

- *Continued operation as a minor source (by restricting hours of operation):* The JAHWWTP could potentially continue to operate as a minor source and not be subject to Title V regulations by applying for a permit modification. The modification will include addition of the new ICEs to the permit and restricted hours of operation for the existing ICE.

- *Greenhouse Gas Applicability:* As new sources, the engines would also have to be evaluated for their potential GHG emissions to make sure they would not subject the facility to major NSR permitting (JAHWWTP currently has a minor NSR permit). It is not expected that the addition of the new engines will cause the facility to exceed the major NSR permitting threshold of 100,000 tpy CO_2e.

5.5 Recommendations

Because of the permitting issues discussed herein, CDM Smith is recommending adopting the following pre-design decisions and/or actions:

- Plan to decommission the existing ICE at the time of initial cogeneration upgrades.
- Based on information provided in the existing permit, the JAHWWTP appears to be a minor source for criteria and hazardous air pollutants. However, it is recommended that emissions from all existing equipment and operations at the facility be re-evaluated to confirm minor source status (this determination will be required if a permit modification becomes necessary).
- The constituents of concern relative to air permitting of an ICE fueled by biogas at a wastewater treatment plant include NO_x, CO, NMHC and PM_{10}. Based on pertinent regulations identified in Section 5.3 for the SI engines, the following emission limits are proposed for the air permit:
  - NO_x = 1.0 g/bHP-hr
  - CO = 2.0 g/bHP-hr
  - VOC = 0.7 g/bHP-hr

The above limits were shared with one of the preferred engine manufacturers and found to be generally achievable.

Section 6

Mechanical – HVAC Design

This section describes the proposed HVAC system designs for the Las Cruces cogeneration system replacement project.

6.1 Introduction

The project HVAC system consists of providing required ventilation for the generator facilities and providing environmental conditioning to protect the generation system electrical equipment.

There are currently four options for providing protection for the project generators. The first option is to provide an open, roof only structure. This option would not require any ventilation at all, so it is not discussed here further. The second option is to provide a prefabricated metal building. The third option is to provide a CMU building. The fourth option is to utilize the existing engine generator building, to be confirmed during the workshop. The fourth option would likely provide room for only one new engine and generator. If only one engine and generator with switchgear is to be provided under this project, with the capability for future expansion to a dual engine generator system, there may be enough room in the existing building for future switchgear, but not likely the future engine and generator. There is adequate room adjacent to the exterior side of the existing building that could be dedicated to a future engine and generator with prefabricated metal building or CMU building addition. The second, third and fourth options require the same basic ventilation system design. All options require the same basic Electrical Room air conditioning system design.

6.2 Codes and Standards

The following codes and standards shall apply:

- 2009 New Mexico Commercial Building Code (NMCBC)
- 2009 New Mexico Mechanical Code (NMMC)
- 2009 New Mexico Energy Conservation Code (NMECC)
- American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE) Handbooks
- Sheet Metal and Air Conditioning Contractors National Association (SMACNA) Duct Construction Manuals
- National Fire Protection Association (NFPA)
- Air Moving and Conditioning Association (AMCA).
- Associated Air Balance Council (AABC).
- National Environmental Balancing Bureau (NEBB).

- American Conference of Governmental Industrial Hygienists (ACGIH).

6.3 Design Criteria

Outdoor design conditions for summer are 99°F DB – 64°F WB, and for winter are 15°F DB.

Based on the system being critical to provide standby power during a power outage, design of the systems is to be based on a higher maximum design temperature. Final temperature will be determined during final design. Selection will be based on frequency of occurrence of the high temperature.

Table 6-1 Indoor Design Conditions

Space	Summer Design Temperature °F	Outdoor Air Ventilation Rate	Winter Design Temperature °F	Outdoor Air Ventilation Rate	Notes
Generator Room	10° F above outdoor ambient temperature	See Note 1	55°	See Note 1	Summer - Independent heat removal ventilation Winter - Gas fired unit heaters
Electrical Room	85°	By Code	55°	By Code	Mechanical cooling w/ standby units. See Note 2

Notes:

1. Ventilation rate based on minimum required by code, or as required for heat removal with engines when operating, or air required for combustion air, whichever is greater.
2. Standby equipment will be two units at 100% capacity, or three units at 50% capacity

6.4 Heating

Heating in the Electrical Room will be provided by electric heat strips in the HVAC units.

Heating in the generator room will be provided by indirect gas fired unit heaters. Units will be interlocked to the generator engines to prevent operation of the unit heaters when the engines are running.

6.5 Air Conditioning

In general, cooling will be provided for Electrical Rooms by split-system or packaged DX cooling units. Configuration of the units will be dependent on the layout the room. Cooling controls will, in general, be provided with the units.

Due to the critical nature of the generators, standby equipment will be provided for the Electrical Room. Depending on the size of the equipment, either two units at 100% capacity each or three units at 50% capacity each will be provided.

To minimize corrosion in the Electrical Room, economizer cooling will not be provided. In addition, chemical filter pressurization units will be provided.

6.6 Generator Room

The generator room will be provided with a ventilation system consisting of roof-mounted exhaust fans and wall mounted intake louvers. If the existing generator building is to be utilized, existing ventilation system modifications will be provided during the design phase.

When the generator room air temperature exceeds the cooling system setpoint (85°F), air will be exhausted through roof-mounted exhaust fans. Makeup air for the exhaust fans and combustion air for the generators will enter the generator room through wall louvers.

If it is determined during final design that filtration is required for dust control, filters will be located at the intake louvers. The static pressure of the exhaust fans will be increased to accommodate the pressure loss of the filters.

When the generators are not operating and the generator room air temperature is below the heating system setpoint (55°F), the gas-fired unit heaters shall operate to maintain the heating system setpoint temperature to protect the generators and generator equipment.

6.7 Fans and Air Handling Units

In general, fans and air handlers will be aluminum or steel construction. Fans will have motors mounted outside of the air stream. Where possible, fans will be backward inclined centrifugal fans. Drives will be belt driven with variable sheaves.

V belt drives will consist of the driver and driven sheaves and one or multiple matched V belts. V belt drives will have belt horsepower ratings equal to or greater than 1.5 times the driving motor nameplate horsepower.

The selection of fans, air handling units, air conditioners, heating, ventilating and air conditioning machinery and mechanical equipment and the installation of system components will be such as not to create noise that will exceed the levels of permissible noise exposures for occupational areas as established by the Occupational Safety and Health Act and other Federal, State and local safety and health standards, codes and ordinances.

All cooling and ventilation equipment required for the operation of the engine generator system to power the plant must be provided with standby power.

Unless otherwise specified, all HVAC machinery and vibrating HVAC system components will be isolated from the building structure by vibration isolators with a minimum absorption efficiency of 90 percent for the lowest disturbing frequency of the particular vibration source.

All HVAC equipment exposed to the weather, wet environments, or corrosive environments will be provided with corrosion protection.

6.8 Hangers, Supports, and Anchors

All piping will be supported at a maximum of 10 ft-0 in intervals. Hangers or rings will be sized to fit outside the insulation. Ductwork support spacing and size of hangers will be as called for in the SMACNA standards. All duct hanger and fastener materials will be of same finish as ductwork which they serve, e.g., galvanized, aluminum, black steel.

Design of all hangers will include the effect of all loads applied to the duct and pipe as well as the load of the duct or pipe. These loads include, but are not limited to, wind, snow, seismic and internal dirt or liquid buildup.

6.9 Automatic Temperature Controls

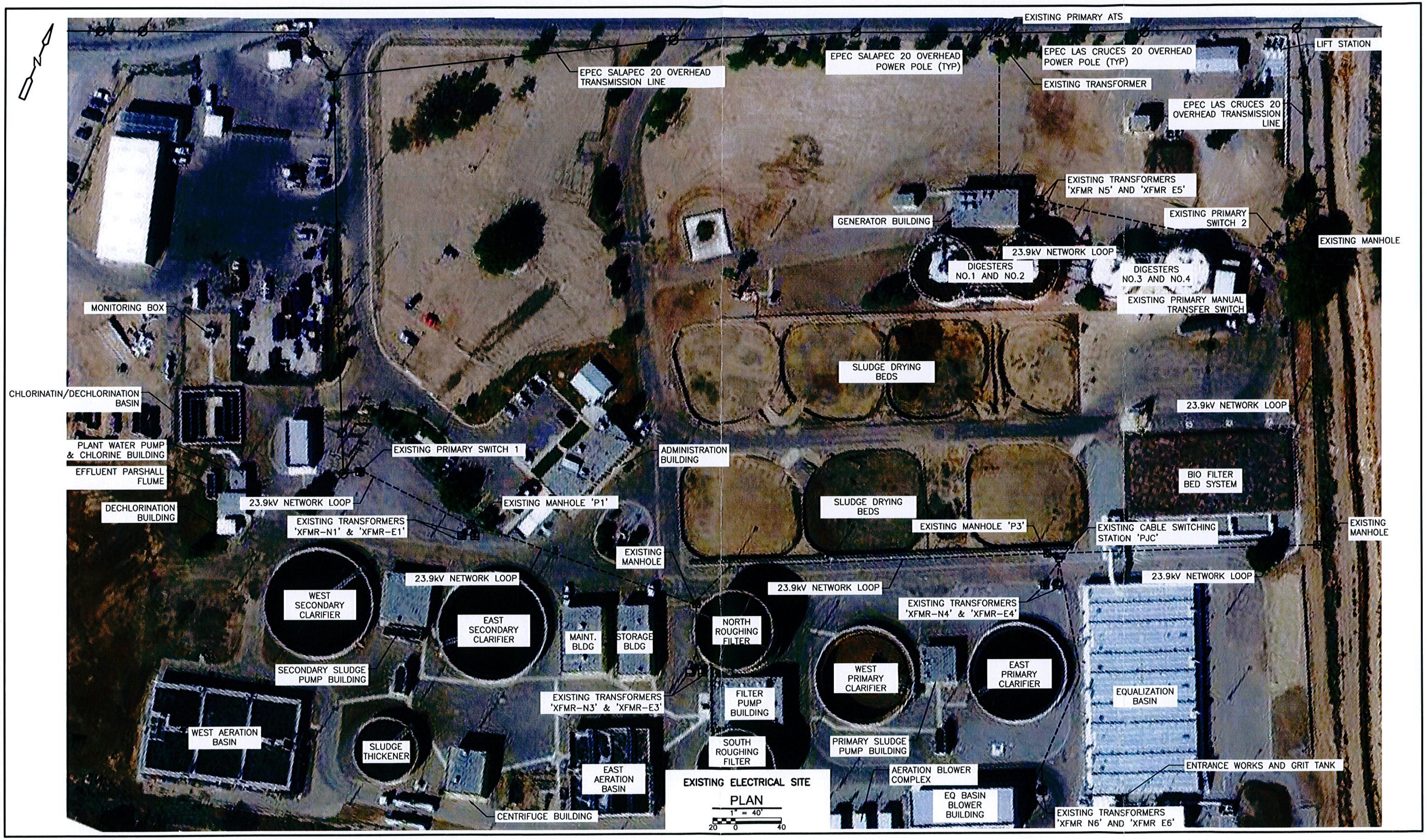
Where specific area classifications are determined by code or the electrical engineer, all equipment and wiring will be in conformance with the requirements for that classification. Special attention shall be given to hazardous areas specifically "Class I Div. 1 Group D" and "Class I Div. 2 Group D" to comply with code requirements for equipment selection and installation procedures.

All devices will be provided with an engraved plastic plate containing the name, function, and system or system number of the device.

A high temperature alarm will be provided in the Electrical Room. The alarm will notify the plant operators that the temperature of the electrical equipment, which is critical to the operation of the engine generators and plant, is exceeding the maximum allowable space temperature of 95°F. This is done in order to maintain plant operations.

Appendix E
Site Plan

Appendix I
Phase 1 and Phase 2 Opinion of Cost of Construction



CDM Smith

Figure 2-10
Existing Electrical Site Plan
MAY 2012

Gas Powered Engine Generator Set With Full Capacity System Infrastructure
Under Phase 1

Opinion of Cost of Construction

	D	E	F	H	I	J	K	M	N	T	U	V	X	AJ	AK	AL	AM	AN
1		Source	Line Number	Description	Crew	Daily Output	Labor Hours	Quantity	Unit	Ext. Material	Ext. Labor	Ext. Equipment	Ext. Total	Ext. Total Incl O&P	Zip Code Prefix	Type	Release	Notes
2		Custom		334kW Low BTU Gas Engine Powered Generator Set, Paralleling Switchgear, and Integrated Power Enclosure				1.00	Ea.	$680,000.00	$10,800.00	$628.00	$691,428.00	$766,510.80	880			
3		Custom		Upgrade Utility Infrastructure and Permitting				1.00	LS	$150,000.00			$150,000.00	$150,000.00	880			
4		Custom		25kV Pad Mounted Medium Voltage Vista 321 Switchgear; 25kV primary, 480Y/277V Secondary, 3 phase, 2500KVA pad mounted Transformer; and cable switching station				1.00	Ea.	$160,808.00	$7,225.00	$1,025.00	$169,058.00	$189,937.55	880			
5		Custom		Wire, copper, stranded, 600 volt, 500 kcmil, 300 kcmil, and 1/0, type XHHW, in raceway				1.00		$32,056.00	$5,561.08		$37,617.08	$44,437.38				
6		Unit	260513163200	Medium-cable single cable, copper, XLP shielding, grounded neutral, 25 kV, 2/0, in conduit, excl splicing & terminations	2 Elec	3.40	4.706	5.40	C.L.F.	$2,997.00	$891.00		$3,888.00	$4,617.16	880	Union	2013	
7		Custom		PVC conduit, schedule 40, 2-1/2" diameter, 3-1/2" diameter, and 5" diameter, to 15' h, incl terminations, fittings, & support				1.00		$11,218.20	$6,760.80		$17,979.00	$23,495.34				
8		Custom		Underground System (duct banks, excavation, concrete, backfill, manhole)				1.00		$11,679.33			$11,679.33	$12,847.26				
9		Custom		Structural concrete equipment pads				1.00		$1,770.00	$1,007.00	$20.71	$2,797.71	$3,631.33				
10		Custom		Biogas Treatment System				1.00		$250,000.00			$250,000.00	$275,000.00				
11		Custom		Compressor System				2.00		$500,000.00			$500,000.00	$550,000.00				
12		Custom		Miscellaneous Piping				1.00	LS	$147,000.00			$147,000.00	$152,000.00				
13		Custom		Grounding Equipment (grounding rods, 4/0 bare copper wire, exothermic welds)				1.00		$1,796.55	$1,515.50		$3,312.05	$4,476.78				
14		Custom		Miscellaneous Hardware (steel channels, threaded rods, nuts, washers, spring nuts)				1.00		$5,895.90	$2,072.00		$7,967.90	$9,904.29				
15		Custom		Cable terminations, 25kV, #4 stranded to 1/0 stranded; and cable splicing, 25kV, #6 stranded to #1 stranded				1.00		$2,962.00	$1,157.00		$4,119.00	$5,167.25				
16		Custom		Terminal lugs, solderless, 500 kcmil and 350 kcmil				1.00		$383.64	$2,634.00		$3,017.64	$4,768.10				
17		Custom		Wire, copper, stranded, 600 volt, #14, #12, and #10, type THWN-THHN, in raceway				1.00		$839.00	$1,650.00		$2,489.00	$3,645.40				
18		Unit	260523200500	Thermostat cable, jacket non-plenum, twisted, #18-2 conductor	1 Elec	8.00	1.000	5.00	C.L.F.	$65.00	$175.00		$240.00	$334.70	880	Union	2013	
19										$1,959,470.62	$41,448.38	$1,673.71	$2,002,592.71	$2,200,773.35				
20																		
21	See Executive Summary for reference.																	

Future Gas Powered Engine Generator Set
Under Phase 2

Opinion of Cost of Construction

	D	E	F	H	I	J	K	M	N	T	U	V	X	AJ	AK	AL	AM	AN
1		Source	Line Number	Description	Crew	Daily Output	Labor Hours	Quantity	Unit	Ext. Material	Ext. Labor	Ext. Equipment	Ext. Total	Ext. Total Incl O&P	Zip Code Prefix	Type	Release	Notes
2		Custom		334kW Low BTU Gas Engine Powered Generator Set With enclosure				1.00	Ea.	$450,000.00	$6,750.00	$628.00	$457,378.00	$506,828.30	880			
3		Unit		Wire, copper, stranded, 600 volt, 500 kcmil and 1/0, type XHHW, in raceway	3 Elec	4.80	5.000	1.00		$5,250.00	$870.00		$6,120.00	$6,987.78	880	Union	2013	
4		Custom		PVC conduit, schedule 40, 2-1/2" diameter and 5" diameter, to 15' H, incl terminations, fittings & support				1.00		$1,948.50	$1,187.00		$3,135.50	$4,101.90				
5		Custom		Grounding Equipment (#4/0 bare copper wire and exotermic welds)				1.00		$142.60	$189.40		$332.00	$469.37				
6		Unit	260519350450	Terminal lugs, solderless, 500 kcmil	1 Elec	6.00	1.333	8.00	Ea.	$64.40	$372.00		$436.40	$631.82	880	Union	2013	
7		Custom		Wire, copper, stranded, 600 volt, #14 and #10, type THWN-THHN, in raceway				1.00		$74.40	$157.00		$231.40	$340.89				
8										$457,479.90	$9,525.40	$628.00	$467,633.30	$519,360.06				
9																		
10	See Executive Summary for reference.																	

Appendix A
Solids and Biogas Production Calculations

Jacob A. Hands Wastewater Treatment Plant
Las Cruces, NM

Combined Heat and Power Project

Solids Production Calculation

Month	Influent Flow (MGD)	Influent BOD (mg/l)	Influent TSS (mg/l)	Influent BOD (lbs/day)	Influent TSS (mg/l)	Effluent BOD (mg/l), assumed	Effluent TSS (mg/l), assumed	Effluent BOD (lbs/day), assumed	Effluent TSS (lbs/day), assumed
Mar-10	8.9	255.5	297.3	18897.3	21990.1	5	15	369.8	1109.5
Apr-10	9.0	230.3	314.1	17228.2	23494.5	5	15	374.0	1122.0
May-10	9.0	200.5	308.1	15092.7	23184.2	5	15	376.3	1128.9
June-10	9.2	226.4	294.0	17348.0	22521.1	5	15	383.1	1149.2
Jul-10	9.5	155.5	273.9	12378.9	21809.6	5	15	398.2	1194.5
Aug-10	9.7	165.4	285.8	13353.3	23082.4	5	15	403.8	1211.3
Sep-10	9.8	196.2	289.7	16034.7	23677.9	5	15	408.7	1226.0
Oct-10	9.9	182.1	273.1	15022.9	22529.4	5	15	412.5	1237.6
Nov-10	9.5	209.4	277.4	16551.5	21931.5	5	15	395.3	1185.9
Dec-10	8.9	237.7	322.6	17640.7	23944.6	5	15	371.1	1113.4
Jan-11	7.8	240.2	325.5	15705.8	21289.4	5	15	327.0	981.0
Feb-11	9.5	218.8	357.8	17421.4	28485.2	5	15	398.1	1194.3
Mar-11	9.1	245.5	349.0	18567.7	26394.8	5	15	378.2	1134.5
Apr-11	9.2	211.7	334.7	16219.3	25642.4	5	15	383.1	1149.2
May-11	9.2	263.3	364.7	20208.8	27993.2	5	15	383.8	1151.4
Jun-11	9.5	207.8	308.8	16403.6	24373.5	5	15	394.7	1184.1
Jul-11	9.9	192.3	290.6	15838.3	23937.2	5	15	411.8	1235.5
Aug-11	10.3	186.9	300.6	15995.7	25730.3	5	15	427.9	1283.8
Sep-11	10.3	204.7	306.1	17573.4	26280.6	5	15	429.2	1287.7
Oct-11	10.1	236.4	311.7	19936.5	26288.9	5	15	421.7	1265.2
Nov-11	9.9	246.5	356.6	20268.5	29322.6	5	15	411.1	1233.3
Dec-11	9.6	223.4	322.8	17854.2	25800.2	5	15	399.6	1198.8
Jan-12	9.2	262.6	291.7	20225.6	22462.9	5	15	385.1	1155.2
Feb-12	9.6	223.4	322.8	17854.2	25800.2	5	15	399.6	1198.8
Mar-12	9.2	234.9	317.1	18061.3	24379.2	5	15	384.4	1153.2
Average=	**9.4**	**218.3**	**311.9**	**17107.3**	**24493.8**	**5.0**	**15.0**	**393.1**	**1179.4**

Average TSS Removed =	15154.4	lbs/day
Average BOD Removed In Primary Clarifiers=	5014.3	lbs/day
Average Scondary Solids Produced =	7020.0	lbs/day
Total Solids Produced at Current Average Flow =	**22174.4**	**lbs/day**
Solids Production Rate (lbs/MG) =	2352.1	lbs/day
Plant Rated Capacity	13.5	MGD
Total Solids Produced at Plant Rated Capacity	**31753.6**	**lbs/day**

Jacob A. Hands Wastewater Treatment Plant
Las Cruces, NM

Combined Heat and Power Project

Biogas Production Evaluation at Average Flow Conditions

At Current Average Flow Conditions

Sludge Concentration	**4.0%**	Assumed	***Gravity Thickner@ 4%***
Cold Sludge Temperature	**50**	°F	
Average Sludge Temperature	**60**	°F	
Summer Sludge Temperature	**70**	°F	
Cold Air Temperature	**16**	°F	
Average Air Temperature	**66**	°F	
Summer Air Temperature	**73**	°F	
Ground Temperature	**50**	°F	
Target Digester Sludge Temp =	**95**	°F	
Total Solids Produced (Current Average Flow) =	**22,174**	lb/day	*(Based on March 2010-March 2012 data)*
Total Solids Produced (At Plant Rated Capacity) =	**31,754**	lb/day	
Sp =	1.000	BTU/lb-°F	
Flow rate =	66,470	gpd	
Peaking factor =	1		
HRT =	**15**	days	Assumed
Volume required for Sludge	**133,295**	ft^3	
% VS in Sludge	75%		
Volatile Solids Loading Rate	0.05	$lbs/day/ft^3$	**Typical VSS loading rate is 0.10-0.20 lbs/cu.ft/day at HRT of 15-20 days, WEF MOP, page 22-27**

Digester Volume Calculation

Volume of Primary Digester

Depth(SWD) =	**24**	ft
Diameter =	**64**	ft

Volume (cylinder section) = 77,208 ft^3
577,514 gal

Number of Digesters = **2**

Volume of Secondary Digester

Depth(SWD) = **24** ft

Diameter = **64** ft

Volume (cylinder section) = 77,208 ft^3
577,514 gal

Number of Digesters = **2**

Total Digester Volume =	154,416	ft^3
	1,155,028	gallons

U value

0.58	Btu/hr-ft^2 ^oF	
0.11	Btu/hr-ft^2 ^oF	
0.83	Btu/hr-ft^2 ^oF	for above grade
0.06	Btu/hr-ft^2 ^oF	for below grade

U Values from M&E, 1999

	U Value
Plain concrete walls above grade	
12-inch, non-insulated	0.83-0.90
12-inch, with air space and brick	0.32-0.42
12-inch, with insulation	0.11-0.14
Plain concrete walls below grade	
Surrounded by dry earth	0.10-0.12
Surrounded by moist earth	0.19-0.25
Plain concrete floors	
12-inch, dry earth	0.10-0.12
12-inch, wet earth	0.05-0.07

	U Value
Floating covers	
1.5-inch wood deck, no insulation	0.32-0.35
With insulation	0.16-0.18
Concrete covers	
4-inch thick with roofing, no ins	0.70-0.88
9-inch, no insulation	0.53-0.63
Fixed steel cover	0.70-0.95

Digester Heating Requirements

	Digester Roof Area, ft^2	Roof- Radiant Heat Loss (BTU/day)	Digester Walls Area, ft^2	Walls - Radiant Heat Loss (BTU/Day)	Digester Cone Area, ft^2	Cone - Radiant Heat Loss (BTU/Day)	Heat Required to Raise Temperature of Incoming Sludge (BTU/Day)				
Cold Weather Conditions	12,868	14,150,642	19,302	8,531,846	9,651	2,293,071	24,946,157				
Summer Weather Conditions	12,868	3,940,685	19,302	3,052,796	9,651	1,146,536	13,858,976				
Average Weather Conditions	12,868	5,194,540	19,302	3,725,661	9,651	1,146,536	19,402,566				

Gas Production

Option	% VS in Sludge	% VS Destroyed	Gas Production Rate (ft^3 gas / lb VS destroyed)	Btu Rating of Gas (Btu per ft^3 gas produced)	Amount of Waste to Digesters (lb /day)	Amount of Gas Generated, ft^3/day	Gas Heat Rate Produced (Btu/day)	Gas Heat Rate Produced (MMBtu/day)	Gas Heat Rate Produced (MW fuel)	Efficiency of Turbine or Engine	Power Production (MW)	% Heat Recoverable From Process	Recoverable Heat (MMBtu/day)
Waste Sludge (Primary and WAS)	75	55	15	435	22,174	137,204	59,683,680	60	0.73	0.3	**0.22**	0.44	8

Average Weather Condition

Option	Amount of Gas Generated, ft^3/day	Gas Heat Rate Produced (Btu/day)	Gas Heat Rate Produced (MMBtu/day)	Gas Heat Rate Produced (MW fuel)	Efficiency of Turbine or Engine	Power Production (MW)	Power Generation Capacity (kW)	Annual Electricity Generated (kWh/yr)	Electricity Generated (kWh/month)	Total Heat Required to Raise Temperature in Digesters (BTU/day)	% Heat Recoverable From Process	Amount Heat Recoverable From Process (BTU/day)	Is Heat Recovered Adequate for Heating Requirement ? (Y/N)
Waste Sludge (Primary and WAS)	137,204	59,683,680	60.00	0.7	0.3	0.2	219	1,915,405	**159,617**	29,469,302.75	0.44	26,260,819	N

Jacob A. Hands Wastewater Treatment Plant
Las Cruces, NM

Combined Heat and Power Project

Biogas Production Evaluation at Rated Plant Capacity

At Plant Rated Capacity

Sludge Concentration	**4.0%**	Assumed	***Gravity Thickner@ 4%***
Cold Sludge Temperature	**50**	°F	
Average Sludge Temperature	**60**	°F	
Summer Sludge Temperature	**70**	°F	
Cold Air Temperature	**16**	°F	
Average Air Temperature	**66**	°F	
Summer Air Temperature	**73**	°F	
Ground Temperature	**50**	°F	
Target Digester Sludge Temp =	**95**	°F	

Total Solids Produced (At Plant Rated Capacity) =	**31,754**	lb/day	*(Based on March 2010-March 2012 data)*
Sp =	1.000	BTU/lb-°F	
Flow rate =	95,185	gpd	
Peaking factor =	1		
HRT =	**15**	days	Assumed
Volume required for Sludge	**190,878**	ft^3	

% VS in Sludge	75%	
Volatile Solids Loading Rate	0.08	lbs/day/ft^3

Typical VSS loading rate is 0.10-0.20 lbs/cu.ft/day at HRT of 15-20 days, WEF MOP, page 22-27

Digester Volume Calculation

Volume of Primary Digester

Depth(SWD) =	**24** ft	308831.1242
Diameter =	**64** ft	
Volume (cylinder section) =	77,208 ft^3 577,514 gal	

Number of Digesters = **2**

Volume of Secondary Digester

Depth(SWD) = **24** ft

Diameter = **64** ft

Volume (cylinder section) = 77,208 ft^3
577,514 gal

Number of Digesters = **2**

Total Digester Volume =	154,416	ft^3
	1,155,028	gallons

U value

0.58	Btu/hr-ft^2 ^oF	
0.11	Btu/hr-ft^2 ^oF	
0.83	Btu/hr-ft^2 ^oF	for above grade
0.06	Btu/hr-ft^2 ^oF	for below grade

U Values from M&E, 1999

	U Value
Plain concrete walls above grade	
12-inch, non-insulated	0.83-0.90
12-inch, with air space and brick	0.32-0.42
12-inch, with insulation	0.11-0.14
Plain concrete walls below grade	
Surrounded by dry earth	0.10-0.12
Surrounded by moist earth	0.19-0.25
Plain concrete floors	
12-inch, dry earth	0.10-0.12
12-inch, wet earth	0.05-0.07

	U Value
Floating covers	
1.5-inch wood deck, no insulation	0.32-0.35
With insulation	0.16-0.18
Concrete covers	
4-inch thick with roofing, no ins	0.70-0.88
9-inch, no insulation	0.53-0.63
Fixed steel cover	0.70-0.95

Digester Heating Requirements

	Digester Roof Area, ft^2	Roof- Radiant Heat Loss (BTU/day)	Digester Walls Area, ft^2	Walls - Radiant Heat Loss (BTU/Day)	Digester Cone Area, ft^2	Cone - Radiant Heat Loss (BTU/Day)	Heat Required to Raise Temperature of Incoming Sludge (BTU/Day)				
Cold Weather Conditions	12,868	14,150,642	19,302	8,531,846	9,651	2,293,071	35,722,803				
Summer Weather Conditions	12,868	3,940,685	19,302	3,052,796	9,651	1,146,536	19,846,001				
Average Weather Conditions	12,868	5,194,540	19,302	3,725,661	9,651	1,146,536	27,784,402				

Gas Production

Option	% VS in Sludge	% VS Destroyed	Gas Production Rate (ft^3 gas / lb VS destroyed)	Btu Rating of Gas (Btu per ft^3 gas produced)	Amount of Waste to Digesters (lb /day)	Amount of Gas Generated, ft^3/day	Gas Heat Rate Produced (Btu/day)	Gas Heat Rate Produced (MMBtu/day)	Gas Heat Rate Produced (MW fuel)	Efficiency of Turbine or Engine	Power Production (MW)	% Heat Recoverable From Process	Recoverable Heat (MMBtu/day)

Waste Sludge (Primary and WAS)	75	55	15	435	31,754	196,475	85,466,805	85	1.04	0.3	0.31	0.44	11

Average Weather Condition

Option	Amount of Gas Generated, ft^3/day	Gas Heat Rate Produced (Btu/day)	Gas Heat Rate Produced (MMBtu/day)	Gas Heat Rate Produced (MW fuel)	Efficiency of Turbine or Engine	Power Production (MW)	Power Generation Capacity (kW)	Annual Electricity Generated (kWh/yr)	Electricity Generated (kWh/month)	Total Heat Required to Raise Temperature in Digesters	% Heat Recoverable From Process	Amount Heat Recoverable From Process (BTU/day)	Is Heat Recovered Adequate for Heating Requirement
Waste Sludge (Primary and WAS)	196,475	85,466,805	85.00	1.0	0.3	0.3	313	2,742,853	**228,571**	37,851,138.52	0.44	37,178,060	N

Appendix B
Digester Biogas Sample Analysis

EMPACT

NATURAL GAS ANALYSIS

PROJECT NO. :	**201201123**	ANALYSIS NO. :	**01**
COMPANY NAME :	**CITY OF LAS CRUCES**	ANALYSIS DATE:	JANUARY 24, 2012
NAME/DESCRIP :	JHWWTF DIG #3 @ 9:24 A.M.	SAMPLE DATE :	JANUARY 19, 2012
	DIGESTER GAS	CYLINDER NO. :	1L TEDLAR
ACCOUNT NO. :	SAMPLE ID #11947		

FIELD DATA

SAMPLED BY :	JOSE A. HERNANDEZ	AMBIENT TEMP.:	
SAMPLE PRES. :		H2S BY GASTEC:	
SAMPLE TEMP. :			
COMMENTS :	SPOT; BI-ANNUAL GAS SAMPLE		

COMPONENTS	NORM. MOLE%
HELIUM	0.00
HYDROGEN	0.00
OXYGEN/ARGON	7.83
NITROGEN	26.84
CO2	25.21
METHANE	40.12
ETHANE	0.00
PROPANE	0.00
ISOBUTANE	0.00
N-BUTANE	0.00
ISOPENTANE	0.00
N-PENTANE	0.00
HEXANES+	0.00
TOTAL	100.00

BTU @ 60 DEG F	**14.73**
LOW NET DRY REAL=	366.3
NET SATURATED REAL=	359.9
HIGH GROSS DRY REAL =	406.9
GROSS SATURATED REAL =	399.8
RELATIVE DENSITY (AIR=1 @ 60F) :	0.9528
COMPRESSIBILITY FACTOR :	0.99810

NOTE: REFERENCE GPA 2261(ASTM D1945 & ASME-PTC), 2145, & 2172 CURRENT PUBLICATIONS

PROJECT NO:	**201201123**	SAMPLE NO:	**01**
COMPANY NAME:	**CITY OF LAS CRUCES**	ANALYSIS DATE:	JANUARY 21, 2012
NAME/DESCRIP:	JHWWTF DIG #3 @ 9:24 A.M.	SAMPLE DATE:	JANUARY 19, 2012
	SAMPLE ID #11947; DIGESTER GAS	SAMPLED BY:	JOSE A. HERNANDEZ
COMMENTS:	SPOT; 1L TEDLAR; BI-ANNUAL SAMPLE		

TEST PROCEDURE / METHOD: SULFUR BY GAS CHROMATOGRAPH SCD350 *

COMPONENT	**SULFUR ppm mole (ul/L)**
Hydrogen Sulfide (H2S)	26.2
Carbonyl Sulfide (COS)/Sulfur Dioxide (SO2)	BDL
Methanethiol (MeSH)	BDL
Ethanethiol (EtSH)	0.2
Dimethylsulfide (DMS)	BDL
Carbon Disulfide (CS2)	BDL
i-Propanethiol (i-PrSH)	0.1
t-Butanethiol (t-BuSH)	0.1
n-Propanethiol (n-PrSH)	BDL
Methylethylsulfide (MES)	0.3
s-Butanethiol (s-BuSH)	BDL
i-Butanethiol (i-BuSH)	BDL
Thiophene (TP)	BDL
Diethylsulfide (DES)	BDL
n-Butanethiol (n-BuSH)	BDL
Dimethyldisulfide (DMDS)	BDL
Methylthiophenes (MTP)	BDL
2-Ethylthiophene (2-ETP)	BDL
Methylethyldisulfide (MEDS)	BDL
Dimethylthiophene (DMTP)	BDL
Unidentified Sulfurs	BDL
Diethyldisulfide (DEDS)	BDL
Benzothiophene (BzTP)	BDL
Methylbenzothiophenes (MBzTP)	BDL
Unidentified Sulfurs	BDL
Dimethylbenzothiophenes (DMBzTP)	BDL
Unidentified Sulfurs	BDL
TOTAL SULFUR	26.9

* ASTM D5504

** DETECTION LIMIT DETERMINED TO BE 0.1 ppm (ul/L) Sulfur - BDL (BELOW DETECTION LIMIT)

EMPACT Analytical Systems, Inc. *365 South Main St.* *Brighton, CO. 80601* *(303) 637-0150*

EMPACT

NATURAL GAS ANALYSIS

PROJECT NO. :	**201201123**	ANALYSIS NO. :	**02**
COMPANY NAME :	**CITY OF LAS CRUCES**	ANALYSIS DATE:	JANUARY 24, 2012
NAME/DESCRIP :	JHWWTF DIG #4 @ 9:26 A.M.	SAMPLE DATE :	JANUARY 19, 2012
	DIGESTER GAS	CYLINDER NO. :	1L TEDLAR
ACCOUNT NO. :	SAMPLE ID #11948		

FIELD DATA

SAMPLED BY :	JOSE A. HERNANDEZ	AMBIENT TEMP.:	
SAMPLE PRES. :		H2S BY GASTEC:	
SAMPLE TEMP. :			
COMMENTS :	SPOT; BI-ANNUAL SAMPLE		

COMPONENTS	NORM. MOLE%
HELIUM	0.00
HYDROGEN	0.00
OXYGEN/ARGON	5.01
NITROGEN	17.10
CO2	27.75
METHANE	50.14
ETHANE	0.00
PROPANE	0.00
ISOBUTANE	0.00
N-BUTANE	0.00
ISOPENTANE	0.00
N-PENTANE	0.00
HEXANES+	0.00
TOTAL	100.00

BTU @ 60 DEG F		**14.73**
LOW NET DRY REAL=		457.9
NET SATURATED REAL=		449.9
HIGH GROSS DRY REAL =		508.7
GROSS SATURATED REAL =		499.9
RELATIVE DENSITY (AIR=1 @ 60F) :		0.9219
COMPRESSIBILITY FACTOR :	0.99774	

NOTE: REFERENCE GPA 2261(ASTM D1945 & ASME-PTC), 2145, & 2172 CURRENT PUBLICATIONS

PROJECT NO: **201201123**

COMPANY NAME: **CITY OF LAS CRUCES**

NAME/DESCRIP: JHWWTF DIG #4 @ 9:26 A.M.
SAMPLE ID #11948; DIGESTER GAS

COMMENTS: SPOT; 1L TEDLAR; BI-ANNUAL SAMPLE

SAMPLE NO: **02**

ANALYSIS DATE: JANUARY 21, 2012

SAMPLE DATE: JANUARY 19, 2012

SAMPLED BY: JOSE A. HERNANDEZ

TEST PROCEDURE / METHOD: SULFUR BY GAS CHROMATOGRAPH SCD350 *

COMPONENT	SULFUR ppm mole (ul/L)
Hydrogen Sulfide (H2S)	20.4
Carbonyl Sulfide (COS)/Sulfur Dioxide (SO2)	BDL
Methanethiol (MeSH)	BDL
Ethanethiol (EtSH)	0.1
Dimethylsulfide (DMS)	BDL
Carbon Disulfide (CS2)	BDL
i-Propanethiol (i-PrSH)	BDL
t-Butanethiol (t-BuSH)	0.1
n-Propanethiol (n-PrSH)	BDL
Methylethylsulfide (MES)	0.2
s-Butanethiol (s-BuSH)	BDL
i-Butanethiol (i-BuSH)	BDL
Thiophene (TP)	BDL
Diethylsulfide (DES)	BDL
n-Butanethiol (n-BuSH)	BDL
Dimethyldisulfide (DMDS)	BDL
Methylthiophenes (MTP)	BDL
2-Ethylthiophene (2-ETP)	BDL
Methylethyldisulfide (MEDS)	BDL
Dimethylthiophene (DMTP)	BDL
Unidentified Sulfurs	BDL
Diethyldisulfide (DEDS)	BDL
Benzothiophene (BzTP)	BDL
Methylbenzothiophenes (MBzTP)	BDL
Unidentified Sulfurs	BDL
Dimethylbenzothiophenes (DMBzTP)	BDL
Unidentified Sulfurs	BDL
TOTAL SULFUR	20.9

* ASTM D5504

** DETECTION LIMIT DETERMINED TO BE 0.1 ppm (ul/L) Sulfur - BDL (BELOW DETECTION LIMIT)

EMPACT Analytical Systems, Inc. 365 South Main St. Brighton, CO. 80601 (303) 637-0150

City of Las Cruces
PEOPLE HELPING PEOPLE

* CHECK ONE BOX

☐ Industrial Pretreatment Program (IPP)
2851 W. Amador Avenue
P.O. Box 20000
Las Cruces, NM 88004
Tel: 575.528.3596
Fax: 575.528.3681

☒ Water Quality Laboratory (WQL)
2851 W. Amador Avenue
P.O. Box 20000
Las Cruces, NM 88004
Tel: 575.528.3604
Fax: 575.528.3630

2012011 23

page 1 of 1

Project No.:

Project Name: JHWWTF Digester Bi-annually Gas Samples

Sampler (Printed): Jose A. Hernandez

Sampler (Signature): [signature]

Contact: Luis Guerra
Tel: 575-528-3604
E-mail: lguerra@las-cruces.org
Fax: 575-528-3630

Lab No.	Date Sampled	Time Sampled	Sample Type	Sample Bottle	Sample Identification	Matrix	No. of Containters	Analysis Requested	Preservation:
11947	1/19/12	9:24	G	Teflon Bag	JHWWTF Dig #3	Gas	1	Hydrocarbon Identification, Sulfur Compounds, Caloric Value	None
11948	1/19/12	9:26	G	Teflon Bag	JHWWTF Dig #4	Gas	1	Hydrocarbon Identification, Sulfur Compounds, Caloric Value	None

Comments and/or Special Instructions:

Samples Received: ____
Total # of Containers: ____

Relinquished by (Printed): / Relinquished by (Signature):	Date / Time	Relinquished by (Printed): / Relinquished by (Signature):	Date / Time
Jose A. Hernandez [signature]	Date: 1-19-12 Time: 0956	Luis Guerra [signature]	Date: 1-19-12 Time: 15:00
Received by (Printed): / Received by (Signature): Luis Guerra [signature]	Date: 1-19-12 Time: 0956	Received by (Printed): / Received by (Signature):	Date: Time:
Received at Laboratory by (Printed/Signature):	Date: Time:	Shipped VIA: Seal #: Airbill #: Seal Date:	Sample Type: Composite - C Grab - G; Sample Bottle: Plastic - P Glass - GL; Matrix: Drinking Water - DW, Wastewater - WW, Sludge - S

Distribution: White - Lab; Yellow - Project files ; Pink - Client

EMPACT

NATURAL GAS ANALYSIS

PROJECT NO. :	**201106143**	ANALYSIS NO. :	**01**
COMPANY NAME :	**CITY OF LAS CRUCES**	ANALYSIS DATE:	JULY 6, 2011
NAME/DESCRIP :	JHWWTF DIG #3 @ 8:15 A.M.	SAMPLE DATE :	JUNE 21, 2011
	11686	CYLINDER NO. :	1L TEDLAR BAG
ACCOUNT NO. :			

FIELD DATA

SAMPLED BY :	PHILIP CAMPBELL	AMBIENT TEMP.:	
SAMPLE PRES. :		H2S BY GASTEC:	
SAMPLE TEMP. :			
COMMENTS :	SPOT; BI-ANNUAL GAS SAMPLE		

COMPONENTS	NORM. MOLE%
HELIUM	0.00
HYDROGEN	0.00
OXYGEN/ARGON	0.93
NITROGEN	1.42
CO2	30.55
METHANE	67.10
ETHANE	0.00
PROPANE	0.00
ISOBUTANE	0.00
N-BUTANE	0.00
ISOPENTANE	0.00
N-PENTANE	0.00
HEXANES+	0.00
TOTAL	100.00

BTU @ 60 DEG F		**14.73**
LOW NET DRY REAL=		613.2
NET SATURATED REAL=		602.5
HIGH GROSS DRY REAL =		681.2
GROSS SATURATED REAL =		669.4
RELATIVE DENSITY (AIR=1 @ 60F) :		0.8620
COMPRESSIBILITY FACTOR :	0.99715	

NOTE: REFERENCE GPA 2261(ASTM D1945 & ASME-PTC), 2145, & 2172 CURRENT PUBLICATIONS

PROJECT NO:	**201106143**	SAMPLE NO:	**01**
COMPANY NAME:	**CITY OF LAS CRUCES**	ANALYSIS DATE:	JULY 8, 2011
NAME/DESCRIP:	JHWWTF DIG #3 @ 8:15 A.M. 11686	SAMPLE DATE:	JUNE 21, 2011
COMMENTS:	SPOT; 1L TEDLAR BAG BI-ANNUAL GAS SAMPLE	SAMPLED BY:	PHILIP CAMPBELL

TEST PROCEDURE / METHOD: SULFUR BY GAS CHROMATOGRAPH SCD350 *

COMPONENT	**SULFUR ppm mole (ul/L)**
Hydrogen Sulfide (H2S)	15.4
Carbonyl Sulfide (COS)/Sulfur Dioxide (SO2)	0.4
Methanethiol (MeSH)	0.0
Ethanethiol (EtSH)	0.2
Dimethylsulfide (DMS)	0.1
Carbon Disulfide (CS2)	0.0
i-Propanethiol (i-PrSH)	0.0
t-Butanethiol (t-BuSH)	0.0
n-Propanethiol (n-PrSH)	0.0
Methylethylsulfide (MES)	0.0
s-Butanethiol (s-BuSH)	0.0
i-Butanethiol (i-BuSH)	0.0
Thiophene (TP)	0.0
Diethylsulfide (DES)	0.0
n-Butanethiol (n-BuSH)	0.0
Dimethyldisulfide (DMDS)	0.0
Methylthiophenes (MTP)	0.0
2-Ethylthiophene (2-ETP)	0.0
Methylethyldisulfide (MEDS)	0.0
Dimethylthiophene (DMTP)	0.0
Unidentified Sulfurs	0.0
Diethyldisulfide (DEDS)	0.0
Benzothiophene (BzTP)	0.0
Methylbenzothiophenes (MBzTP)	0.0
Unidentified Sulfurs	0.0
Dimethylbenzothiophenes (DMBzTP)	0.0
Unidentified Sulfurs	0.0
TOTAL SULFUR	16.2

* ASTM D5504

** DETECTION LIMIT DETERMINED TO BE 0.1 ppm (ul/L) Sulfur - BDL (BELOW DETECTION LIMIT)

EMPACT

NATURAL GAS ANALYSIS

PROJECT NO. :	**201106143**	ANALYSIS NO. :	**02**
COMPANY NAME :	**CITY OF LAS CRUCES**	ANALYSIS DATE:	JULY 6, 2011
NAME/DESCRIP :	JHWWTF DIG #4 @ 8:10 A.M.	SAMPLE DATE :	JUNE 21, 2011
	11687	CYLINDER NO. :	1L TEDLAR BAG
ACCOUNT NO. :			

FIELD DATA

SAMPLED BY :	PHILIP CAMPBELL	AMBIENT TEMP.:	
SAMPLE PRES. :		H2S BY GASTEC:	
SAMPLE TEMP. :			
COMMENTS :	SPOT; BI-ANNUAL GAS SAMPLE		

COMPONENTS	NORM. MOLE%
HELIUM	0.00
HYDROGEN	0.00
OXYGEN/ARGON	2.37
NITROGEN	6.53
CO2	28.22
METHANE	62.88
ETHANE	0.00
PROPANE	0.00
ISOBUTANE	0.00
N-BUTANE	0.00
ISOPENTANE	0.00
N-PENTANE	0.00
HEXANES+	0.00
TOTAL	100.00

BTU @ 60 DEG F		**14.73**
LOW NET DRY REAL=		574.5
NET SATURATED REAL=		564.5
HIGH GROSS DRY REAL =		638.2
GROSS SATURATED REAL =		627.1
RELATIVE DENSITY (AIR=1 @ 60F) :		0.8684
COMPRESSIBILITY FACTOR :	0.99740	

NOTE: REFERENCE GPA 2261(ASTM D1945 & ASME-PTC), 2145, & 2172 CURRENT PUBLICATIONS

EMPACT Analytical Systems Inc. 365 S Main St Brighton, CO 80601 303-637-0150

PROJECT NO: **201106143**
COMPANY NAME: **CITY OF LAS CRUCES**
NAME/DESCRIP: JHWWTF DIG #4
11687
COMMENTS: SPOT; 1L TEDLAR BAG;
BI-ANNUAL GAS SAMPLE

SAMPLE NO: **02**
ANALYSIS DATE: JULY 8, 2011
SAMPLE DATE: JUNE 21, 2011
SAMPLED BY: PHILIP CAMPBELL

TEST PROCEDURE / METHOD: SULFUR BY GAS CHROMATOGRAPH SCD350 *

COMPONENT	SULFUR ppm mole (ul/L)
Hydrogen Sulfide (H2S)	16.6
Carbonyl Sulfide (COS)/Sulfur Dioxide (SO2)	1.1
Methanethiol (MeSH)	0.0
Ethanethiol (EtSH)	0.1
Dimethylsulfide (DMS)	0.0
Carbon Disulfide (CS2)	0.1
i-Propanethiol (i-PrSH)	0.0
t-Butanethiol (t-BuSH)	0.0
n-Propanethiol (n-PrSH)	0.0
Methylethylsulfide (MES)	0.0
s-Butanethiol (s-BuSH)	0.0
i-Butanethiol (i-BuSH)	0.0
Thiophene (TP)	0.0
Diethylsulfide (DES)	0.0
n-Butanethiol (n-BuSH)	0.0
Dimethyldisulfide (DMDS)	0.0
Methylthiophenes (MTP)	0.0
2-Ethylthiophene (2-ETP)	0.0
Methylethyldisulfide (MEDS)	0.0
Dimethylthiophene (DMTP)	0.0
Unidentified Sulfurs	0.0
Diethyldisulfide (DEDS)	0.0
Benzothiophene (BzTP)	0.0
Methylbenzothiophenes (MBzTP)	0.0
Unidentified Sulfurs	0.0
Dimethylbenzothiophenes (DMBzTP)	0.0
Unidentified Sulfurs	0.0
TOTAL SULFUR	17.9

* ASTM D5504

** DETECTION LIMIT DETERMINED TO BE 0.1 ppm (ul/L) Sulfur - BDL (BELOW DETECTION LIMIT)

☐ Industrial Pretreatment Program (IPP)
2851 W. Amador Avenue
P.O. Box 20000
Las Cruces, NM 88004
Tel: 575.528.3596
Fax: 575.528.3681

City of Las Cruces®
PEOPLE HELPING PEOPLE

☒ Water Quality Laboratory (WQL)
2851 W. Amador Avenue
P.O. Box 20000
Las Cruces, NM 88004
Tel: 575.528.3604
Fax: 575.528.3630

201106143

page 1 of 1

* CHECK ONE BOX

Project No.:
Project Name: JHWWTF Digester Bi-annually Gas Samples
Sampler: (Printed): × Philip Campbell
Sampler (Signature): × [signature]

Contact: Luis Guerra
Tel: 575-528-3609
E-mail: lguerra@las-cruces.org
Fax: 575-528-3630

Lab No.	Date Sampled	Time Sampled	Sample Type	Sample Bottle	Sample Identification	Matrix	No. of Containters	Analysis Requested	Preservation:
11686	6/21/11	8:15	G	Teflon Bag	JHWWTF Dig #3	Gas	1	Hydrocarbon Identification, Sulfur Compound, Caloric Value	None
11687	6/21/11	8:10	G	Teflon Bag	JHWWTF Dig #4	Gas	1	Hydrocarbon Identification, Sulfur Compound, Caloric Value	None

Comments and/or Special Instructions:

Samples Received: ____
Total # of Containers: ____

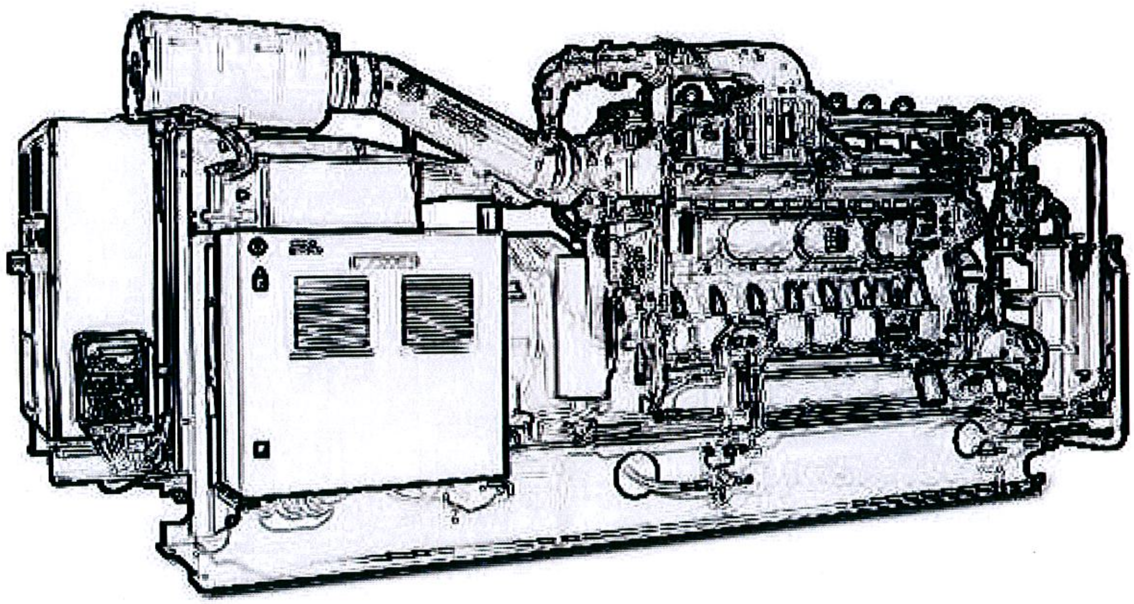
Relinquished by (Printed): [signature] Relinquished by (Signature): Phil Campbell	Date: 6/21/11 Time: 8:30	Relinquished by (Printed): Luis Guerra Relinquished by (Signature): [signature]	Date: 6/21/11 Time: 15:00
Received by (Printed): [signature] Received by (Signature): Luis Guerra [signature]	Date: 6/21/11 Time: 8:30	Received by (Printed): [signature] Received by (Signature): Steven Ashley	Date: 6/22/11 Time: 11:25 AM
Received at Laboratory by (Printed/Signature): Diamond Percivill [signature]	Date: 6/23/11 Time: 8:00am	Shipped VIA: Seal #: Airbill #: Seal Date:	Sample Type: Composite - C Grab - G Sample Bottle: Plastic - P Glass - GL Matrix: Drinking Water - DW Wastewater - WW Sludge - S

Distribution: White - Lab; Yellow - Project files ; Pink - Client

Appendix C
Engine Generator Vendor Information

Jenbacher gas engines

Technical Specification



JMS 208 GS-B.L

Biogas 335kW el.

GE Jenbacher GmbH & Co OHG
A-6200 Jenbach, Austria

Tel. +43 5244 600-0
Fax +43 5244 63255

http://information.jenbacher.com
jenbacher.info@ge.com

Jenbacher gas engines
Technical Specification

JMS 208 GS-B.L
Biogas 335kW el.

CO-GEN Module data:

Electrical output	kW el.	335
Recoverable thermal output (356 °F)	MBTU/hr	1.372
Energy input	MBTU/hr	3.153
Fuel Consumption based on a LHV of 0 BTU/scft	cfhr	#DIV/0!
Electrical efficiency	%	36,3%
Thermal efficiency	%	43,5%
Total efficiency	%	79,8%
Heat to be dissipated (2nd stage IC-circuit)	MBTU/hr	177

Emission values:

NOx < 500 mg/Nm³ (5% O2)

Additional information:

Sound pressure level (engine, average value 3.28ft)	dB(A)	92
Sound pressure level exhaust gas (3.28ft, 30° off en	dB(A)	108
Exhaust gas mass flow rate, wet	lbs/hr	4.409
Exhaust gas volume, wet	cfhr	54.948
Max.admissible exhaust back pressure after engine	psi	0,870
Exhaust gas temperature at full load	°F [8]	968
Combustion air mass flow rate	lbs/hr	4.045
Combustion air volume	CFM	836
Max. inlet cooling water temp. (intercooler)	°F	140
Max. pressure drop in front of intake-air filter	psi	0,145
Return temperature	°F	140
Forward temperature	°F	194
Hot water flow rate	GPM	50,8

Engine data:

Engine type		J 208 GS-C81
Configuration		In - Line
No. of cylinders		8
Bore	in	5,31
Stroke	in	5,71
Piston displacement	cu.in	1.013
Nominal speed	rpm	1.800
Mean piston speed	in/s	343
Mean effe. press. at stand. power and nom. sp	psi	203
Compression ratio	Epsilon	12,00
ISO standard fuel stop power ICFN	bhp	468
Spec. fuel consumption of engine	BTU/bhp.hr	6.737
Specific lube oil consumption	g/bhp.hr	0,22
Weight dry	lbs	3.968
Filling capacity lube oil	gal	35
Based on methane number|Min. methane num	MN(*)	135|100

(*)based on methane number calculation software AVL 3.1

Alternator:

Manufacturer		STAMFORD e)
Type		HCI 534 D2 e)
Type rating	kVA	644
Efficiency at p.f. = 1,0	%	96,0%
Efficiency at p.f. = 0,8	%	95,2%
Ratings at p.f. = 1,0	kW	335
Ratings at p.f. = 0,8	kW	332
Frequency	Hz	60
Voltage	V	480
Protection Class		IP 23
Insulation class		H
Speed	rpm	1.800
Mass	kg	1.395

Technical parameters:

Applicable standards:

Based on DIN-ISO 3046 and VDE 0530 REM with specified tolerance
Volume values based on standard conditions at 60°F and 1atm
reference value --> 55%CH4 / 40%CO2 / rest N2, O2

Standard contitions:

Air pressure: 14.50 psi or 328ft above sea level
Air temperature: 77°F or 298 K
Relative Humidity: 30%

Engine output derating:

for plants installed at > 1640.5 ft above see level and/or intake temperature > 86°F, the reduction of engine power is determined for each project.

Gas quality:

according to TA 1000-0300
Gas flow pressure: 1.2 - 2.9 psi
(Lower gas pressures upon inquiry)

Max. variation in gas pressure: ±10%

All data are based on engine full load at specified media temperatures and are subject to change.
The technical Instruction TA 1100-0110 "PARAMETER FOR GE Jenbacher GAS ENGINES" must be strictly observed.

>>> Scope of supply genset - JGS 208 GS-B.L

Basic engine equipment:
*Exhaust gas turbocharger, Intercooler
*Motorized carburator for LEANOX control
*Electronic contactless high performance ignition system
*Lubricating oil pump (gear driven)
*Lubricating oil filters in main circuit
*Oil trip pan; Lubricating oil heat exchanger
*Jacket water pump
*Fuel-, lubricating oil and jacket water pipe work on engine
*Flywheel for alternator operation; Exhaust gas manifold
*Viscous damper
*Knock sensors

Engine accessories:
*Electric starter motor
*Electronic speed governor
*Electronic speed monitoring device including starting and overspeed control
*Transducers and switches for oil pressure, jacket water temp., jacket water pressure, charge pressure and mixture temperature
*One thermocouple per cylinder

Supplied loose:
Gas train according to DIN-DVGW consisting of:
*Manual stop valve, fuel gas filter, two solenoid valves, Leakage control device, gas pressure regulator

Documentation:
*Operating and maintenance manual
*Spare parts manual
*Drawings

Assembly, painting, testing in Jenbach/Austria

equipment:
*Base frame for gas engine, alternator and heat exchangers
*Internal pole alternator with excitation alternator and with automatic voltage regulator; p.f. 0.8 lagging to 1.0
*Flexible coupling, bell housing
*Anti-vibration mounts
*Air filter
*Automatic lube oil replenishing with level control
*Wiring of components to module control panel
*Crankcase breather
*Jacket water electric preheating

Engine control panel:
*Totally enclosed , single door cubicle, wired to terminals and ready to operate, protection IP 40 outside, IP 10 inside, according to VDE-standards

Control equipment:
*Engine-Management-System dia.ne (Dialog Network)
**Visualisation (industry PC-10.4" color graphics display): Operation data, controller display,Exh. gas temp.,Generator electr. connection,etc.
**Central engine- and module control: Speed-, Power output-, LEANOX-Control and knock control, etc.
*Multi-transducer
*Lockable operation mode selector switch
Positions: "OFF", "MANUAL", "AUTOMATIC"
*Demand switch

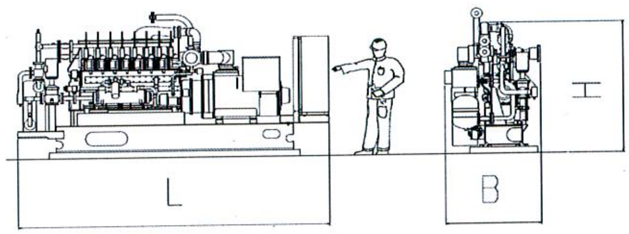
>>> Scope of supply module - JMS 208 GS-B.L

Identical to Genset except that heat recovery is included.
*jacket water heat exchanger mounted on module frame
*exhaust gas heat exchanger mounted on module frame;
*all heat exchangers with complete pipework
*Heat exchangers and all inherent auxiliaries

>>> Scope of supply container - JG(M)C 208 GS-B.L

*Identical to module/genset but installed in 40' ISO container (65 dB(A) @ 32.8ft); complete with all pipework and fittings
*Two-core horizontal radiator for dissipation of intercooler, jacket water and lube oil heat; exhaust ventilation equipment
*Gas & smoke detectors; exhaust silencer; lube oil equipment; starting system; flexible connections
*Seperate control room complete with generator switchgear and all internal power and monitoring cables

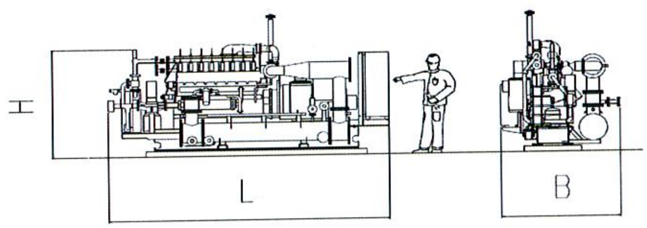
Genset



Main dimensions and weights (approximate value)		
Length L	in	200
Width B	in	70
Height H	in	80
Weight empty	lbs	10.740
Weight filled	lbs	11.180

Connections (at genset)		
Jacket water inlet and outlet	in/lbs	2"/232
Exhaust gas outlet	in/lbs	8"/145
Fuel gas (at gas train)	in/lbs	2½"/232
Intercooler water connection:		
Low Temperature Circuit	in/lbs	2"/145

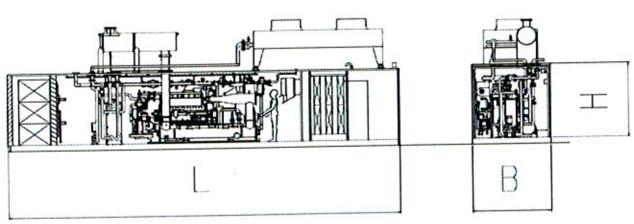
Module



Main dimensions and weights (approximate value)		
Length L	in	200
Width B	in	70
Height H	in	80
Weight empty	lbs	12.450
Weight filled	lbs	12.890

Connections (at module)		
Hot water inlet and outlet	in/lbs	2"/232
Exhaust gas outlet	in/lbs	8"/145
Fuel gas (at gas train)	in/lbs	2½"/232
Intercooler water connection:		
Intercooler water-Inlet/Outlet 2nd stage	in/lbs	2"/145

Container



Main dimensions and weights (approximate value)		
Length L	in	490
Width B	in	100
Height H	in	110
Container weight (dry)	lbs	37.590
Container weight (filled)	lbs	39.350

Connections (on container)		
Jacket water inlet and outlet	in/lbs	2"/232
Exhaust gas outlet	in/lbs	8"/145
Fuel gas connection (on container)	in	4"/232
Fresh oil connection	G	28x2"

Model: 334GFBA
Frequency: 60 Hz
Fuel Type: Low BTU
Emissions NOx: 2.0 g/hp-h
LT Water Inlet Temp: 40°C (104°F)
HT Water Outlet Temp: 95°C (203°F)

Generator set data sheet
334 kW continuous

Our energy working for you.™

Cummins Power Generation

Measured Sound Performance Data Sheet:	TBD
Prototype Test Summary Data:	TBD
Remote Radiator Cooling Outline:	TBD

Fuel Consumption (ISO3046/1)	100% Load	90% Load	75% Load	50% Load
Fuel Consumption (LHV) ISO3046/1, kW (MMBTU/hr) [1,2,3,4,5]	1045 (3.57)	956 (3.26)	825 (2.82)	605 (2.07)
Mechanical Efficiency ISO3046/1, percent [1,2,4,5]	33.4%	32.8%	31.8%	29.4%
Electrical Efficiency ISO3046/1, percent [1,2,3,4,5]	32.0%	31.5%	30.4%	27.6%

Engine	
Engine Manufacturer	Cummins
Engine Model	QSK19G
Configuration	In-line 6
Displacement, L (cu.in)	19 (1157)
Aspiration	Turbocharged (1)
Gross Engine Power Output, kWm (hp)	349 (468)
BMEP, bar (psi)	12.4 (180)
Bore, mm (in)	159 (6.26)
Stroke, mm (in)	159 (6.26)
Rated Speed, rpm	1800
Piston Speed, m/s (ft/min)	9.54 (1877)
Compression Ratio	11.0:1
Lube Oil Capacity, L (qt)	124.9 (130)
Overspeed Limit, rpm	2250
Regenerative Power, kW	N/A
Full Load Lubricating oil consumption, g/kWe-hr (g/hp-hr)	<0.5 (0.37)
Fuel System	
Gas supply pressure range, bar (psi) [6]	0.14-0.3 (2.03-4.35)
Minimum Methane Index	90
Engine Electrical System(s)	
Electric starter voltage, volts	24
Ignition timing, deg before top dead center	17 deg BTC
Minimum battery capacity @ 10 deg.C (50 deg.F) and above, CCA	600
Genset Dimensions	
Genset Length, m (ft) [7]	3.5 (11.48)
Genset Width, m (ft) [7]	1.3 (4.27)
Genset Height, m (ft) [7]	1.8 (5.91)
Genset Weight (wet), kg (lbs) [7]	3990 (8796.44)

Notes:

1.At ISO3046 reference conditions, altitude 152m (498.6ft), air inlet temperature 27.8°C (82°F)
2. Power output and efficiency include the affect of Cummins supplied coolant pumps.
3. At electrical output of 1.0 Power Factor
4. Based on gas with LHV of 21.09MJ/Nm^3 (571 BTU/ft^3)
5. Subtract 3°C ambient temperature capability for each 100 mm (4 in) H_2O back pressure above the information shown on page 2.
6. At inlet to fuel shut-off valve, with 21.09MJ/Nm3 (571 BTU/ft3)
7. Weights and dimensions represent a generator set with its standard features only. See outline drawing for other configurations.

Energy Data	100% Load	90% Load	75% Load	50% Load
Continuous Generator Electrical Output kWe [1,5,6,7]	334	301	251	167
Continuous Shaft Power, kWm (bhp)[1,5,6,7]	349 (468)	314 (421)	263 (353)	178 (239)
Total Heat Rejected in LT Circuit, kW (MMBTU/h) [2]	79 (0.27)	71 (0.24)	60 (0.2)	32 (0.11)
Total Heat Rejected in HT Circuit, kW (MMBTU/h) [2]	219 (0.75)	212 (0.72)	198 (0.68)	167 (0.57)
Unburnt, kW (MMBTU/h) [2]	8 (0.03)	7 (0.02)	7 (0.02)	5 (0.02)
Heat Radiated to Ambient, kW (MMBTU/h) [2]	69 (0.24)	63 (0.21)	55 (0.19)	42 (0.14)
Available Exhaust heat to 105C, kW (MMBTU/h) [2]	312 (1.06)	281 (0.96)	236 (0.81)	169 (0.58)
Intake Air Flow				
Intake Air Flow Mass, kg/s (lb/hr) [2]	0.52 (4120)	0.48 (3800)	0.4 (3170)	0.28 (2220)
Intake Air Flow Volume, m3/s @ 0°C (scfm) [2]	0.4 (890)	0.37 (830)	0.31 (690)	0.22 (490)
Maximum inlet restriction (after filter, limit for changing filters), below 35°C ambient temp, mm HG, (in H_2O)	22.4 (12)	17.9 (9.6)	12.2 (6.6)	5.1 (2.8)
Maximum inlet restriction (after filter, limit for changing filters), above 35°C ambient temp, mm HG, (in H_2O)	22.4 (12)	17.9 (9.6)	12.2 (6.6)	0 (2.8)
Exhaust Air Flow				
Exhaust Gas Flow Mass, kg/s (lb/hr) [2]	0.58 (4590)	0.53 (4200)	0.44 (3480)	0.31 (2460)
Exhaust Gas Flow Volume, m3/s (cfm) [2]	1.4 (2960)	1.28 (2710)	1.05 (2220)	0.74 (1570)
Exhaust Temperature After Turbine, °C (°F) [1]	581 (1014)	580 (1012)	572 (998)	570 (994)
Max Exhaust System Back Pressure, mmHG (in H_2O)	47 (25)	39 (21)	29 (16)	16 (9)
HT Cooling Circuit				
HT Circuit Engine Coolant Volume, l (gal)	34 (9)	34 (9)	34 (9)	34 (9)
HT Coolant Flow @ Max Ext Restriction, m^3/h (gal/min)	33 (145)	33 (145)	33 (145)	33 (145)
Maximum HT Engine Coolant Inlet Temp, °C (°F) [3]	88 (190)	88 (190)	89 (192)	90 (194)
HT Coolant Outlet Temp, °C (°F) [3]	95 (203)	94 (201)	95 (203)	95 (203)
Max Pressure Drop in External HT Circuit, bar (psig)	0.35 (5)	0.35 (5)	0.35 (5)	0.35 (5)
HT Circuit Maximum Pressure, bar (psig)	3.5 (51)	3.5 (51)	3.5 (51)	3.5 (51)
Static Head Pump Inlet, bar (psig)	0.28 (4)	0.28 (4)	0.28 (4)	0.28 (4)
LT Cooling Circuit				
LT Circuit Engine Coolant Volume, l (gal)	5 (1)	5 (1)	5 (1)	5 (1)
LT Coolant Flow @ Max Ext Restriction, m^3/h (gal/min)	6 (26)	6 (26)	6 (26)	6 (26)
Maximum LT Coolant Inlet Temp, °C (°F) [4]	39 (102)	39 (102)	39 (102)	39 (102)
LT Coolant Outlet Temperature °C (°F) [4]Reference Only	51 (124)	50 (122)	48 (118)	44 (111)
Max Pressure Drop in External LT Circuit, bar (psig)	0.35 (5)	0.35 (5)	0.35 (5)	0.35 (5)
LT Circuit Maximum Pressure, bar (psig)	3.5 (51)	3.5 (51)	3.5 (51)	3.5 (51)
Static Head Pump Inlet, bar (psig)	0.5 (7)	0.5 (7)	0.5 (7)	0.5 (7)

Notes:

1.At ISO3046 reference conditions, altitude 152m (498.6ft), air inlet temperature 27.8°C (82°F)

2. Production variation/tolerance ±5%

3. Outlet temperature controlled by thermostat. Inlet temperature for reference only.

4. Inlet temperature controlled by thermostat to 40 °C but is allowed to go to 55°C but power output must be derated per Table B on page 3

5. Power output and efficiency include the affect of Cummins supplied coolant pumps.

6. At electrical output of 1.0 Power Factor

7. Based on natural gas with LHV of 21.09MJ/Nm3 (571 BTU/ft3)

Table A Altitude and Ambient Temperature Derate Multiplication Factor [1,2]

Barometer		Altitude										
In Hg	mbar	Feet	Meters	Derate Multiplier for all operation modes								
20.7	701	9843	3000	0.74	0.74	0.74	0.74	0.74	0.74	0.72	0.70	0.68
21.4	723	9022	2750	0.77	0.77	0.77	0.77	0.77	0.77	0.75	0.73	0.71
22.1	747	8202	2500	0.80	0.80	0.80	0.80	0.80	0.80	0.78	0.76	0.74
22.8	771	7382	2250	0.83	0.83	0.83	0.83	0.83	0.83	0.81	0.79	0.77
23.5	795	6562	2000	0.86	0.86	0.86	0.86	0.86	0.86	0.84	0.82	0.80
24.3	820	5741	1750	0.89	0.89	0.89	0.89	0.89	0.89	0.87	0.85	0.83
25.0	846	4921	1500	0.91	0.91	0.91	0.91	0.91	0.91	0.89	0.87	0.85
25.8	872	4101	1250	0.94	0.94	0.94	0.94	0.94	0.94	0.92	0.87	0.88
26.6	899	3281	1000	0.97	0.97	0.97	0.97	0.97	0.97	0.95	0.93	0.91
27.4	926	2461	750	1.00	1.00	1.00	1.00	1.00	1.00	0.98	0.96	0.94
28.3	954	1640	500	1.00	1.00	1.00	1.00	1.00	1.00	0.98	0.96	0.94
29.1	983	820	250	1.00	1.00	1.00	1.00	1.00	1.00	0.98	0.96	0.94
29.5	995	492	150	1.00	1.00	1.00	1.00	1.00	1.00	0.98	0.96	0.94
30.0	1012	0	0	1.00	1.00	1.00	1.00	1.00	1.00	0.98	0.96	0.94
Air Filter Inlet Temperature			**°C**	**0**	**15**	**20**	**25**	**30**	**35**	**40**	**45**	**50**
			°F	**32**	**59**	**68**	**77**	**86**	**95**	**104**	**113**	**122**

Altitude and Temperature Derate

1. Determine Altitude vs Air Filter inlet temperature derate from Table A.
2. Determine Altitude vs. LT inlet temperature derate from Table B.
3. Your site rating will be determined by the lowest multiplier from steps 1 and 2.
4. If the LT temperature exceeds 40deg C (113deg F), consult factory for recommendations

Table B Altitude and LT Cooling Temperature Derate Multiplication Factor [1,2]

Barometer		Altitude										
In Hg	mbar	Feet	Meters	Derate Multiplier for all operation modes								
20.7	701	9843	3000	0.74	0.74	0.74	0.74	0.74	0.74	0.69	0.64	0.59
21.4	723	9022	2750	0.77	0.77	0.77	0.77	0.77	0.77	0.72	0.67	0.62
22.1	747	8202	2500	0.80	0.80	0.80	0.80	0.80	0.80	0.75	0.70	0.65
22.8	771	7382	2250	0.83	0.83	0.83	0.83	0.83	0.83	0.78	0.73	0.68
23.5	795	6562	2000	0.86	0.86	0.86	0.86	0.86	0.86	0.81	0.76	0.71
24.3	820	5741	1750	0.89	0.89	0.89	0.89	0.89	0.89	0.84	0.79	0.74
25.0	846	4921	1500	0.91	0.91	0.91	0.91	0.91	0.91	0.86	0.81	0.76
25.8	872	4101	1250	0.94	0.94	0.94	0.94	0.94	0.94	0.89	0.84	0.79
26.6	899	3281	1000	0.97	0.97	0.97	0.97	0.97	0.97	0.92	0.87	0.82
27.4	926	2461	750	1.00	1.00	1.00	1.00	1.00	1.00	0.95	0.90	0.85
28.3	954	1640	500	1.00	1.00	1.00	1.00	1.00	1.00	0.95	0.90	0.85
29.1	983	820	250	1.00	1.00	1.00	1.00	1.00	1.00	0.95	0.90	0.85
29.5	995	492	150	1.00	1.00	1.00	1.00	1.00	1.00	0.95	0.90	0.85
30.0	1012	0	0	1.00	1.00	1.00	1.00	1.00	1.00	0.95	0.90	0.85
LT Cooling Inlet Temperature			**°C**	**0**	**20**	**25**	**30**	**35**	**40**	**45**	**50**	**55**
			°F	**32**	**68**	**77**	**86**	**95**	**104**	**113**	**122**	**131**

Methane Number Capability Table

Load (Percent of Rated)			
100%	90%	75%	50%
90	90	90	90

Table D Altitude and AmbientHeat Rejection Factor adjustment for HT and LT Circuits

Barometer		Altitude										
In Hg	mbar	Feet	Meters	Multiplier for HT & LT Heat Rejection vs Alt & Temp.								
20.7	701	9843	3000	1.06	1.10	1.11	1.13	1.14	1.15	1.17	1.18	1.19
21.4	723	9022	2750	1.05	1.09	1.10	1.12	1.13	1.14	1.15	1.17	1.18
22.1	747	8202	2500	1.04	1.08	1.09	1.10	1.12	1.13	1.14	1.16	1.17
22.8	771	7382	2250	1.03	1.07	1.08	1.09	1.11	1.12	1.13	1.14	1.16
23.5	795	6562	2000	1.02	1.06	1.07	1.08	1.09	1.11	1.12	1.13	1.15
24.3	820	5741	1750	1.01	1.04	1.06	1.07	1.08	1.10	1.11	1.12	1.14
25.0	846	4921	1500	0.99	1.03	1.05	1.06	1.07	1.09	1.10	1.11	1.12
25.8	872	4101	1250	0.98	1.02	1.04	1.05	1.06	1.07	1.09	1.10	1.11
26.6	899	3281	1000	0.97	1.01	1.02	1.04	1.05	1.06	1.08	1.09	1.10
27.4	926	2461	750	0.96	1.00	1.01	1.03	1.04	1.05	1.07	1.08	1.09
28.3	954	1640	500	0.95	0.99	1.00	1.02	1.03	1.04	1.05	1.07	1.08
29.1	983	820	250	0.94	0.98	0.99	1.00	1.02	1.03	1.04	1.06	1.07
29.5	995	492	150	0.94	0.97	0.99	1.00	1.01	1.03	1.04	1.05	1.06
30.0	1012	0	0	0.93	0.97	0.98	0.99	1.01	1.02	1.03	1.05	1.06
Air Filter Inlet Temperature			**°C**	**0**	**15**	**20**	**25**	**30**	**35**	**40**	**45**	**50**
			°F	**32**	**59**	**68**	**77**	**86**	**95**	**104**	**113**	**122**

LT & HT Circuit Heat Rejection Calculation Procedure

1. Determine power output derate from Tables A & B.
2. Using the multipliere from #1 above as the percent load factor, determine the heat rejection
3. From table D find the HT and LT circuit multiplier
4. Multiply the result of step 2 by the result of step 3 to obtain the heat rejection at your altitude and temperature.

Notes:

1. Ambient temperature is the same as air filter inlet temperature and LT inlet temperature is 10°C above ambient or 40°C whichever is higher.
2. Subtract 3°C ambient temperature capability for each 100 mm (4 in) H2O back pressure above the information shown on page 2.

Alternator Data

Voltage Range	Connection Configuration	Temp Rise Degrees C	Duty Cycle[4]	Single Phase	Max Surge kVA [5]	Alternator Data Sheet	Feature Code
416-480	Wye, 3 Phase	80	C	N/A	1896	306	B587-2
380-480	Wye, 3 Phase	105	C	N/A	1896	306	B655-2
600	Wye, 3 Phase	80	C	N/A	1896	306	B589-2

Base Load (Continuous) Power (COP) Definition

Applicable for supplying power continuously to a constant electrical load for unlimited hours. No sustained overload capability is available for this rating. Consult authorized distributor for rating. Continuous Power (COP) in accordance with ISO8528, ISO3046, AS2789, DIN6271, and BS5514).

Emissions

Emissions	100% Load	90% Load	75% Load	50% Load
NO_x Emissions dry, ppm [1]	293	276	276	264
NO_x Emissions mg/Nm^3 @ 5% O_2, (g/hp-h) [1]	680 (2)	650 (2)	620 (2)	580 (2)
THC Emissions wet, ppm [2]	746	779	878	1066
THC Exhaust Emissions, mg/Nm^3 @ 5% O_2, (g/hp-h) [2]	610 (1.7)	630 (1.8)	700 (2)	830 (2.5)
NMHC Emissions wet, ppm [2,3]	53	60	66	81
NMHC Exhaust Emissions, g/hp-h [2,3]	0.12	0.14	0.15	0
HCHO Emissions (wet), ppm [6]	N/A	N/A	N/A	N/A
HCHO Exhaust Emissions, mg/Nm^3 @ 5% O_2, (g/hp-h) [6]	N/A	N/A	N/A	N/A
CO Emissions (dry), ppm [2]	682	659	679	654
CO Emissions Rate, mg/Nm3 [2] @ 5% O_2, (g/hp-h)	960 (2.7)	930 (2.6)	930 (2.7)	870 (2.7)
CO2 Emisions (dry), percent [1]	10.2	10.1	10.4	11
O2 Emissions (dry), percent [2]	6.8	6.8	6.5	6
Particulates PM10, g/hp-h [2]	N/A	N/A	N/A	N/A

Notes

1. Production variation/tolerance ±5%
2. Tolerance +/- 15%.
3. NMHC are measured per CFR 40 part 86
   NMHC emission are an estimate. Actual NMHC emsisions are a function of the non-methane hydrocarbons in the fuel.
4. Standby (S), Prime (P), Continuous (C) ratings.
5. Maximum rated starting kVA that results in minimum of 90% of rated sustained voltage during starting.
6. Tolerance +/- 35%.

Cummins Power Generation
1400 73rd Avenue NE
Minneapolis, MN 55432 USA
Telephone: 763 574 5000
Fax: 763 574 5298
Web: www.cumminspower.com

Cummins Power Generation
Manston Park, Columbus Avenue
Manston, Ramsgate
Kent CT12 5BF, UK
Telephone: +44 (0) 1843-255000
Fax: +44 (0) 1843-255902
Email: cpg.uk@cummins.com
Web: www.cumminspower.com

Cummins Power Generation
8 Tanjong Penjuru
Singapore 609019
Telephone: +65 265-0155
Fax: +65 264-0664 or 265-6909
Email: mktg@sing.cummins.com
Web: www.cumminspower.com

Cummins Class 'A' Non Pipeline Gas Engine Fuel Component Limits

Power Generation

Cummins Inc Confidential

Component In Fuel Gas		Published Limits based on 36MJ/Nm3 LHV	Limits Based on a Methane Content of 60 %	Limits Based on a Methane Content of 40 %
Total sulphur content, including sulphur from H_2S	mg/Nm^3	30	18	12
Hydrogen	% (vol)	3	1.8	1.2
Hydrocarbon condensate	ppm (vol)	20	12	8
Oxygen	% (vol)	1	1	1
Relative Humidity	%	80% with No Droplets	80% with No Droplets	80% with No Droplets
Oil content	mg/Nm^3	5	5	5
Ammonia	mg/Nm^3	25	15	10
Total Halogen content, including chlorinated and fluorinated hydrocarbons. (Sum of Cl+2*sum Fl mg). Express individual measurements.	mg/Nm^3	1	0.6	0.4
Total gaseous silicon content as Si, (this includes Si content from siloxanes and other sources)	mg/Nm^3	1	0.6	0.4
Particulate or solid content	mg/Nm^3	30	18	12
Max particle size	Micro m	5	1	1
Minimum methane (CH_4) concentration	% (vol)	100	60	40
Minimum methane number (index) as calculated by appropriate method (AVL 3.2 Software Programme) with dilutant gases removed.	Theoretical measure of methane in blend with hydrogen	77	77	77
Minimum gas delivery pressure at inlet to double solenoid valve	m bar g	170	170	170
Gas inlet temperature range	Deg C	5 to 50	5 to 50	5 to 50
Gas density range	Kg/m^3	0.7 to 1.2	0.7 to 1.3	0.7 to 1.4
Maximum variation for calorific content based on the lowest figure used for the fuel system calibration.	%	+/- 4	+/- 4	+/- 4
Maximum variation rate for calorific content.	%/minute	1	1	1

HX-101

POLARIS Design Calculation

V0098A

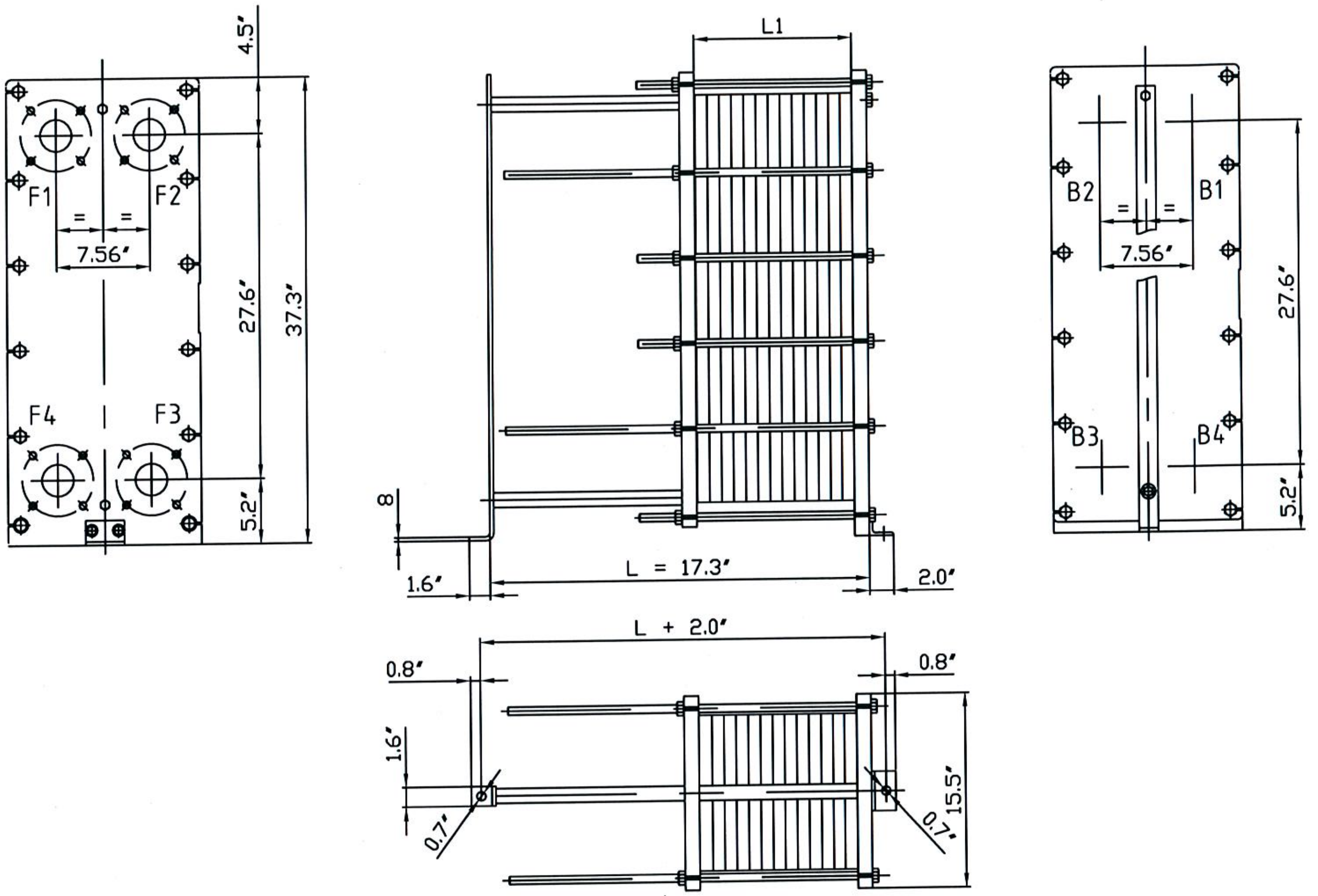
MODEL S19A-IG10-42-TM-		Hot side	Cold side
Flow Rate	(g.p.m.)	97.00	99.89
Inlet Temperature	(°F)	210.20	160.00
Outlet Temperature	(°F)	177.77	190.00
Pressure Drop	(PSI)	2.79	2.69
Heat Exchanged	(Btu/h)	1461630	
Thermodynamic Properties:		40 % PropGlycol	Water
Density	(Lb/Ft³)	61.71	60.67
Specific Heat	(Btu/Lb*F)	0.94	1.00
Thermal Conductivity	(Btu/h*Ft*F)	0.25	0.39
Mean Viscosity	(cP)	0.82	0.38
Wall Viscosity	(cP)	0.98	0.33
Inlet Locations		F1	F3
Outlet Locations		F4	F2

Materials / Dimensions		
Plate Arrangement (Passes*Channels)		1 × 20 + 0 × 0
Plate Arrangement (Passes*Channels)		1 × 21 + 0 × 0
Number of Plates		42
Effective Surface Area	(Ft²)	105.49
Overall U-value Duty/Clean	(Btu/Ft²*h*F)	731 / 756
Plate Material		0.0157 inch AISI316
Gasket Material / Max. Temp.		NBR CLIP-TITE
Max. Design Temperature	(°F)	284
Max. Design/Test Pressure	(PSI)	150.0 / 195.0
Frame Type		IG Length Code: 1
Connections HOT Side		2.5 INCH Flange Mild steel ANSI B16.5 #150
Connections COLD Side		2.5 INCH Flange Mild steel ANSI B16.5 #150
Hold-Up Volume	(Ft³)	0.87
Frame Length	(Ft)	1.44 Max. No. of Plates 60
Net Weight	(Lb)	542

DATE	3/2/2011
CUSTOMER	
ADDRESS	
CUSTOMER REFERENCE	
QUOTE#	
ITEM#	

Polaris P.H.E. LLC **28 May Street** **Edison, NJ 08837**
Phone: +1 732 225 3100 **Fax: +1 732 225 9155** **sales@polarisphe.com**

HX-101



CONNECTION PROPERTIES

LOCATION	DESIGNATION	SIZE	TYPE	MATERIAL
F1	SIDE 1 INLET	2.5"	ANSI-150#	C. S.
F2	SIDE 2 OUTLET	2.5"	ANSI-150#	C. S.
F3	SIDE 2 INLET	2.5"	ANSI-150#	C. S.
F4	SIDE 1 OUTLET	2.5"	ANSI-150#	C. S.
B1	NOT USED			
B2	NOT USED			
B3	NOT USED			
B4	NOT USED			

NOTES

DIMENSIONS ARE APPROXIMATE.
DO NOT USE FOR CONSTRUCTION.

Polaris
PLATE HEAT EXCHANGERS

28 MAY STREET
EDISON, NJ 08837
732-225-3100
732-225-9155 - FAX

POLARIS MODEL	S19A-IG10-42-TM	POLARIS REF.#	
CUSTOMER			
JOB NAME		CUST. REF.#	
DATE	DWG NO.		REV

EWHRS101

Subject: Noise Attenuation Data From MAXIM MFT Heat Recovery Silencer
Tom Waxham, Design Engineer
Beaird Industries 6/3/03

The numbers shown in the table below may be used in predicting the noise performance of the MFT silencers:

MFT Octave Band Values of Attenuation

Octave Band	31.5	63	125	250	500	1k	2k	4k	8k
4"to 6" SIZE	5	11	19	29	32	26	26	26	26
8"to 10" SIZE	8	14	23	31	31	26	26	26	26
12"to 16" SIZE	13	20	30	29	26	26	26	26	26

EWHRS101

MAXIM SILENCERS

10635 Brighton Lane, Stafford, Texas 77477
Tel (832) 554-0980 - Fax (832) 554-0990
http://www.maximsilencers.com

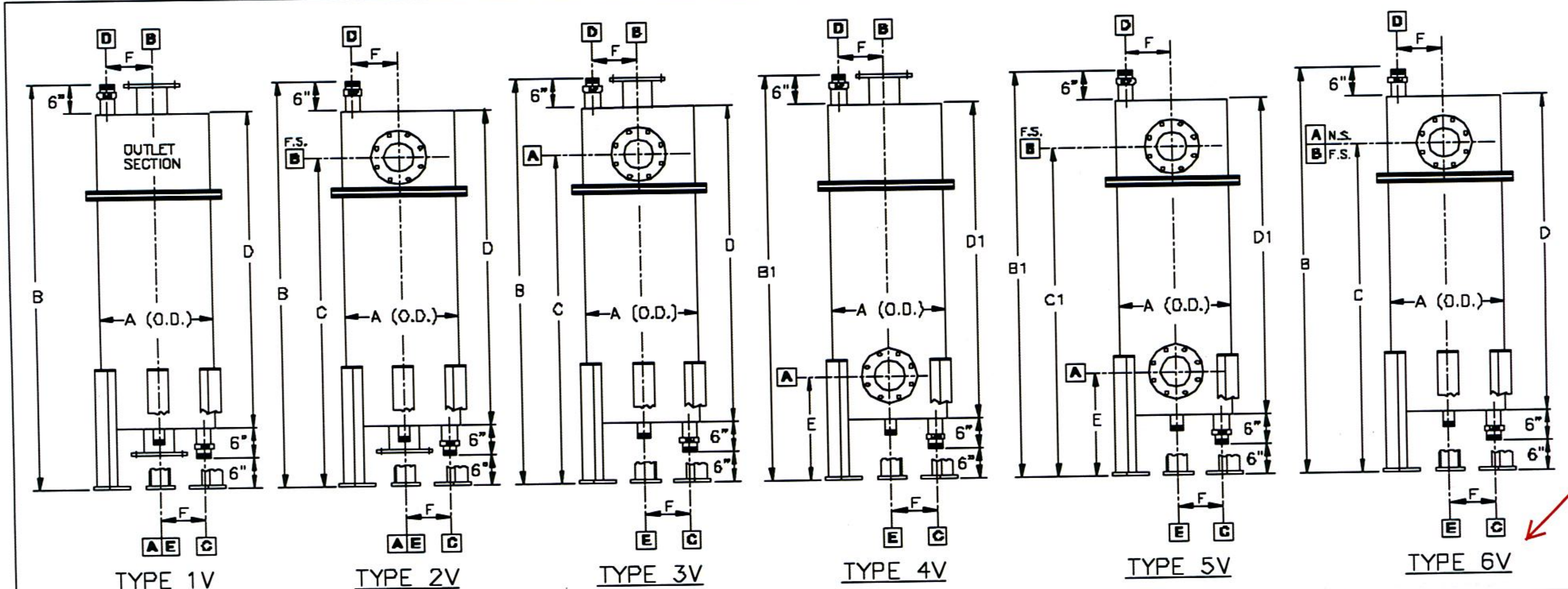
Maxim Heat Recovery

Ref:	Cummins	**Date:**	__/__/____
Model:	MFT	**Size:**	495-10
Unit Performance:	STD		

Exhaust Gas Data		**Liquid Data**	
Type Fuel	Natural Gas	Type Liquid	Water
Excess Air	20.0 PCT	Operating Pressure	25.0 PSIG
Flowrate	4883.0 LB/HR	Flowrate	140.0 GPM
Inlet Temp.	986.0 F	Inlet Temp.	180.0 F
Outlet Temp.	365.1 F	Outlet Temp.	192.6 F
Press.Drop (WET)	2.5 IN.W.C.	Press. Drop	0.848 PSI
Fouling Factor	0.003	Fouling Factor	0.001

Heat Recovery:

Exhaust 858396.9 BTU/HR (251.6 kw)



MFT		DIMENSIONS IN INCHES									INTERFACE POINTS					* WEIGHTS IN POUNDS			
MODEL-SIZE																DRY		WET	
STD PERF	HI PERF	A	B	B1	C	C1	D	D1	E	F	A	B	C	D	E	STD PERF	HI PERF	STD PERF	HI PERF
80-4	100-4	16 1/4	111	117	99	105	93	99	16	6 3/8	4	4	1 1/2	1 1/2	1	684	697	699	712
135-5	165-5	18 1/4	113	120	100	107	95	102	16 1/2	7 1/4	5	5	1 1/2	1 1/2	1	798	815	817	834
195-6	235-6	22 1/4	116	124	101	109	98	106	17	9	6	6	2	2	2	1058	1088	1091	1121
325-8	400-8	26 1/4	120	130	102	112	102	112	18	11 1/8	8	8	2	2	2	1632	1683	1681	1732
495-10	600-10	30 3/8	127	139	110	118	109	121	19	11 1/2	10	10	3	3	2	2933	3011	3050	3128
740-12	900-12	40 3/8	131	145	108	121	113	127	20	15 1/2	12	12	3	3	2	4174	4289	4344	4459
1010-14	1235-14	50 3/8	135	151	109	124	117	133	21	20 1/2	14	14	3	3	2	5821	5979	6131	6289

NOTES:

1. TUBE BUNDLE DESIGNED TO ASME CODE, SECTION VIII DIV 1 FOR 165 PSI STEAM OR HOT WATER SERVICE.
2. OVER PRESSURE PROTECTION REQUIRED (SAFETY-RELIEF VALVE)
3. STEAM SEPARATOR IS REQUIRED FOR STEAM SERVICE. (MAXIM MODEL HSS SIZED FOR MFT RATED RECOVERY)
4. INSULATION IS REQUIRED TO ACHIEVE RATED PERFORMANCE.
5. OUTLET SECTION IS REMOVABLE FOR ACCESS TO TUBE BUNDLE.

A EXHAUST INLET – 150 LB. ASME/ANSI DRILLING
B EXHAUST OUTLET – 150 LB. ASME/ANSI DRILLING
C WATER INLET – MNPT
D WATER OUTLET – MNPT
E SHELL DRAIN – MNPT

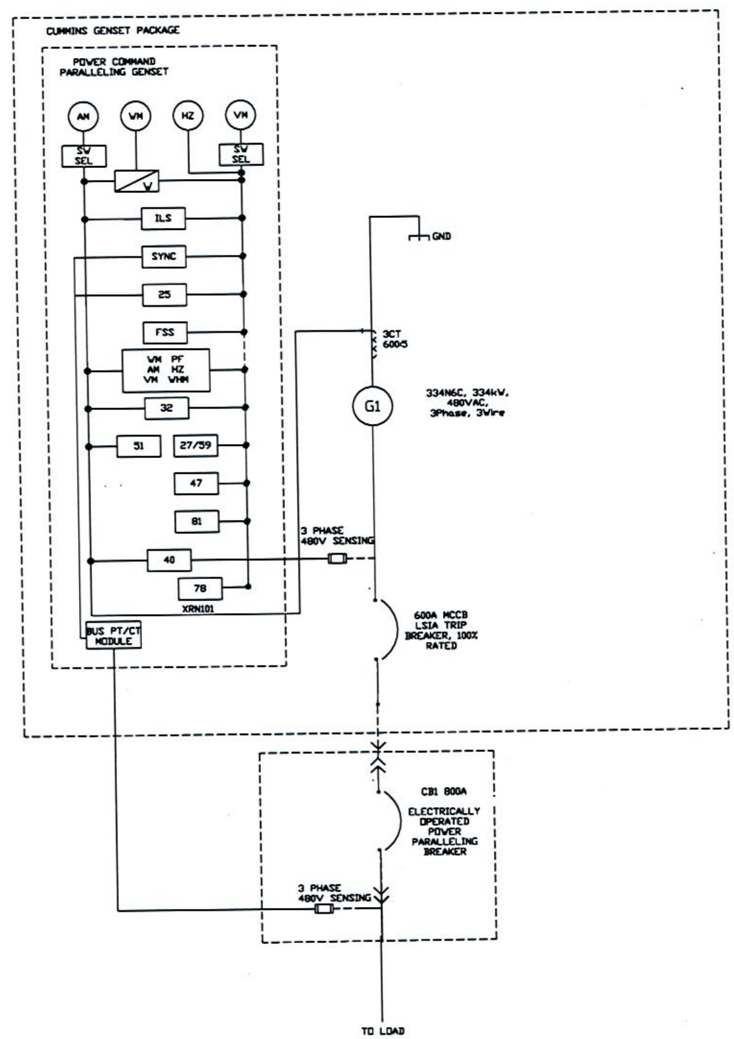
* HEAVIEST UNIT – TYPE 5V

VERTICAL MFT ARRANGEMENTS

MAXIM SILENCERS, INC.
10635 BRIGHTON LANE
STAFFORD, TEXAS 77477
PHONE (832) 554-0980
FAX (832) 554-0990

99-1 CAD FILE NAME: VMFT-ARR.DWG

NOT FOR CONSTRUCTION (PRELIMINARY)



PROJECT: EL PASO WATER UTILITIES GEN 1000

DISTRIBUTOR: CUMMINS POWER GENERATON ENERGY SOLUTIONS BUSINESS

SUBMITTAL	4/4/11
PRE-SUBMITTAL	2/28/11

DO NOT SCALE PRINT

AUTOCAD DWG

DR	JR	4/4/11
CHKR	JR	4/4/11
APPROVED	PK	4/4/11

CUMMINS POWER GENERATION

ELECTRICAL SCHEMATIC

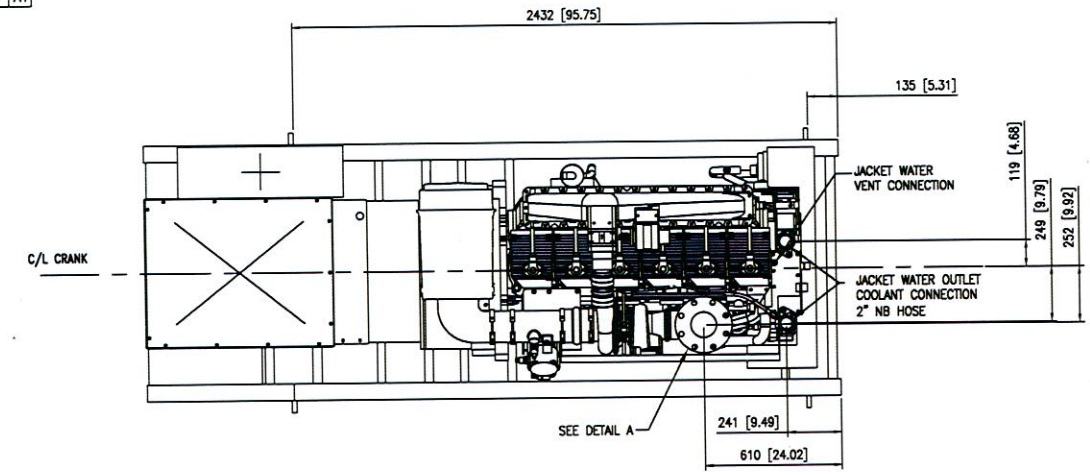
SITE CODE: PGA

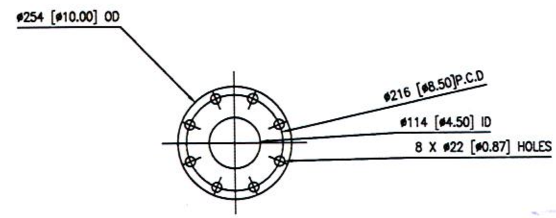
A0074-1-E104

1 of 1

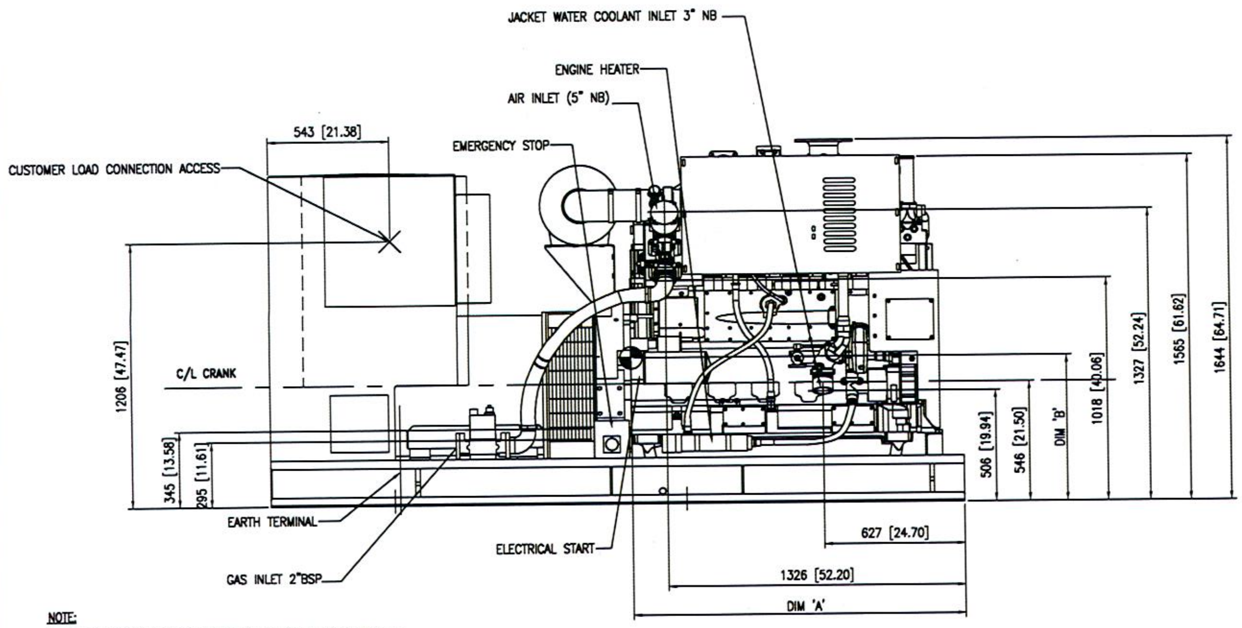
B

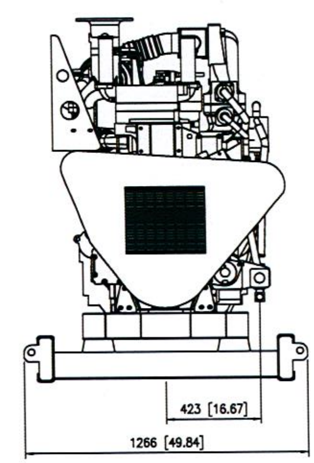
TABULATION						
GEN. FRAME SIZE	DIM 'A' C.G. (WET)	DIM 'B' C.G. (WET)	GENSET DRY WEIGHT		GENSET WET WEIGHT	
			KGS	LBS	KGS	LBS
HC5C	1482 [58.00]	665 [26.20]	3856	8501	3990	8796





DETAIL A
EXHAUST FLANGE
SCALE 1:5



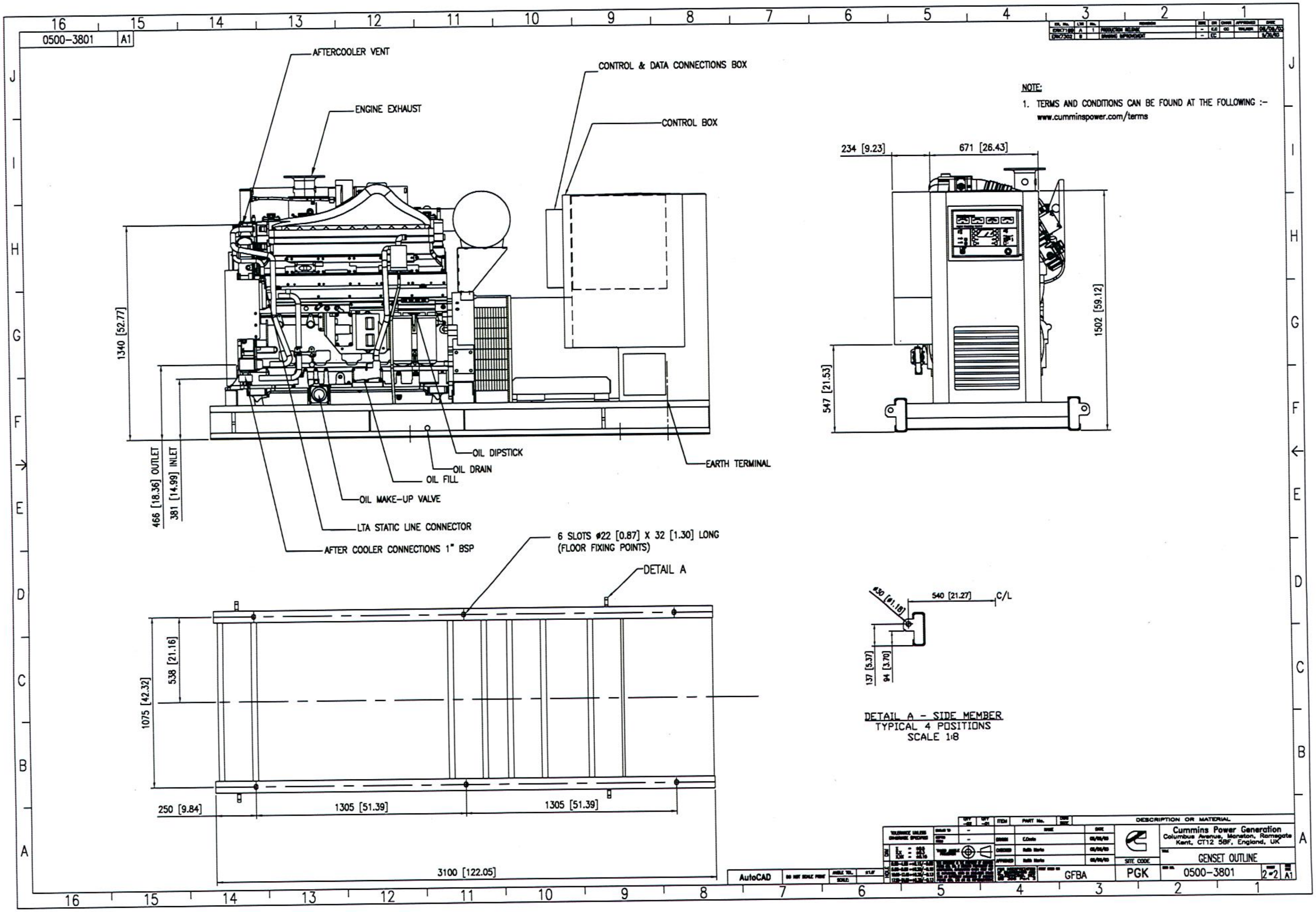


NOTE:
1. TERMS AND CONDITIONS CAN BE FOUND AT THE FOLLOWING :-
www.cumminspower.com/terms

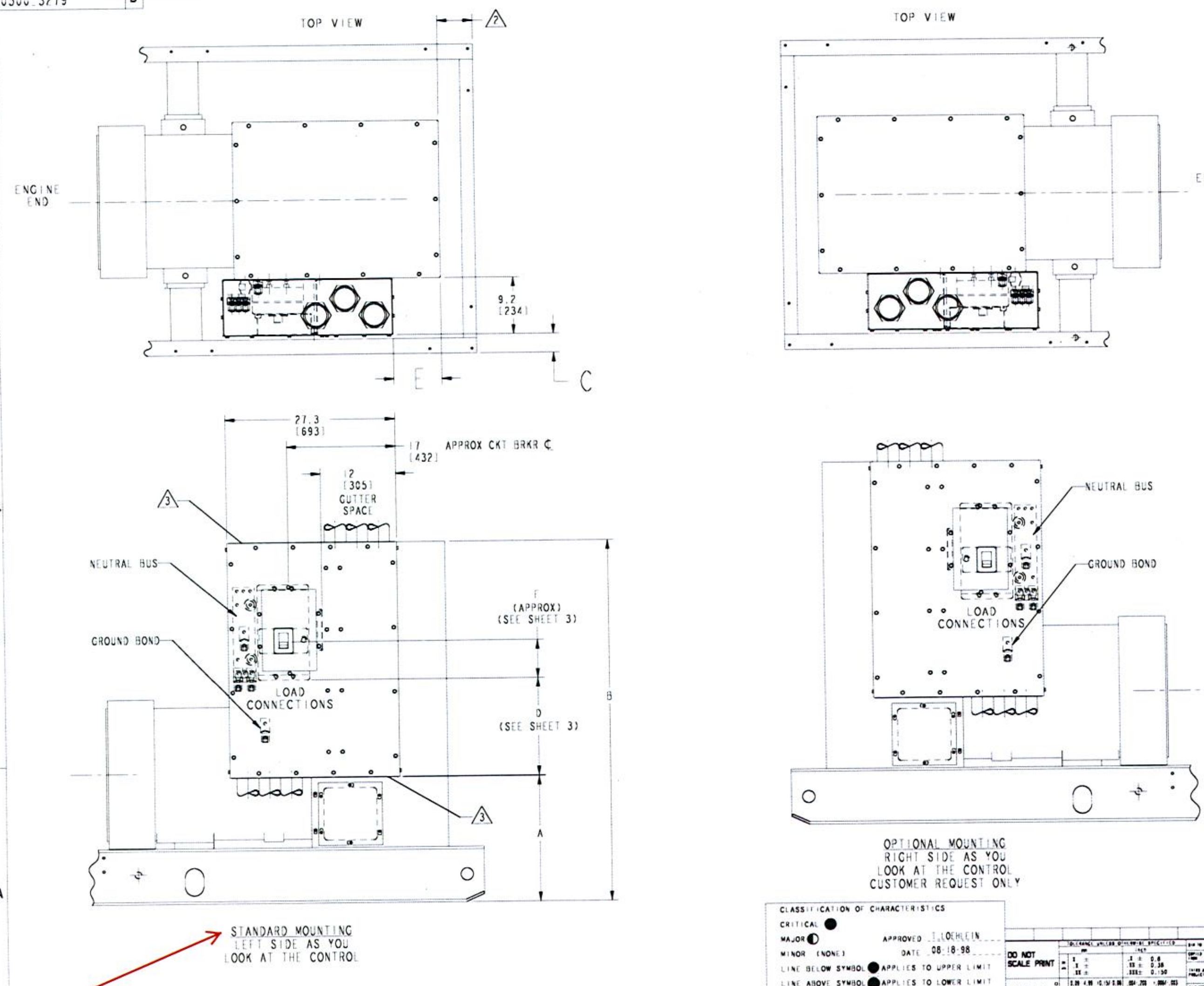
Cummins Power Generation
Columbus Avenue, Manston, Ramsgate
Kent, CT12 5BF, England, UK

GENSET OUTLINE

AutoCAD | GFBA | PGK | 0500-3801 | 1 of 2 | A1


0500-3801 A1
AFTERCOOLER VENT
ENGINE EXHAUST
CONTROL & DATA CONNECTIONS BOX
CONTROL BOX
NOTE:
1. TERMS AND CONDITIONS CAN BE FOUND AT THE FOLLOWING :-
www.cumminspower.com/terms
234 [9.23]
671 [26.43]
1502 [59.12]
547 [21.53]
1340 [52.77]
466 [18.36] OUTLET
381 [14.99] INLET
OIL DIPSTICK
OIL DRAIN
OIL FILL
EARTH TERMINAL
OIL MAKE-UP VALVE
LTA STATIC LINE CONNECTOR
AFTER COOLER CONNECTIONS 1" BSP
6 SLOTS ø22 [0.87] X 32 [1.30] LONG
(FLOOR FIXING POINTS)
DETAIL A
ø30 [ø1.18]
540 [21.27]
C/L
137 [5.37]
94 [3.70]
DETAIL A - SIDE MEMBER
TYPICAL 4 POSITIONS
SCALE 1:8
1075 [42.32]
538 [21.16]
250 [9.84]
1305 [51.39]
1305 [51.39]
3100 [122.05]
AutoCAD
DESCRIPTION OR MATERIAL
Cummins Power Generation
Columbus Avenue, Manston, Ramsgate
Kent, CT12 5BF, England, UK
GENSET OUTLINE
GFBA
SITE CODE
PGK
0500-3801
2 of 2
A1

ECO NO.	LTR	NO.	REVISION	ZONE	DR	CHKR	APPROVED	DATE
ECO-103746	N	1	ADDED NOTE 8 & 9		RJP	VO	PV	26JAN09
		2	SEE SHEET 3		RJP	VO	PV	26JAN09
		3	MOVED ALL NOTES TO SHEET 1 & RE NUMBERED FLAGS TO MATCH		RJP	VO	PV	26JAN09



NOTES:

1. DIMENSIONS SHOWN IN [ ] ARE IN MILLIMETERS.
2. ..... DIMENSION IS GENERATOR FRAME SPECIFIC (REFER TO SET OUTLINE DRAWING).
3. TOP AND BOTTOM COVERS ARE ADJUSTABLE VERTICALLY PLUS OR MINUS .25" [6] TO EASE CONDUIT ATTACHMENT.
4. THESE WIRE-CONDUIT COMBINATIONS MEET NEC AND CEC. TO USE OTHER COMBINATIONS, REFER TO APPLICABLE CODES TO ENSURE THAT WIRE AMPACITY, BEND SPACE AND GUTTER SPACE MEET THE REQUIREMENTS.
5. THESE SHUNT TRIP UNITS CAN BE OPERATED AT 75% OF NOMINAL VOLTAGE AND WILL ACCEPT MOMENTARY OR CONTINUOUS APPLIED VOLTAGE.
6. "NS" SHUNT TRIP HAS NO INTERNAL CONTACTS, IT MUST BE USED IN CONJUNCTION WITH AUXILIARY CONTACTS TO ACCEPT CONTINUOUS APPLIED VOLTAGE. IT CAN OPERATE AT 75% OF NOMINAL VOLTAGE.
7. THE SHUNT TRIP CAN OPERATE AT 70% TO 100% OF NORMAL VOLTAGE AND WILL ACCEPT MOMENTARY OR CONTINUOUS APPLIED VOLTAGE.
8. 800 AMP BREAKER: A LUG ACCEPTING (2) 3/0-600 kcmil CONDUCTORS IS AVAILABLE THRU ACCESSORIES. PGA PART NUMBER 0332-4278.
9. 1200 AMP BREAKER: A LUG ACCEPTING (3) 3/0-600 kcmil CONDUCTORS IS AVAILABLE THRU ACCESSORIES. PGA PART NUMBER 0332-4279.

DIMENSION TABULATIONS

MODEL NAME	ENGINE SIZE	DIM A	DIM B	DIM C	DIM E
DQDAA DQDAB DQDAC	QSL9	18.2 [462]	58.8 [1493]	3.0 [77]	3.8 [97]
DFAA DFAB DFAC DQAA DQAB DQAD DQAE DQAF DQHAA DQHAB	L10/M11/ QSM11	18.2 [463]	58.8 [1494]	2.7 [69]	7.8 [198]
DFBF DFCB DFCC DFCE DQBA DQBB	855/N14	18.1 [460]	58.7 [1491]	2.1 [53]	7.8 [198]
DFEB DFEC DFED DFFB	K19	19.2 [488]	59.9 [1521]	7.4 [188]	7.8 [198]
DFCA DFCB	V28	26.1 [663]	66.8 [1696]	8.6 [218]	7.8 [198]
DFEK DFEJ DFEH DFEG	QSX15	19.9 [506]	60.5 [1537]	5.4 [137]	3.5 [90]

CLASSIFICATION OF CHARACTERISTICS
CRITICAL ●
MAJOR ◐
MINOR (NONE)
APPROVED T.LOEHLEIN
DATE 08-18-98
LINE BELOW SYMBOL ● APPLIES TO UPPER LIMIT
LINE ABOVE SYMBOL ● APPLIES TO LOWER LIMIT
NO LINE WITH SYMBOL APPLIES TO BOTH LIMITS
▼ KEY INSTRUCTION (NO TOLERANCE)

Pro/ENGINEER

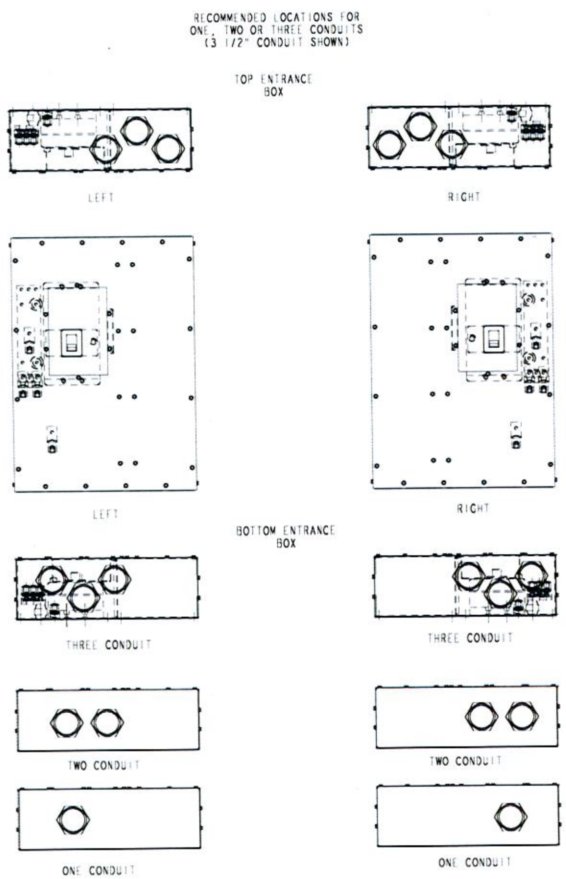
DO NOT SCALE PRINT

DR C.COLLEEN 08-17-98
CHKR S.JULIK 08-18-98
APPROVED T.LOEHLEIN 08-18-98
HC4-HC5

Minneapolis, Minnesota 55432
Onan
OUTLINE-CKT BRKR
0500 3279
1 of 3 D

Sheet 1 of 4

0500 3279 | D



TYPICAL CONDUIT AND WIRE SIZE BASED ON NEC 2008, ARTICAL 310.15 AT 75C TEMPERATURE RATED CONDUCTOR AT 30C AMBIENT AND ANNEX C (LIQUID TIGHT FLEXIBLE METAL CONDUIT - LFMC)

MAX BRKR AMPS	WIRE (COPPER)		CABLE AMPACITY	TOTAL NUMBER OF CONDUITS	
	QTY	SIZE		QTY	SIZE (IN INCHES)
1200	3	500 KCMIL	380	3	3 1/2
1000	3	400 KCMIL	335	3	3
800	3	300 KCMIL	285	2	3
630	2	350 KCMIL	310	2	3
600	2	350 KCMIL	310	2	3
400	1	600 KCMIL	420	1	4
250	1	250 KCMIL	255	1	2 1/2
100	1	2 KCMIL	115	1	2

CO 103746 | N | RJP | VO | PV | 26JAN09

CLASSIFICATION OF CHARACTERISTICS
CRITICAL
MAJOR
MINOR (NONE)
APPROVED T.LOEHLEIN
DATE 08-18-98
LINE BELOW SYMBOL APPLIES TO UPPER LIMIT
LINE ABOVE SYMBOL APPLIES TO LOWER LIMIT
NO LINE WITH SYMBOL APPLIES TO BOTH LIMITS
KEY INSTRUCTION (NO TOLERANCE)

Pro/ENGINEER

DO NOT SCALE PRINT

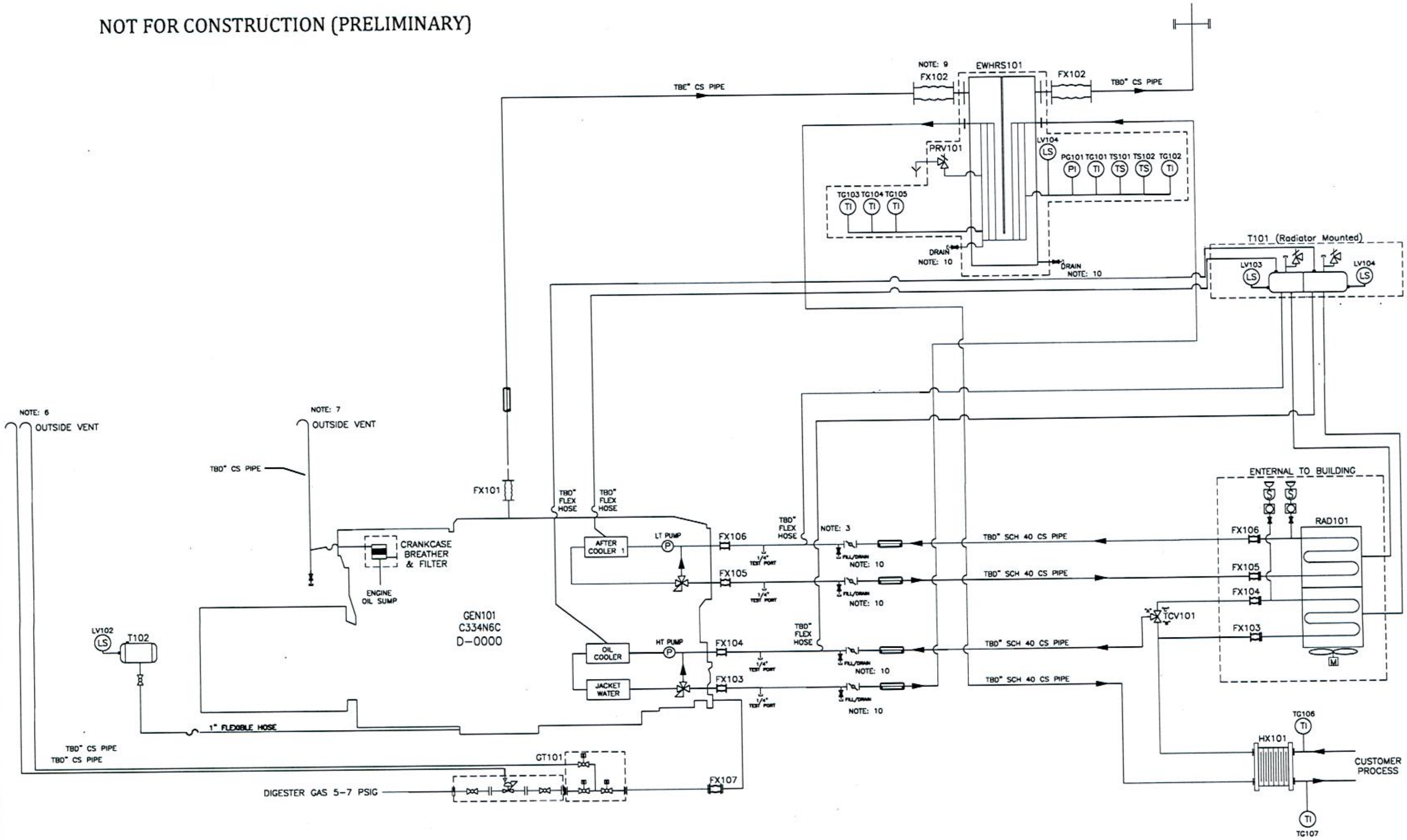
DR G.COLLEEN 08-17-98
CHK'D S.JULIK 08-18-98
APPROVED T.LOEHLEIN 08-18-98
HC4-HC5

Onan — Minneapolis, Minnesota 55432

OUTLINE-CKT BRKR

0500 3279 | 2 3 | D

NOT FOR CONSTRUCTION (PRELIMINARY)



NOTES:

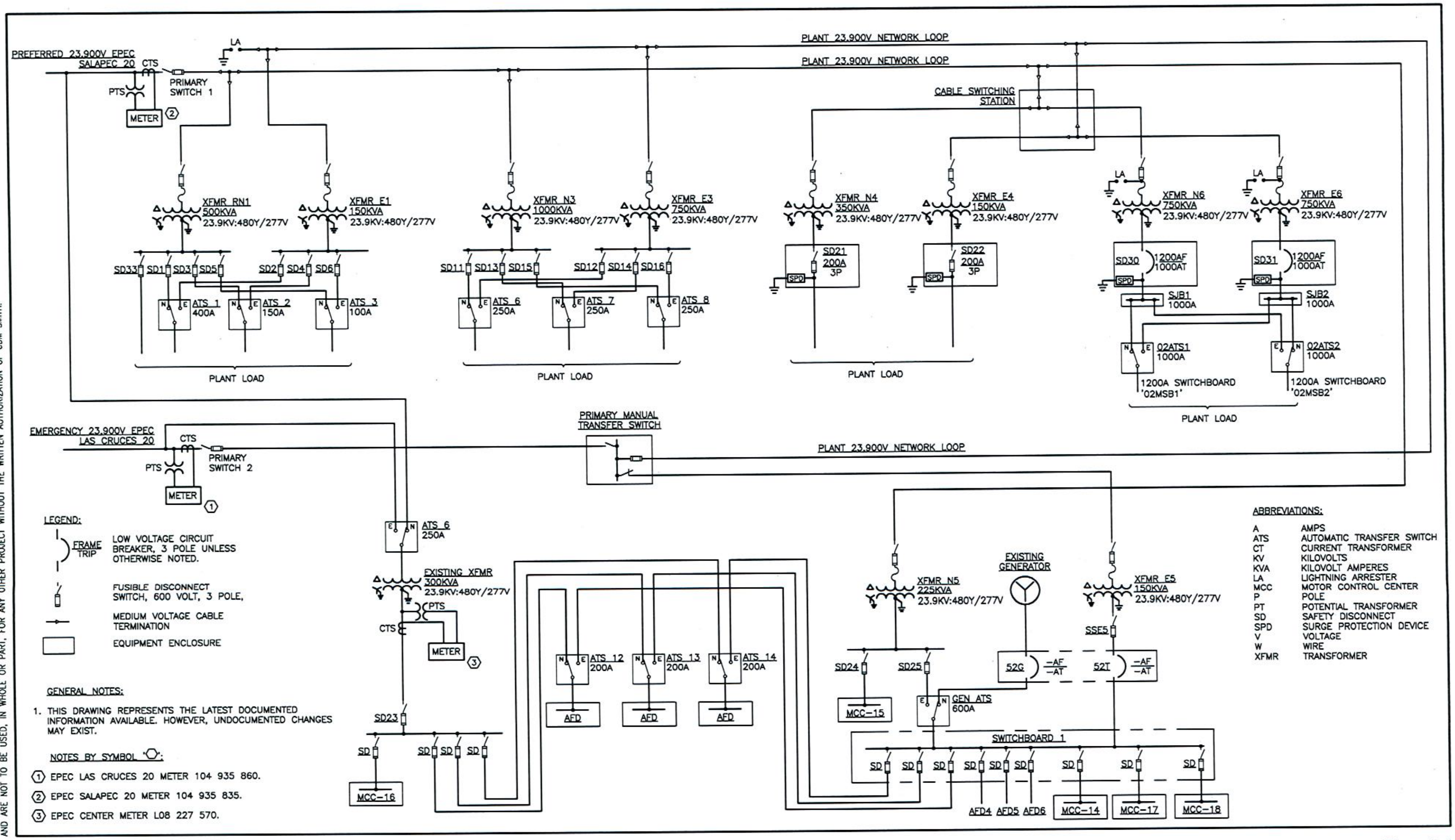
1. VERIFICATION OF HT, LT & EXHAUST RESTRICTIONS AND COMPLIANCE TO DATA SHEET LIMITS BY OTHERS
2. EQUIPMENT IDENTIFIED WITH A TAG # (EX. T101) IS SUPPLIED BY CUMMINS ESB, ALL OTHER EQUIPMENT, PIPING AND INSULATION BY OTHERS.
3. T101 FILL LINES TO TERMINATE AT LOW POINT IN COOLING SYSTEM AT MAXIMUM 60" BEFORE PUMP INLET.
4. PIPING TO DRAINS BY OTHERS.
5. TCV101 PORT DESIGNATION PER FPE SPEC SHEET.
6. GT101 TO BE VENTED FROM REGULATOR HOUSING, TO BE TERMINATED WITH BUG SCREEN AND WEATHER CAP, VENT SIZE TO BE COORDINATED WITH CUMMINS ESB, CUSTOMER TO CONFIRM VENT ARRANGEMENT IS TO APPLICABLE CODES.
7. CRANKCASE VENT SIZE TO BE COORDINATED WITH CUMMINS ESB.
8. CUSTOMER TO PROVIDE MANUAL VENTS FROM HIGH POINTS IN PIPING.
9. EXHAUST EXPANSION JOINTS (FX102) TO MOUNT DIRECTLY TO BOILER INLET & OUTLET. CUSTOMER PIPE WORKS TO BE SUPPORTED EXTERNALLY FROM BOILER.
10. CUSTOMER TO PROVIDE LOW POINT DRAIN VALVES AS NEED.

PROJECT:	EL PASO WATER UTILITIES GEN 1000
DISTRIBUTOR:	CUMMINS POWER GENERATION ENERGY SOLUTIONS BUSINESS
DO NOT SCALE PRINT	AUTOCAD DWG
DR	JR 4/4/11
CHKR	JR 4/4/11
APPROVED	PK 4/4/11
SITE CODE	PGA
TITLE	MECHANICAL SCHEMATIC
DWG NO.	A0074-01- M101
SHEET	1 of 1
REV	B

SUBMITTAL 4/4/11

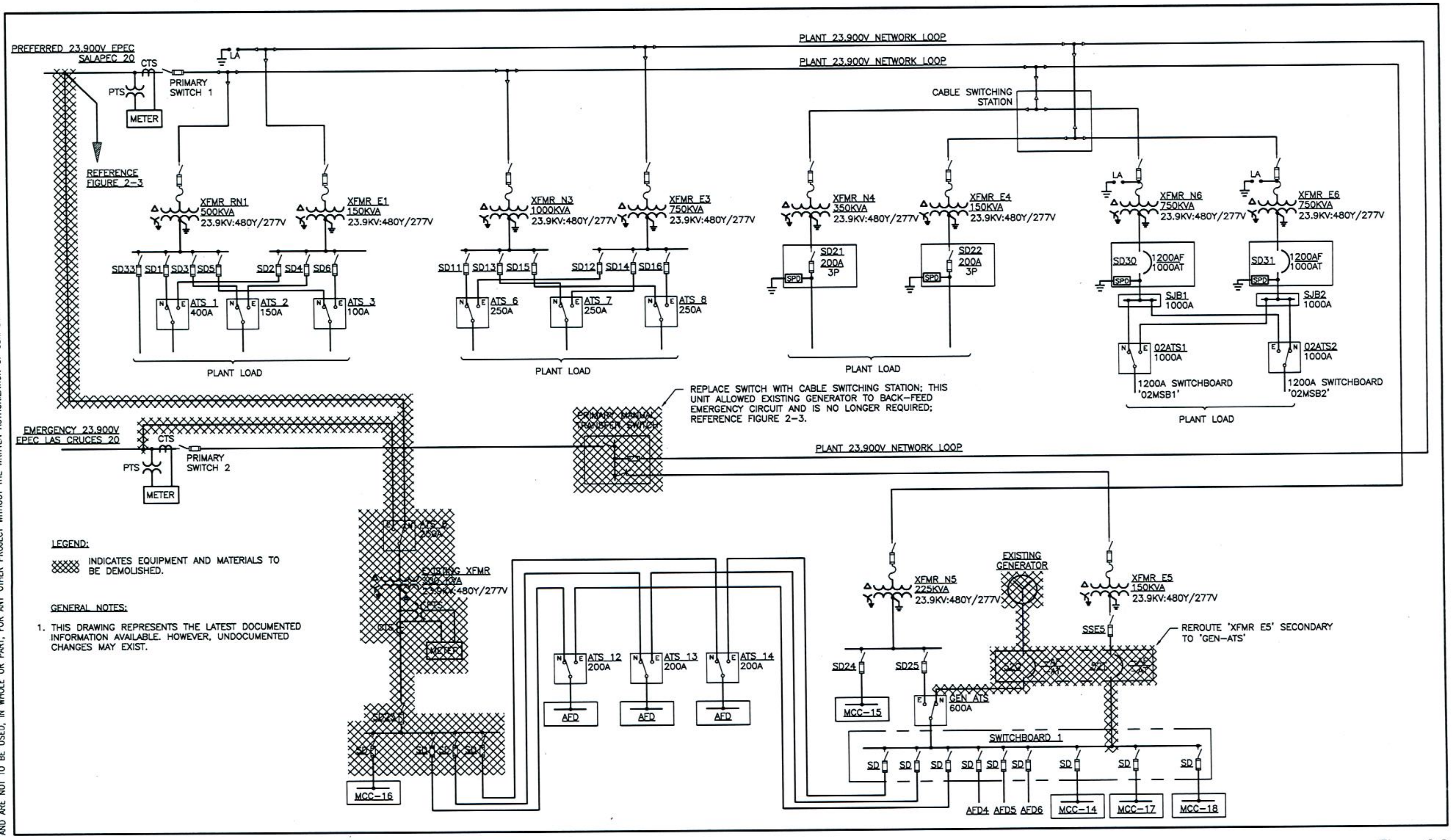
CUMMINS POWER GENERATION

Appendix D
Figures



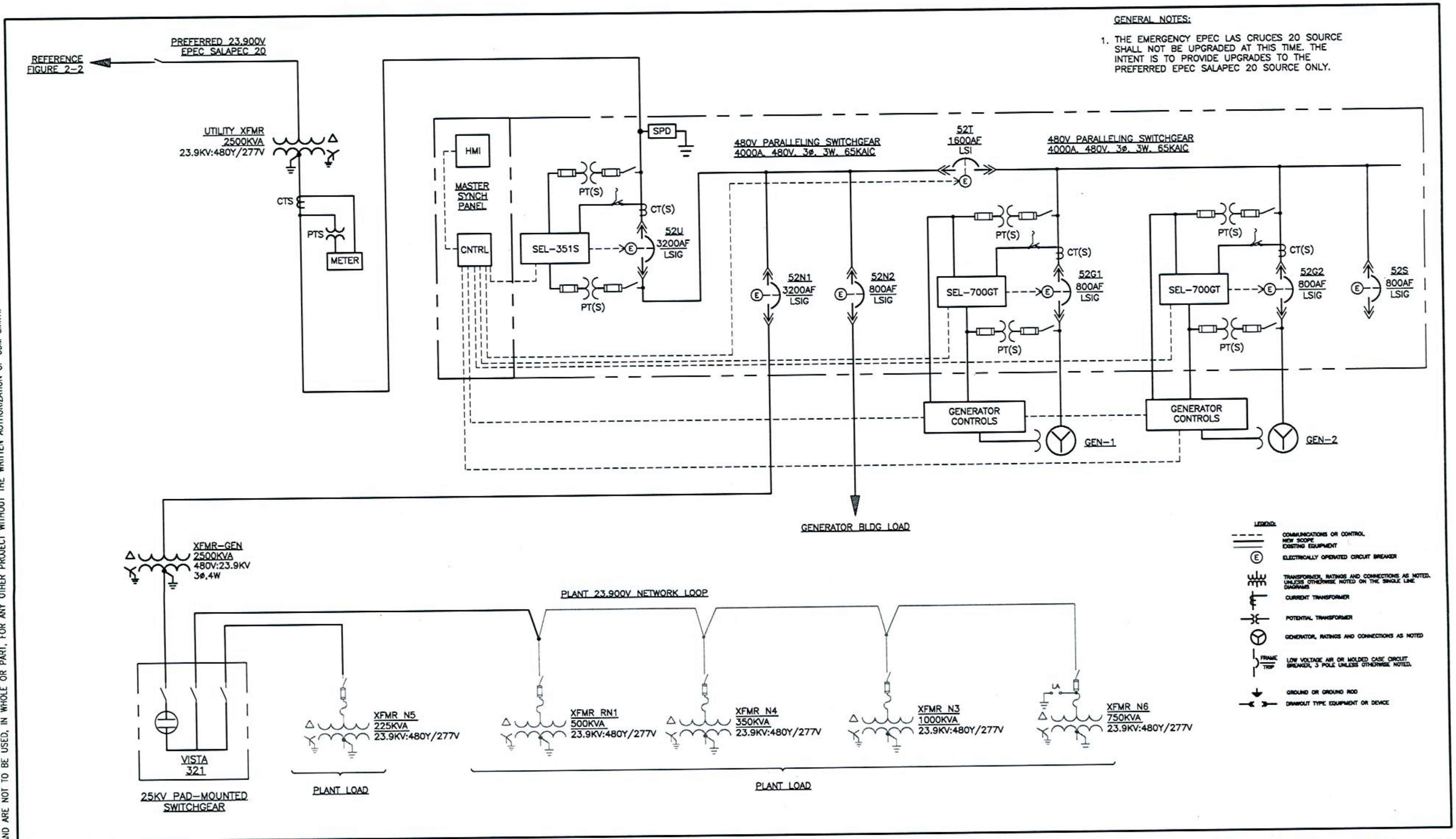
CDM Smith

Figure 2-1
Existing Electrical One-Line Diagram
MAY 2012



CDM Smith

Figure 2-2
Electrical Demolition One-Line Diagram
MAY 2012



CDM Smith

Figure 2-3
Combined Heating and Power Upgrades Electrical One-Line Diagram
MAY 2012

Appendix F
Biogas Treatment System Vendor Proposals

UNISON
SOLUTIONS
Leaders in Biogas Technology

BUDGET PROPOSAL

PROJECT INFORMATION

Date: 05/04/2012
Expires: 06/05/2012

Sri Koduri
CDM Smith

Proposal Number: PX-212-1099.1
Project Name: Las Cruces, NM WWTP

Unison Solutions, Inc. is pleased to provide you with this proposal for a Biogas Conditioning System for the Las Cruces WWTP Project. This proposal includes all the engineering, technician labor, fabrication, CAD design services and materials to construct a Complete Gas Conditioning System.

EQUIPMENT/SUB-SYSTEMS

HYDROGEN SULFIDE REMOVAL SYSTEM
- Standalone
- Class I, Division 1 Electrical Area

Components
- Hydrogen Sulfide Removal Inlet Moisture/Particulate Filter (Located on Gas Compression/Moisture Removal Skid)
- Hydrogen Sulfide Removal Media Vessel
- Initial charge of SulfaTreat Media
- Piping and Valves

GAS COMPRESSION/MOISTURE REMOVAL SYSTEM
- Skid Mounted
- Class I, Division 1 Electrical Area

Components
- Gas Blower Inlet Moisture/Particulate Filter
- Gas Blower
- Dual Core Heat Exchanger
- Gas Recirculation

GLYCOL CHILLER
- Standalone
- Unclassified Electrical Area

Components
- Glycol Chiller
- Initial Fill of 50/50; PG/Water Mixture

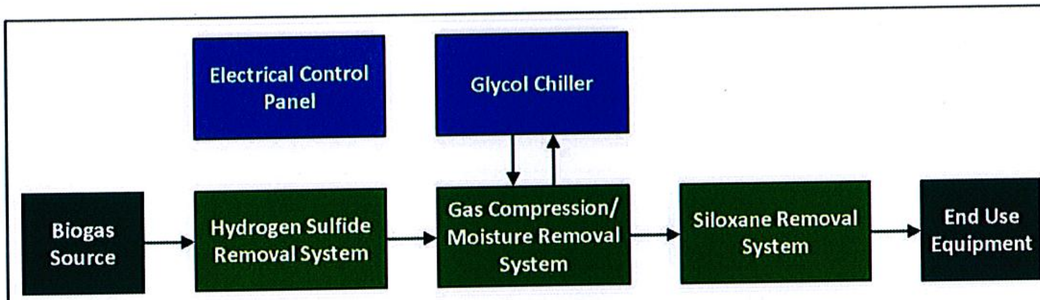
SILOXANE REMOVAL SYSTEM
- Standalone
- Class I, Division 1 Electrical Area

Components
- Siloxane Removal Vessels
- Siloxane Removal Final Particulate Filter (Located on Gas Compression/Moisture Removal Skid)
- Initial charge of Siloxane Removal Media
- Piping and Valves

CONTROL SYSTEM
- Standalone
- Unclassified Electrical Area

Components
- Gas Conditioning System Control Panel
- Transformer

PROCESS FLOW DIAGRAM



Equipment	Mounting	Electrical Classification
Hydrogen Sulfide Removal System	Standalone	Class I, Division 1
Gas Compression/Moisture Removal System	Skid Mounted	Class I, Division 1
Siloxane Removal System	Standalone	Class I, Division 1
Glycol Chiller	Standalone	Unclassified
Electrical Control Panel	Standalone	Unclassified

DESIGN CONDITIONS

SITE INFORMATION

Minimum Ambient Temperature	0°F
Maximum Ambient Temperature	100°F
Site Elevation	4044'AMSL

SYSTEM REQUIREMENTS

Minimum Gas Flow	95 scfm
Maximum Gas Flow	140 scfm

ASSUMED INLET GAS CONDITIONS

Inlet Gas Pressure	10"WC
Inlet Gas Temperature	100°F
Relative Humidity	100%
Methane*	50%
Carbon Dioxide*	50%
Hydrogen Sulfide*	26 ppmv
Siloxane	unknown*

**No gas data was available at the time of this proposal.*

DISCHARGE GAS CONDITIONS

Discharge Gas Pressure	7.0 psig
Discharge Gas Temperature	80°F
Dew Point Temperature	40°F
Maximum Hydrogen Sulfide	<5 ppmv
Maximum Siloxane	unknown*
Particulate Removal	99% removal of >3 micron

SYSTEM DETAILS

HYDROGEN SULFIDE REMOVAL SYSTEM

- Hydrogen Sulfide Removal Inlet Moisture/Particulate Filter
  - 99% removal of 3micron and larger particulates and liquid droplets
  - Mounted upstream of the Hydrogen Sulfide Removal Media Vessel
  - Materials of construction will be 304L stainless steel
  - 150# ANSI B16.5 inlet and outlet connections
  - Fasteners will be Grade 5 zinc plated steel
  - Cleanable polypropylene structured mesh element
  - Differential pressure gauge across the filter element
  - Level indicator for liquid level indication
  - Level switch above the condensate drain to warn of failure
  - Bottom drain with strainer, no gas loss drip trap, manual bypass and piping
- (1) Hydrogen Sulfide Removal Media Vessel
  - Vessel rated for 15psig pressure and 2psig vacuum
  - 12' diameter x 10' straight side
  - Materials of construction will be 304L stainless steel
  - Flanged and dished top and bottom heads
  - Vessel will be free-standing on four 304L stainless steel legs
  - Vessel will be equipped with a top mounted work platform. Platform and hand rails will be powder-coated carbon steel. Access ladder will be galvanized steel
  - Vessel equipped with a top manway
  - Vessel equipped with a side manway
  - Internal supports and grating for media
  - 150# ANSI B16.5 side inlet and outlet connections
  - Fasteners will be Grade 5 zinc plated steel

  - Pressure/Vacuum relief valve included
  - Two (2) top vents with stainless steel ball valves
  - Bottom manual condensate drain with stainless steel ball valves
- Hydrogen Sulfide Removal Media
  - Initial charge of SulfaTreat media is included
  - SulfaTreat media to be loaded into Hydrogen Sulfide Removal Vessel by INSTALLATION CONTRACTOR
- Instrumentation
  - Inlet Pressure Transmitter
- Piping
  - All piping shall be minimum Type 304/304L stainless steel in IPS standard sizes
  - All piping 2 inches and smaller may be threaded or 150# ANSI B16.5 flanged, but threaded piping shall be a minimum of Schedule 40
  - All piping 2 inches and larger shall be welded with 150# ANSI B16.5 flanged connections
  - Fabricated in accordance with ASME B31.3 - Process Piping
  - Fasteners will be Grade 5 zinc plated steel
- Valves
  - Inlet Electric Actuated Butterfly Valve
    - Butterfly valve with cast iron body, stainless steel disk and stem, and Viton seats. Butterfly valve will be lug style
    - Type 7 explosion proof actuator
    - Spring return closed upon power loss
    - 120VAC weatherproof
  - All valves 3 inches and larger shall be butterfly valves with cast iron bodies, stainless steel disk and stem, and Viton seats. Butterfly valves will be lug style.
  - All valves 2-1/2 inches and smaller will be ball valves
    - Ball valves 1 inch and smaller shall have NPT threaded connections. Bodies and balls shall be 316 stainless steel. Packing or seats will be PTFE.
    - Ball valves 1-1/2 inches and larger shall have 150# flanged connections. Bodies and balls shall be 316 stainless steel. Packing or seats will be PTFE.

<u>GAS COMPRESSION/MOISTURE REMOVAL SYSTEM</u>
- Gas Blower Inlet Moisture/Particulate Filter
  - 99% removal of 3micron and larger particulates and liquid droplets
  - Mounted upstream of the Gas Blowers
  - Materials of construction will be 304L stainless steel
  - 150# ANSI B16.5 side inlet and outlet connections
  - Fasteners will be Grade 5 zinc plated steel
  - Cleanable polypropylene structured mesh element
  - Differential pressure gauge across the filter element
  - Level indicator for liquid level indication
  - Level switches above the condensate drain to warn of failure
  - Bottom drain with strainer, flex connectors, condensate pump, check valve, manual bypass and piping
- Gas Blower
  - Positive Displacement Blower
  - Belt driven 15Hp 480V/3Ph/60Hz EXP electric motor

  - Motor speed will be controlled by a VFD
  - Cast iron casing
  - Inlet and discharge flex connectors
  - Discharge silencer
  - Discharge check valve
  - Discharge pressure safety valve
- Dual Core Heat Exchanger
  - Within the heat exchanger, the gas will be cooled to 40°F and re-heated to 80°F
  - Aluminum fins on stainless steel tubes
  - Mounted in single 304 stainless steel housing
  - All condensation generated during cooling will be removed inside the heat exchanger housing
  - Level switch mounted on the housing to warn of drain failure
  - RTD mounted on the housing to verify the coldest temperature that the gas reaches
  - Bottom drain with no gas loss drip trap, manual bypass, strainer and piping
- Gas Recirculation
  - A Modulating Valve will be provided to allow excess gas to flow from the discharge of the system back to the inlet of the Gas Blower.
    - Butterfly valve with cast iron body, stainless steel disk and stem, and Viton seats. Butterfly valve shall be lug style.
    - Type 7 explosion proof actuator
    - 120VAC weatherproof
- Instrumentation
  - Inlet Pressure Transmitter
  - High Level Switches at each Condensate Drain
  - RTD's at each Temperature Change Point
  - Temperature Gauges at each Temperature Change Point
  - RTD to monitor Glycol Temperature
  - Blower Discharge Pressure Transmitter
  - Delivery Pressure Transmitter
- Piping
  - All piping shall be minimum Type 304/304L stainless steel in IPS standard sizes.
  - All piping 2 inches and smaller may be threaded or 150# ANSI B16.5 flanged, but threaded piping shall be a minimum of Schedule 40.
  - All piping 2 inches and larger shall be welded with 150# ANSI B16.5 flanged connections
  - Fabricated in accordance with ASME B31.3 - Process Piping
  - Fasteners will be Grade 5 zinc plated steel
- Valves
  - All valves 3 inches and larger will be butterfly valves with cast iron bodies, stainless steel disk and stem, and Viton seats. Butterfly valves shall be lug style.
  - All valves 2-1/2 inches and smaller shall be ball valves
    - Ball valves 1 inch and smaller shall have NPT threaded connections. Bodies and balls shall be 316 stainless steel. Packing or seats will be PTFE.
    - Ball valves 1-1/2 inches and larger shall have 150# flanged connections. Bodies and balls shall be 316 stainless steel. Packing or seats will be PTFE.
  - Check valves 2 inch and smaller shall be ball type, stainless steel and have NPT threaded connections. Check valves 2-1/2 inches and larger shall be spring loaded,

stainless steel, with a Viton seat. Valves will be inserted in the pipeline between two flanges.

- Skid Base
    - All components **except** the Hydrogen Sulfide Removal System, Siloxane Removal System, Glycol Chiller and the Gas Conditioning System Control Panel will be mounted on a single skid.
        - All components mounted, piped and wired on skid
        - Electrical components pre-wired to one of two junction boxes on edge of skid
        - Condensate drains piped to edge of skid
        - Conduit to be rigid aluminum
        - Satin black powder coated

<u>GLYCOL CHILLER</u>

- Glycol Chiller
    - Sized for the heat load of the Dual Core Heat Exchanger
    - Suitable for outdoor installation
    - Refrigeration System
        - One refrigeration circuit
        - One compressor
        - EC motor driven condenser fans with die cast aluminum blades
        - Aluminum micro-channel air cooled condenser
        - 316L stainless steel evaporator
        - R-410a refrigerant. R-410a is an HFC refrigerant with 0 ODP
        - Refrigeration circuit has replaceable core filter drier, liquid line solenoid valve, liquid line shut-off valve, sight glass/moisture indicator and unload solenoid valve
        - Glycol Chiller will be shipped with complete refrigerant charge
    - Glycol Circulation
        - Two glycol circulation pumps sized for 100% capacity
        - Pumps are dual impeller end suction centrifugal
        - Pump isolation valves on inlet and outlet
        - Pump discharge check valves
        - Glycol reservoir
        - Glycol piping is copper with heresite coating
        - Armaflex insulation
        - Glycol Chiller to utilize propylene glycol
        - Propylene glycol will be supplied
        - 35°F glycol delivery temperature
    - Support Structure
        - G90 galvanized steel member frame
        - Powder coated steel cover panels
        - All components mounted, piped and wired on skid
    - Glycol Chiller Control Panel
        - Type 4, UL 508A listed Control Panel
        - Painted Carbon Steel
        - 480V/3Ph/60Hz feed will be required
        - 480V disconnect
        - Microprocessor based controller with full text LCD display

- 480VAC to 120VAC transformer

SILOXANE REMOVAL SYSTEM

- (2) Siloxane Removal Media Vessels
  - 6' diameter x 8' straight side
  - Materials of construction will be 304L stainless steel
  - Flanged and dished top and bottom heads
  - Vessels will be free-standing on four 304L stainless steel legs
  - Platform and hand rails will be powder-coated carbon steel. Access ladder will be galvanized steel
  - Elliptical manway on top of each vessel
  - Internal septas for even gas distribution through media
  - 150# ANSI B16.5 side inlet and outlet connections
  - Fasteners will be Grade 5 zinc plated steel
  - Pressure relief valves included
  - Bottom manual condensate drain with stainless steel ball valves
  - Test/purge ports with valves on the inlet and exit of each vessel
- Siloxane Removal Media
  - Initial charge of Siloxane Removal Media is supplied
  - The media is specifically engineered for removal of siloxanes and similar contaminants from landfill and digester gas sources
  - Siloxane media to be loaded into Siloxane Removal Vessel by INSTALLATION CONTRACTOR
- Siloxane Removal Final Particulate Filter
  - 99% removal of 3micron and larger particulates and liquid droplets
  - Mounted downstream of the Siloxane Removal Vessels
  - Materials of construction will be 304L stainless steel
  - 150# ANSI B16.5 side inlet and outlet connections
  - Fasteners will be Grade 5 zinc plated steel
  - Cleanable polypropylene structured mesh element
  - Sight glass for liquid level indication
  - Level switch above the condensate drain to warn of failure
  - Bottom drain with stainless steel ball valve
- Instrumentation
  - Delivery Pressure Transmitter
- Piping
  - Lead/Lag piping between the Siloxane Removal Vessels will be provided
  - All piping shall be minimum Type 304/304L stainless steel in IPS standard sizes
  - All piping 2 inches and smaller may be threaded or 150# ANSI B16.5 flanged, but threaded piping shall be a minimum of Schedule 40
  - All piping 2 inches and larger shall be welded with 150# ANSI B16.5 flanged connections
  - Fabricated in accordance with ASME B31.3 - Process Piping
  - Fasteners will be Grade 5 zinc plated steel
- Valves
  - All valves 3 inches and larger shall be butterfly valves with cast iron bodies, stainless steel disk and stem, and Viton seats. Butterfly valves shall be lug style.
  - All valves 2-1/2 inches and smaller shall be ball valves.

- Ball valves 1 inch and smaller shall have NPT threaded connections. Bodies and balls shall be 316 stainless steel. Packing or seats will be PTFE.
- Ball valves 1-1/2 inches and larger shall have 150# flanged connections. Bodies and balls shall be 316 stainless steel. Packing or seats will be PTFE.

GAS CONDITIONING SYSTEM CONTROL PANEL

- Gas Conditioning System Control Panel
    - Enclosure
        - UL Type 4
        - UL 508A Listed Industrial Control Panel
        - Painted Carbon Steel
        - Shipped loose for remote installation outdoors, out of direct sunlight
    - Thermal Management *(as necessary)*
        - Rated for installation in ambient temperatures from 40°F to 104°F
        - Air Conditioner
    - Power Distribution
        - Fused Disconnect
        - 480V/3Ph/60Hz feed required
        - 35kA Short Circuit Current Rating
        - Over current and branch circuit protection via fuses
        - 480VAC field wiring to terminate at the component or terminal strips inside control panel
        - 5kVA Transformer *(shipped loose)*
            - 480VAC to 120VAC
            - NEMA 3R; Painted Carbon Steel
    - Surge Suppression
        - 480VAC Transient Voltage Surge Suppressor
        - 120VAC Surge Filter
    - Motor Control (480V/3Ph/60Hz)
        - (1) 15 HP Rated VFD for Blower
    - Control
        - Programmable Logic Controller
            - Allen Bradley
            - Compact Logix PLC and I/O
            - Native Allen Bradley Ethernet IP data network
        - Managed Ethernet switch - (8) 10/100 BaseTX RJ-45 Ports
        - Proface AGP3400, Human Machine Interface
            - TFT Color LCD Display
            - 7.5" diagonal
            - 640 x 480 pixels
        - Instrument wiring to terminate at terminal strips inside control panel

TESTING

- Complete system will be tested on ambient air at the Unison Solutions manufacturing facility in Dubuque IA. If customer would like to witness the testing Unison will inform the customer two (2) weeks prior to anticipated testing date so customer can make travel arrangements.

SUBMITTALS

- Three Copies of 3 Ring Binders and one electronic CD copy

OPERATION & MAINTENANCE MANUALS

- Six Copies of 3 Ring Binders and one electronic CD copy

DELIVERY SCHEDULE

- Submittals delivered 4 weeks after order acknowledgement
- Equipment delivery 20 to 24 weeks after submittal approval
- Delivery is subject to confirmation at the time of order placement and/or submittal approval

PRICING SUMMARY

- Price includes all labor and expenses associated with the fabrication of the system.
- Prices do not reflect any taxes that may be applicable and are valid for 30 days.
- Price is EXW; Factory, Dubuque, IA 52002. Shipping costs not included, see estimate below.
- Price does not include Start-up and Commissioning. Costs are shown below.

Budget Hydrogen Sulfide Removal System.. $140,000.00

Budget Gas Compression/Moisture Removal System $265,000.00

Budget Siloxane Removal System $85,000.00

Shipping Estimate to Las Cruces, NM $15,000.00

Cost is an estimate and is subject to change without notice. It does not include any special packaging or permitting that may be required and is dependent on the final equipment dimensions and weights.

Start-up and Commissioning Services Estimate.. $10,000.00

Price includes Four (4) consecutive, 8 hour days, for one Unison Technician onsite with travel and expenses included. Additional days may be necessary to complete start-up and commissioning, they will be billed to the Buyer/Owner/End User at the cost of $1,200 per day, per technician, plus travel & expenses.

PAYMENT SCHEDULE

- 30% upon order acceptance.
- 30% at midpoint of construction.
- 30% upon equipment delivery.
- 10% upon site acceptance not to exceed 180 days from shipment.
- Net 30 days on all payments.

PROVIDED BY OTHERS

- VPN connection for remote access to Unison supplied equipment for troubleshooting and remote assistance.
- Sun shield if control panel is mounted outdoors

PRICE DOES NOT INCLUDE

- Shipping of equipment to jobsite
- Start-up or commissioning
- Wind or seismic calculations for all equipment
- Any maintenance work after start-up
- Siloxane or H2S removal media after initial fill
- Performance guarantee or service/maintenance contract
- Any gas testing or analyses

ASSUMPTIONS

- Vessels & Media
  - The Hydrogen Sulfide Removal System, Gas Compression/Moisture Removal System and the Siloxane Removal System will be considered a Class I, Division 1 Electrical Area around all gas components.
  - H2S and VOC's present in the gas will foul Siloxane media, additional gas testing will be necessary to finalize all vessel and media requirements, budget pricing is dependent on gas data given at the time of the proposal.
  - No assumption of media life has been given; additional gas testing will be required at the Buyer/Owner/End Users expense.
  - Vessel sizes are estimates only, gas testing will be necessary to finalize all vessel sizing.

- Mechanical
  - Flare is supplied by others
  - If an existing flare is being used, it is assumed this flare is in good working order, with all safety and control equipment.
  - It is assumed the flare is located downstream of the gas conditioning equipment

- Electrical & Controls
  - 480V/3Ph/60Hz is available
  - The Gas Compression/Moisture Removal System will be considered a Class I, Division 1 Electrical Area around all gas components.- The Glycol Chiller and Gas Conditioning System Control Panel will be located in an Unclassified Electrical Area.
  - A native Allen Bradley Ethernet/IP protocol is available for communication with an existing LFG extraction system
  - No historical data acquisition is included in this proposal

INSTALLATION CONTRACTOR RESPONSIBILITIES

- Installation responsibilities are broken out below into three categories to outline the work; these responsibilities by no means fall on any single contractor or individual. It is the responsibility of the Buyer/Owner/End User to ensure all these conditions are adhered to, as necessary. It is responsibility of the Buyer/Owner/End User to install all equipment in compliance with local and national codes applicable to the installation site.

- Buyer/Owner/End User Responsibilities
    - All field and installation work
    - All rigging and setting of equipment at site
    - Provide installation of Equipment per the Unison Solutions Installation Guide
    - Proper storage of the equipment and media prior to installation
    - Media is to be installed in respective vessel(s)

- Mechanical Contractor Responsibilities
    - Provide all field piping between the system components, including but not limited to the Hydrogen Sulfide Removal System, Gas Compression/Moisture Removal System, Glycol Chiller and the Siloxane Removal System. *(Unless defined above)*
    - Provide pipe supports as necessary. Piping shall be self-supporting, and not supported off of the Unison supplied equipment.
    - Provide all Heat Trace and/or Insulation as necessary to provide proper freeze protection as defined by Unison Solutions.
    - Provide and seal all roof and building penetrations as necessary.
    - Install all field located or shipped loose devices

- Electrical Contractor Responsibilities
    - Provide conduit seals entering and/or leaving the Class I, Division 1 Electrical Area. Conduit seals will need to be filled during Start-up & Commissioning after verification of field wiring by Unison's Start-up Technician. Conduit seals are to be filled prior to the introduction of gas to the equipment.
    - Provide local disconnects as necessary
    - Provide all field wiring and conduits between the supplied equipment to the Gas Conditioning Control Panel and associated equipment.
    - Provide all Hazardous location conduits & wiring systems per Article 500 of the NEC.
    - Provide heat trace power from local lighting panel, as necessary.

WARRANTY

Unison Solutions, Inc. will warrant all workmanship and materials in conformance with the attached Warranty Statement. Warranty is valid for 18 months from the time the equipment is shipped from Unison's factory or 12 months from the date of startup, whichever occurs first.

Thank you for giving Unison Solutions the opportunity to propose our services. If you have any questions or require additional information, please contact me at your convenience.

WARRANTY STATEMENT

Unison Solutions, Inc. (Unison) is committed to providing quality products and services to its customers. As a demonstration of this commitment, Unison offers the following warranty on its products.

Grant of Warranty: Unison provides this warranty for its equipment under the terms and conditions which are detailed herein. This warranty is granted to the person, corporation, organization, or legal entity (Owner), which owns the equipment on date of start-up. This warranty applies to the owner during the warranty period, and is not transferable.

Warranty Coverage: Equipment that is determined by Unison to have malfunctioned during the warranty period under normal use solely as a result of defects in manufacturing workmanship or materials shall be repaired or replaced at Unison's option. Unison's liability under this warranty to the Owner shall be limited to Unison's decision to repair or replace, at its factory or in the field, items deemed defective after inspection at the factory or in the field.

Warranty Exclusions: All equipment, parts and work not manufactured or performed by Unison carry their own manufacturer's warranty and are not covered by this warranty. Unison's warranty does not override, extend, displace or limit those warranties. Unison's only obligation regarding equipment, parts and work manufactured or performed by others shall be to assign to the Owner whatever warranty Unison receives from the original manufacturer. Unison does not warrant its products from malfunction or failure due to shipping or storage damage, deterioration due to exposure to the elements, vandalism, accidents, power disturbances, or acts of nature or God. This warranty does not cover damage due to misapplication, abuse, neglect, misuse, improper installation, or lack of proper service and/or maintenance, nor does it cover normal wear and tear. This warranty does not apply to modifications not specifically authorized in writing by Unison or to parts and labor for repairs not made by Unison or an authorized warranty service provider. This warranty does not cover incidental or consequential damages or expenses incurred by the Owner or any other party resulting from the order, and/or use of its equipment, whether arising from breach of warranty, non-conformity to order specifications, delay in delivery, or any loss sustained by the Owner. No agent or employee of Unison has any authority to make verbal representations or warranties of any goods manufactured and sold by Unison without the written authorization signed by an authorized officer of Unison. Unison warrants the equipment designed and fabricated to perform in accordance with the specifications as stated in the proposal for the equipment and while the equipment is properly operated within the site specific design limits for that equipment. Any alterations or repair of Unison's equipment by personnel other than those directly employed by, or authorized by Unison shall void the warranty unless otherwise stated under specific written guidelines issued by Unison to the Owner. This warranty does not cover corrosion or premature wear or failure of components resulting from the effects caused by siloxanes, hydrogen sulfide or volatile organic contaminants in excess of the design limits. The design limit is based on site specific data provided by the Owner prior to the proposal for the equipment. Owner shall be responsible for all maintenance service, including, but not limited to, lubricating and cleaning the equipment, replacing expendable parts, making minor adjustments and performing operating checks, all in accordance with the procedures outlined in Unison's maintenance literature. Unison does not warrant the future availability of expendable maintenance items.

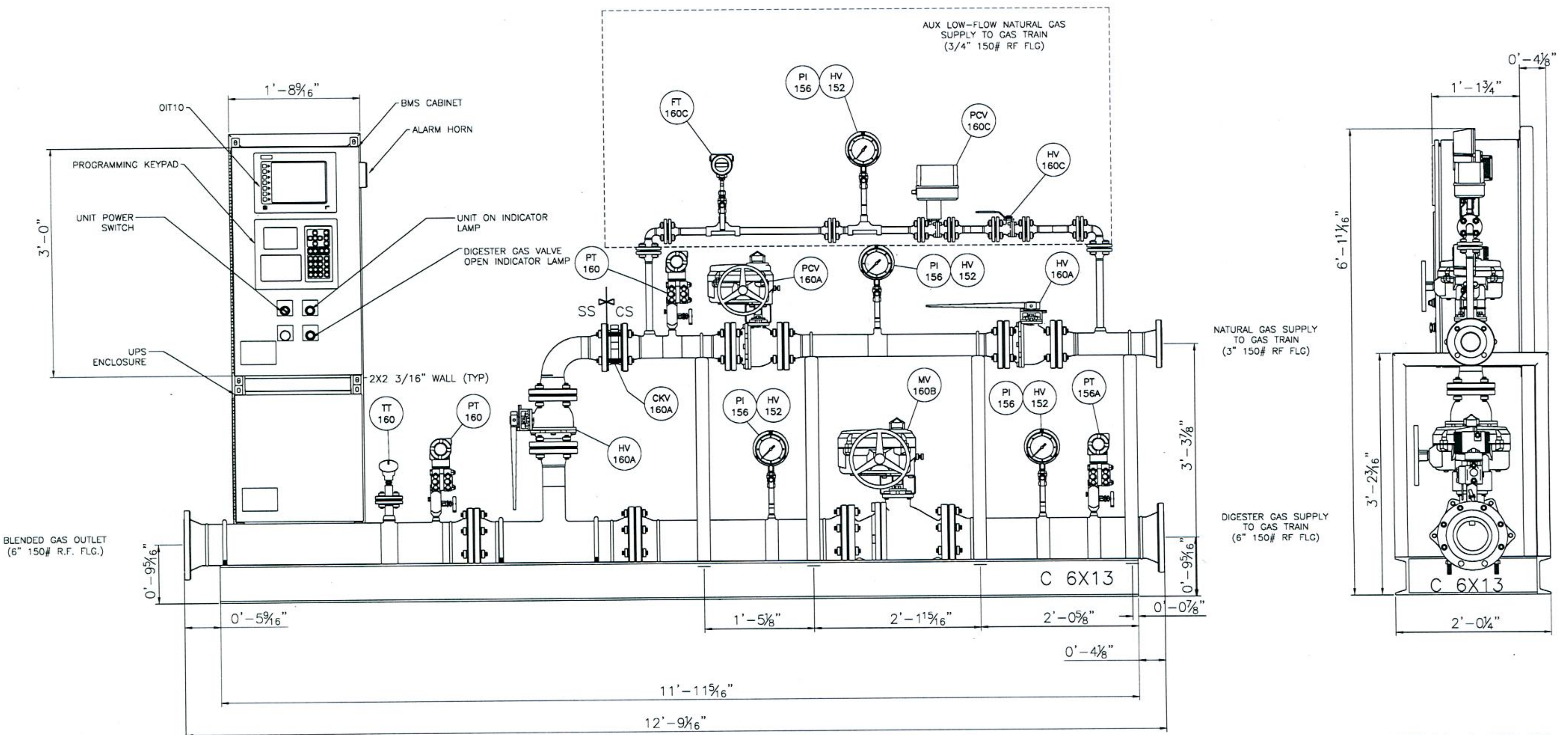
Warranty Period: This Unison warranty is valid for 18 months from the time the equipment is shipped from Unison's factory or 12 months from the date of startup, whichever occurs first.

Repairs During Warranty Period: All warranty claim requests must be initiated with a Return Material Authorization (RMA) number for processing and tracking purposes. The RMA number shall be issued to the Owner upon claim approval and/or field inspection. When field service is deemed necessary in order to determine a warranty claim, the costs associated with travel, lodging, etc. shall be the responsibility of the Owner except under prior agreement for a field inspection. This warranty does not include reimbursement of any costs for shipping the equipment or parts to Unison or an authorized service establishment, or for labor and/or materials required for removal or reinstallation of equipment or parts in connection with a warranty repair. This warranty covers only those repairs that have been conducted by Unison or by a Unison authorized warranty service provider, or by someone specifically authorized by Unison to perform a particular repair or service activity. All component parts replaced under the terms of this warranty shall become the property of Unison.

UNISON ASSUMES NO OTHER WARRANTY FOR ITS EQUIPMENT, EITHER EXPRESS OR IMPLIED, INCLUDING ANY IMPLIED WARRANTY OF MERCHANTABILITY, FITNESS FOR ANY PARTICULAR PURPOSE, OR NONINFRINGEMENT, OR LIABILITY FOR ANY INCIDENTAL OR CONSEQUENTIAL DAMAGE.

5451 Chavenelle Road, Dubuque, Iowa 52002 ■ [O] 563.585.0967 [F] 563.585.0970 ■ www.unisonsolutions.com

Appendix G
Fuel Train for Blending



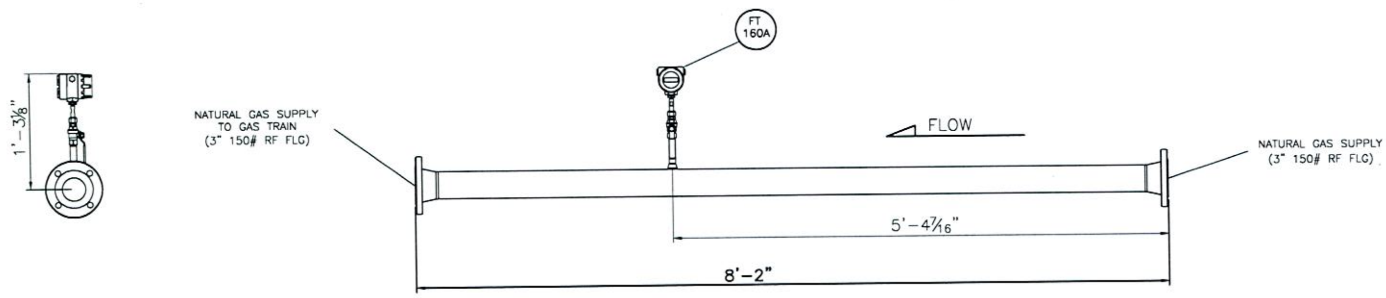
GAS BLENDING PIPE TRAIN IS
PRE-PIPED AND WIRED AS NOTED

JOB: DIGESTER GAS AND NATURAL GAS BLENDING SYSTEM, LAGUNA TREATMENT PLANT
CUST.: CUMMINS ENERGY SOLUTIONS BUSINESS

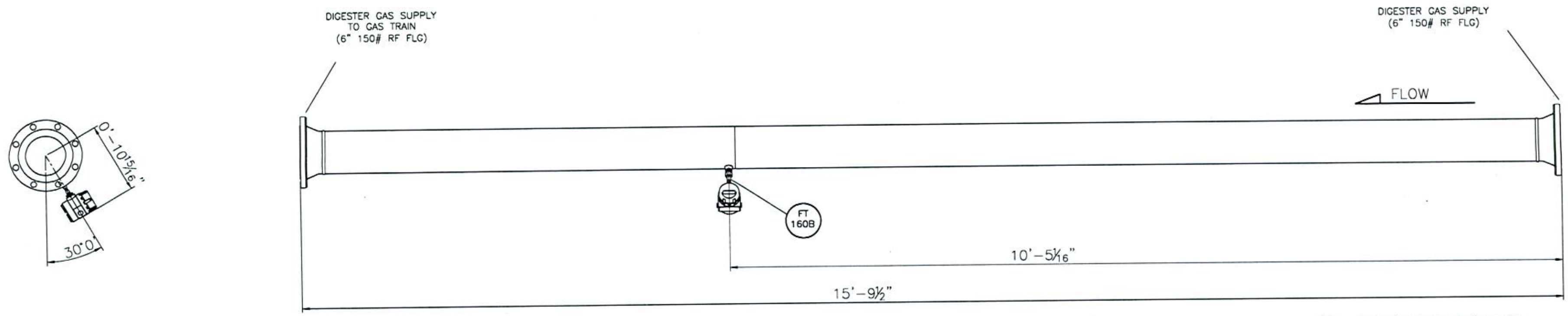
GENERAL NOTES

1. MATERIAL: NG TRAIN CARBON STEEL
DIGESTER GAS STAINLESS STEEL

REVISIONS				
ZONE	REV	DESCRIPTION	DATE	APPROVED
...	0	SUPERCEDES WNB-030711-4E	6/13/11	BDO
...	1	REVISED PER CUSTOMER COMMENTS	7/15/11	BDO



METER RUN SPOOLS TO BE FABRICATED AND SHIPPED LOOSE FOR FIELD INSTALATION UPSTREAM OF BLENDING SKID.



JOB: DIGESTER GAS AND NATURAL GAS BLENDING SYSTEM, LAGUNA TREATMENT PLANT

CUST.: CUMMINS ENERGY SOLUTIONS BUSINESS

TOLERANCE UNLESS OTHERWISE SPECIFIED			
PLATE WORK		MACHINING	
CUTTING	±0.063	0.000-3.000	±0.016
ASSEMBLY:		3.001-24.00	±0.031
0"-36"	±0.063	24.00 & UP	±0.062
36" & UP	±0.125	ANGLES	±1°00'
ANGLES	±2°30'	HOLE DIA.	
HOLE DIA.		0.000-0.250	+0.003 -0.002
0.000-0.250	+0.006 -0.002	0.251-0.500	+0.005 -0.002
0.251-0.500	+0.008 -0.002	0.501 & UP	+0.010 -0.003
0.501 & UP	+0.010 -0.003	FINISH	125 RMS
BREAK ALL SHARP EDGES			

PROPRIETARY INFORMATION NOTICE

Preferred Special Combustion Engineering

A division of Preferred Utilities Mfg. Corp.

RACK MOUNTED GAS BLENDING TRAINS,
(NAT. GAS AND DIGESTER GAS)
FCI METER RUNS (SHIPPED LOOSE)

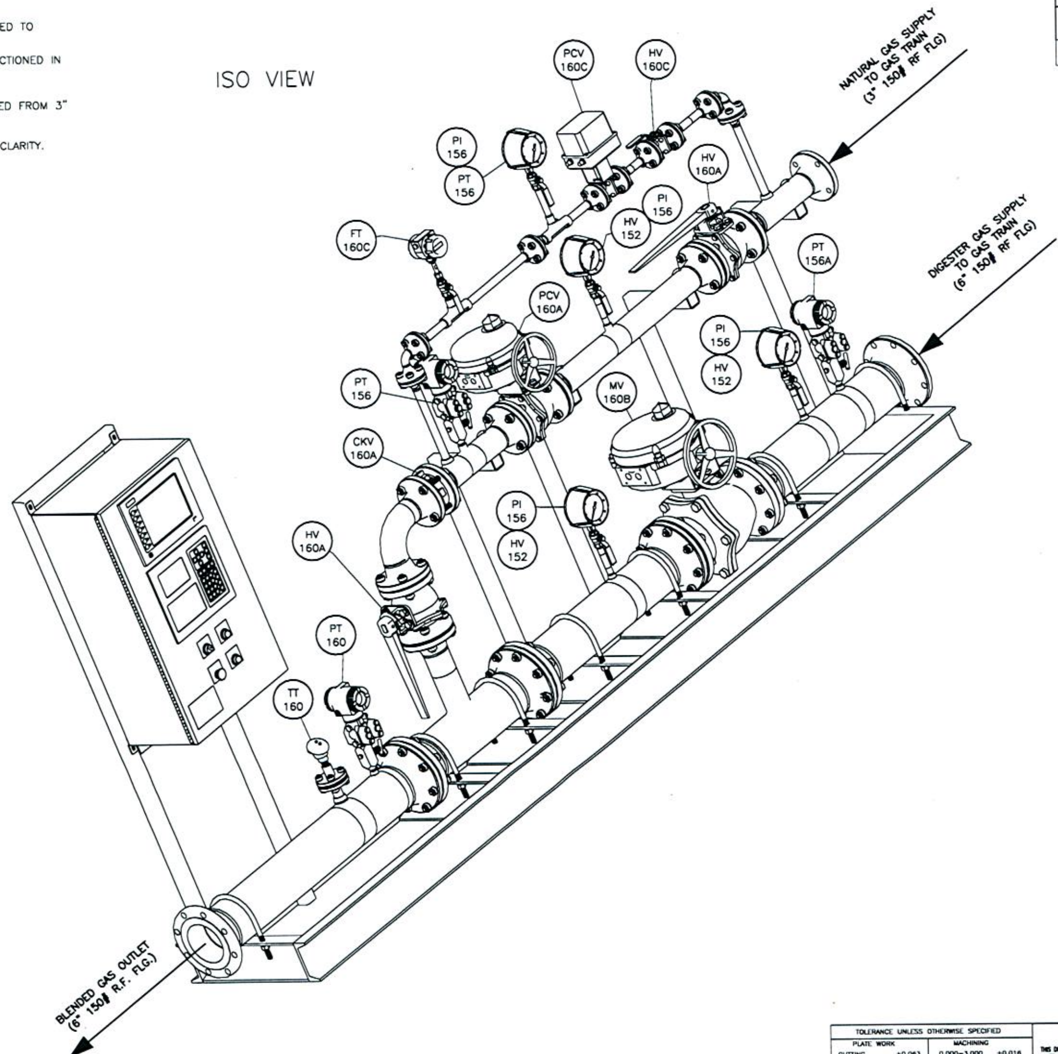
SIZE	JOB NO.	DWG NO.	REV
D	J12254	PSCE-12254-D-GA	1
SCALE N.T.S.		SHEET 2 of 3	

Pete C.

GENERAL NOTES

1. METER RUNS ARE NOT REQUIRED TO BE DIRECTLY BOLTED TO THE INLET OF THE BLENDING SKID.
2. NATURAL GAS TRAIN UPRIGHT SUPPORTS HAVE BEEN SECTIONED IN THIS VIEW FOR CLARITY.
3. 3/4" NATURAL GAS LOW FLOW BYPASS SHOWN SEPARATED FROM 3" GAS NAT. GAS LINE.
4. UPS ENCLOSURE (LOWER) REMOVED IN THIS VIEW FOR CLARITY.

ISO VIEW



REVISIONS				
ZONE	REV	DESCRIPTION	DATE	APPROVED
...	0	SUPERCEDES WNB-030711-4E-GA	6/13/11	BDD
...	1	REVISED PER CUSTOMER COMMENTS	7/15/11	BDD

JOB: DIGESTER GAS AND NATURAL GAS BLENDING SYSTEM, LAGUNA TREATMENT PLANT

CUST.: CUMMINS ENERGY SOLUTIONS BUSINESS

TOLERANCE UNLESS OTHERWISE SPECIFIED			
PLATE WORK		MACHINING	
CUTTING	±0.063	0.000–3.000	±0.016
ASSEMBLY:		3.001–24.00	±0.031
0"–36"	±0.063	24.00 & UP	±0.062
36" & UP	±0.125	ANGLES	±1°00'
ANGLES	±2°30'	HOLE DIA.	
HOLE DIA.		0.000–0.250	+0.003 −0.002
0.000–0.250	+0.006 −0.002	0.251–0.500	+0.005 −0.002
0.251–0.500	+0.008 −0.002	0.501 & UP	+0.010 −0.003
0.501 & UP	+0.010 −0.003	FINISH	125 RMS
BREAK ALL SHARP EDGES			

Preferred Special Combustion Engineering
A division of Preferred Utilities Mfg. Corp.

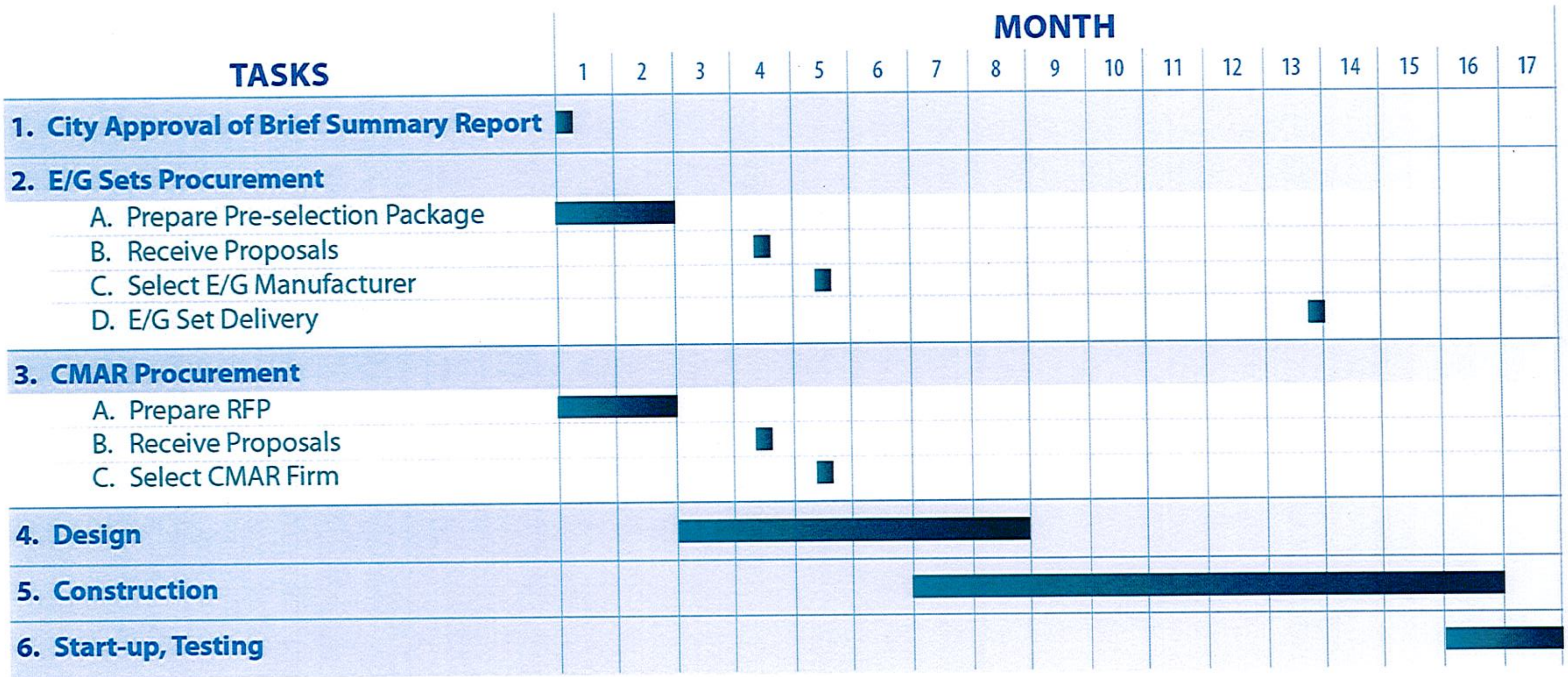
RACK MOUNTED GAS BLENDING TRAINS, (NAT. GAS AND DIGESTER GAS) ISOMETRIC VIEW

SIZE	JOB NO.	DWG NO.	REV
D	J12254	PSCE-12254-D-GA	1
SCALE N.T.S.		SHEET 3 of 3	

Pete C.

Appendix H
Schedule

Anticipated Project Schedule – CMAR Approach



CDM Smith