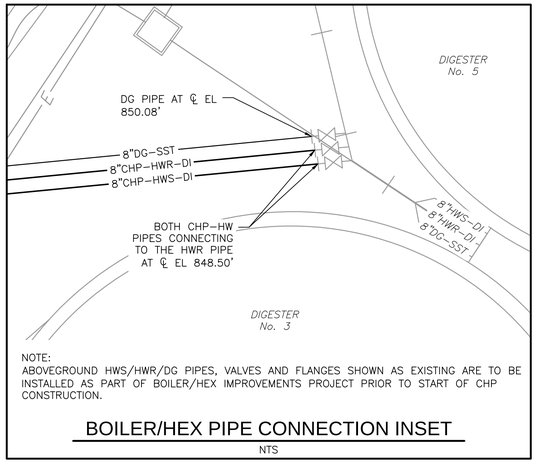
ATTACHMENTS



NOTE:
ABOVEGROUND HWS/HWR/DG PIPES, VALVES AND FLANGES SHOWN AS EXISTING ARE TO BE INSTALLED AS PART OF BOILER/HEX IMPROVEMENTS PROJECT PRIOR TO START OF CHP CONSTRUCTION.

BOILER/HEX PIPE CONNECTION INSET

NTS

1" = 30'

WAS THICKENING AND SCUM BUILDING

PRIMARY HANDHOLE. REFER TO ELECTRICAL DRAWINGS.

8" DIGESTER GAS–SS

DIGESTER No. 5

3" NG–HDPE (BY KUB)

8" HWS

8" HWR

8" DG

SEE BOILER/HEX PIPE CONNECTION INSET, THIS SHEET

WASTE GAS BURNER

ABOVEGROUND 8" SST DIGESTER GAS SUPPLY PIPE TO CHP EQUIPMENT

DIGESTER No. 3

DIGESTER No. 6

3" NG–HDPE (BY KUB)

PRIMARY HANDHOLE. REFER TO ELECTRICAL DRAWINGS.

UNDERGROUND 8" DI HOT WATER RETURN PIPE FROM GENSETS

UNDERGROUND 8" DI HOT WATER SUPPLY PIPE TO GENSETS

UNDERGROUND 8" SST DIGESTER GAS SUPPLY PIPE TO CHP EQUIPMENT

UNDERGROUND 8" CONDITIONED GAS SUPPLY PIPE TO GENSETS

KNOXVILLE & HOLSTON RIVER RAILROAD

ABOVEGROUND 8" DI HOT WATER RETURN PIPE FROM GENSETS

ABOVEGROUND 8" DI HOT WATER SUPPLY PIPE TO GENSETS

TRANSITION FROM ABOVEGROUND TO UNDERGROUND PIPING

DIGESTER BUILDING

DIGESTER No. 4

BOILERS NG METER (BY KUB)

CONNECT 4"NG–HDPE TO NG METER PROVIDED BY KUB.

GLYCOL PIPE (NOTE 3)

UNIVERSITY OF TENNESSEE SHERRI PARKER LEE SOFTBALL STADIUM

2" PLANT WATER TO CHP EQUIPMENT (TYPICAL)

LOCATE AND CONNECT TO EXISTING 2" PLANT WATER

THIRD CREEK STORAGE TANK

4" NG–HDPE

CONNECT TO EXISTING NATURAL GAS MAIN IN NEYLAND DRIVE RIGHT–OF–WAY (BY KUB)

3" NG–HDPE TO GENERATOR #2

STUB SERVICES FOR FUTURE GENSET (TYPICAL)

LOCATE AND CONNECT TO EXISTING 6" DIP MUNICIPAL WATER

DIGESTER No. 2

4" NATURAL GAS SERVICE LINE TO GENSETS

4" SSWR CONDENSATE DRAIN (TYP)

6" SSWR @ 1.00% MIN SLOPE

4" NATURAL GAS SERVICE LINE TO GENSETS

8"SSWR

FIRE HYDRANT

SSWR CLEANOUT (TYPICAL)

6" MUNICIPAL WATER SERVICE

3" NG–HDPE TO GENERATOR #1

CHP GENSETS. REFER TO SHEET C–1.

SSMH TOP=840.90 IE (N)=836.00 IE (S)=835.80

8" SSWR @ 1.00% MIN. SLOPE

SSMH TOP=833.30 IE (S)=824.72

SSMH TOP=830.29 IE (N)=820.49 IE (S)=820.39

D.H. SIGN

NEYLAND DRIVE

N59320O

NOTES:

1. ALL NEW PIPING SHOWN ON THIS PLAN TO BE INSTALLED UNDERGROUND UNLESS SPECIFICALLY INDICATED OTHERWISE.
2. REFER TO ELECTRICAL DRAWINGS FOR UNDERGROUND DUCTBANK.
3. GLYCOL PIPING BETWEEN THE MOISTURE REMOVAL SKID AND THE GLYCOL CHILLER IS NOT SHOWN FOR CLARITY. THE PIPING SHALL NOT IMPEDE VEHICULAR ACCESS TO THE PARTICULATE FILTER.

REV. NO.	DATE	DRWN	CHKD	REMARKS
1	10/17	EWB	TJN	ADDENDUM NO. 1

DESIGNED BY: T. NANGLE
DRAWN BY: C. ROBINSON
SHEET CHK'D BY: T. NANGLE
CROSS CHK'D BY: B. MALOY
APPROVED BY: J. OSGOOD
DATE: SEPTEMBER 2017

CDM Smith
1100 Marion Street, Suite 300
Knoxville, TN 37921
Tel: (865) 963-4300

KNOXVILLE UTILITIES BOARD
KNOXVILLE, TENNESSEE

KUWAHEE WASTEWATER TREATMENT PLANT
COMBINED HEAT AND POWER IMPROVEMENTS

YARD PIPING PLAN

PROJECT NO. 10561–212495
FILE NAME: C004STPL.DWG

SHEET NO.
C-4

30% SUBMITTAL - NOT FOR CONSTRUCTION

SECTION 00515B

OPERATIONS AND MAINTENANCE AGREEMENT

This **AGREEMENT,** made at Knoxville, Tennessee, this _____ day of _____, 2017, by and between **KNOXVILLE UTILITIES BOARD,** a municipal utility created by charter of the City of Knoxville, Tennessee, a municipal corporation, (hereinafter called "KUB"), which municipal agency is authorized to contract in its own name, and_____**,** a corporation created and existing under the laws of _____ (hereinafter called "OPERATOR").

W I T N E S S E T H

WHEREAS, KUB is an agency of a municipality which provides water, wastewater, natural gas, and electric utility services to customers located in and around the Knoxville, Tennessee and Knox County, Tennessee area; and

WHEREAS, under a Request for Proposal ("RFP"), KUB invited proposals for the design and construction, operation and maintenance of **the KUB Kuwahee Wastewater Treatment Plant Combined Heat and Power (CHP) Facility, Control Number: 952,** as called for in said RFP; and

WHEREAS, under the RFP, _____, submitted an original, qualified proposal in response to the RFP ("Proposal") dated _____that is the most responsive and best conforms to the specifications and needs of KUB, and such Proposal has been accepted by KUB for the performance of CHP Facility operations and maintenance; and

WHEREAS, a written contract for the subject design and construction portion of the project has been executed on_____, by and between KUB and _____ ("Construction Agreement"); and

WHEREAS, in accordance with the terms and conditions of the RFP and Construction Agreement 00515A paragraph 19 states that a written contract for the subject operations and maintenance portion of the project ("O&M Agreement") should be executed by and between KUB and_____, covering the operation and maintenance services described in the O&M Agreement, the submitted RFP and the _____Proposal; and

WHEREAS, this O&M Agreement (00515B) shall include the following documents in order of precedence:

1. This O&M Agreement; and
2. Operator's Proposal including any supplements and negotiations thereto, attached hereto as Attachment "A"; and
3. The RFP, including any Addenda or modifications, and any other KUB documents to include but not be limited to technical specifications, etc. attached hereto as Attachment "B".

(hereinafter referred to collectively as "Contract Documents").

In the event of a conflict between any of the above listed documents, which together comprise the O&M Agreement, the document with the first order of precedence above shall control.

SECTION 00515B

OPERATIONS AND MAINTENANCE AGREEMENT

NOW, THEREFORE, in consideration of the covenants and agreements herein contained to be performed by the parties hereto, and of the payments herein agreed to be made, it is agreed by the parties hereto as follows:

ARTICLE I. GENERAL TERMS AND CONDITIONS

1. **Term of O&M Agreement:** The initial term of the O&M Agreement shall be for a period of eight (8) years, beginning upon the successful final completion of the 00515A Construction Agreement ("Effective Date"). Upon written agreement of the parties, the term may be extended for up to one (1) additional four (4) year renewal term, for a maximum period of twelve (12) years.

If either party elects not to extend the Agreement for a subsequent renewal term, such party shall notify the other party in writing at least 180 days in advance of the expiration of the then active term, the O&M Agreement will terminate at the expiration of the then active term and shall not be extended for subsequent term(s).

The O&M Agreement is subject to earlier termination pursuant to Paragraph 2 below.

2. **Termination of Agreement:**

2.1 **Termination for Cause and Cure Notice:** KUB or Operator may terminate this Agreement for cause at any time by giving thirty (30) days written notice to the other party if the other party defaults on any material obligation. Prior to the issuance of the 30-day termination notice the defaulting party must be given written notice of the existence and nature of the default and allowed not more than 20 days to cure the default to the satisfaction of the other party.

2.2 **Contract Authority to Terminate:** KUB may immediately terminate this O&M Agreement (i) upon the bankruptcy of Operator, (ii) upon the occurrence of a Force Majeure event that is not remedied within 120 days of its initial occurrence or (iii) for any action(s) as specifically defined in the Contract Documents for immediate termination.

2.3 **Termination Without Cause:** KUB may terminate this O&M Agreement without cause by giving the Operator one hundred eighty (180) days written notice.

2.4 **Compensation during Last Billing Cycle:** In the event of a Termination as defined in this Paragraph 2, Operator shall be compensated for all completed work or portions thereof performed and invoiced in accordance with this agreement up to the effective date of any Termination.

2.5 **Surviving Termination:** Unless otherwise agreed to by both parties in writing, Operator's warranty obligations, record transfers, record keeping and auditing, pending financial transactions and clearings (third party or otherwise), backlogged maintenance or services unfulfilled, or other unfulfilled obligations, if any, shall survive Termination**.** After the effective date of Termination, Operator shall not be obligated to perform any of the Work or services that would have otherwise been required but for the Termination.

3. **Amendment of Agreement:** This O&M Agreement may only be amended by written agreement signed by authorized representatives of each party.

4. **Assignment of Agreement:** Operator may not assign its obligations under this O&M Agreement without providing KUB with 90-days prior written notice and thereafter KUB has given express written consent for such assignment, which consent shall not be unreasonably withheld. KUB may, at its sole discretion, require Operator to fully vet the potential assignee to assure KUB that such assignee has equal or greater capability of executing all terms and conditions of this O&M Agreement including but not limited to the full execution of the Work.

5. **Notifications:** Any notices required to be provided hereunder shall be provided in writing, unless verbal communication is expressly permitted or verbal communication is appropriate because of exigencies of time, in which case verbal communication shall be confirmed in writing at the earliest possible time. All notices shall be delivered or mailed to the addresses set forth below or to such other address as the parties may from time to time designate in writing:

If to KUB:

Knoxville Utilities Board
Attention: Michelle W. Wilson, Acting Procurement Manager
Mail Stop PC28
4505 Middlebrook Pike
Knoxville, Tennessee 37921-5599

If to Operator:

_____
_____
_____
_____

If mailed, the notices shall be deemed given three days after deposited, postage prepaid, in the United States Mail, certified mail, return receipt requested, or one day after paid deposit with a nationally recognized overnight delivery service using next day delivery.

6. **Insurance:** Reference RFP Appendix III, part G as accepted by Operator in its proposal. Operator shall not commence any service in connection with the O&M Agreement until it has obtained all of the following types of insurance and such insurance has been approved by KUB. (Worker's Compensation, Public Liability and Property Damage and Subcontractor's Liability and Property Damage as outlined in this section). Operator shall not allow any subcontractor to commence service on their subcontract until all similar insurance required of the subcontractor has been obtained and approved. All insurance policies shall be with insurers approved and admitted to do business in Tennessee. KUB shall be furnished proof of coverage of insurance by certificates of insurance

accompanying the contract documents and shall name KUB as an additional insured as respects commercial general liability and business automobile liability. Operator shall provide KUB a thirty (30) day cancellation notice in the event any insurance required by this O&M Agreement is canceled.

6.1 **Employer's Liability Insurance:** Operator shall secure and maintain during the term of the O&M Agreement, Employer's Liability Insurance with minimum limits of: $1,000,000 Bodily injury each accident $1,000,000 Disease policy limit.

6.2 **Worker's Compensation Insurance:** Operator shall secure and maintain during the term of the O&M Agreement, worker's compensation insurance for all of their employees connected with the work on this project and, in case any work is sublet, shall require the subcontractor similarly to provide worker's compensation insurance for all of the latter's employees unless such employees are covered by the protection afforded by the Operator. Such insurance shall comply fully with Tennessee Worker's Compensation Law. In case any class of employees engaged in hazardous work under this O&M Agreement at the site of the project is not protected under the Worker's Compensation Statute, Operator shall provide, and cause each Subcontractor to provide, adequate insurance satisfactory to KUB, for protection of their employees not otherwise protected.

6.3 **Commercial General Liability and Business Auto Liability:** Operator shall secure and maintain during the term of the O&M Agreement, comprehensive general liability and comprehensive automobile liability insurance which shall protect them from claims for damage for personal injury, including accidental death, as well as claims for property damages which may arise from operations under this O&M Agreement whether such operation be by themselves or by anyone directly or indirectly employed by them. The amount of such insurance shall be minimum as follows:

6.4	**General Liability**	
	Per Occurrence Limit	$2,000,000
	Products/Completed Operations Aggregate Limit	$2,000,000
	Fire Damage Legal Liability	$1,000,000
	Medical Expense	$5,000
6.5	**Automobile Liability**	$1,000,000 CSL *
		**Combined Single Limit*
6.6	**Uninsured/Underinsured Motorist**	$1,000,000
6.7	**Umbrella Liability(1)**	$5,000,000

(1) Provides $5,000,000 liability over and above: General Liability, Automobile Liability and Employer's Liability.

All policies of insurance referred to herein shall be written on an occurrence basis unless otherwise agreed to by KUB in writing.

7. **Indemnification:** Operator agrees to indemnify and hold harmless KUB its Commissioners, officers, agents and employees from and against any and all claims in whatever form (including cost and attorney's fees) for damages because of bodily injury, including death, at any time resulting there from, sustained by any person or persons or damage to property, including loss of use thereof, arising out of or in consequences of the performance under the O&M Agreement whether such injuries to persons or damage to property is due or claimed to be done due to the negligence of KUB, KUB's subcontractor, their agents or employees, except only such injury or damage as shall have been occasioned by the sole negligence of KUB In no way does this indemnification constitute a waiver by KUB of the defenses and limitations of liability available to it under the Governmental Tort Liability Act as codified in Tenn. Code Ann. §§29-20-101 et. seq.

8. **Damages to KUB Property**: The Operator shall be responsible and liable for any damages to property of KUB caused by its employees, or subcontractors, and will replace and make good such damages to the satisfaction of KUB. If the Operator fails to perform repairs in a timely manner, as determined by KUB, KUB will complete said repairs and subtract the cost of the repairs from the monies owed the Operator.

9. **Division of Funds:** The obligations of the OWNER hereunder are payable only from the revenues of the **Wastewater Division** of the Knoxville Utilities Board.

10. **Invoicing and Payment:** Invoices and payments shall be processed in accordance with the following requirements:

10.1 **Operator's Compensation:** During the term, KUB shall compensate Operator for the Work performed hereunder in accordance with the CHP Facility**,** Pricing, attached, to Operator's Proposal. Payment for all services performed under this O&M Agreement will be made at the rates listed unless amended by contract amendment. No additional payments will be made for items not listed.

10.2 **Invoice Timing, Format, and Submittal Address:** The Operator will provide KUB with a monthly invoice on or around the 15th of each month for the Work completed containing the information as agreed upon by KUB. The format of the invoice will be as proposed by the Operator and as agreed to by KUB's Representative. All invoices will be submitted as follows:

Knoxville Utilities Board
Mailstop: GS04
Attn: Accounts Payable
P.O. Box 51326
Knoxville, Tennessee 37950-1326

10.3 **Invoicing and Invoice Dispute Resolution Procedures:** KUB shall have five (5) days to do an independent evaluation of the billing to determine the accuracy of and finally

approve each invoice from the receipt date of the invoice. KUB shall then pay the Operator within thirty (30) days of each approved invoice, unless KUB disputes the invoice. KUB retains the right to do an independent evaluation of the billing to determine the accuracy thereof. KUB shall have the right to return to the Operator within the five (5) day approval period any invoice that is not correct and the payment of which it disputes (hereafter referred to as "Billing Dispute"). In the case of a Billing Dispute, KUB shall set forth in writing addressed to Contractor the exact nature of the dispute and its proposed solution. Operator will respond within ten (10) business days of receipt of said writing and include a proposed solution if different that the one suggested by KUB. KUB shall adhere to the same five (5) day evaluation and payment within thirty (30) days from approval for revised invoices submitted from Billing Disputes. The Operator may also resubmit an invoice for approved items for processing and work on resubmitting un-approved items separately. KUB shall have the right to modify or amend the format of the invoice as to customer information fields upon written notice to the Operator provided that Operator is not required to amend or change its standard "blank" invoicing form. For invoices returned to the Operator in the event of validated billing errors KUB reserves the right to charge the Operator $100.00 per invoice returned to cover the costs of KUB administrative time. Notwithstanding the foregoing, if KUB disputes less than the whole invoice, KUB shall timely pay the undisputed portion of the invoice and the disputed portion shall be subject to the procedure described in this Section 10.3.

10.4 **Pricing Inclusive of Fees and Adders:** The price to be paid to Operator by KUB for the Work as set forth in Article II. Paragraph 2.1 of this O&M Agreement includes all costs, overhead, and profit to the Operator in fulfillment of this Agreement and no other charges or fees shall be billed to KUB, except as specified herein. All taxes, fees, surcharges, training or other requirements of any jurisdiction concerned in the Work, which are in place at the time of the proposal, are included in the prices quoted. The Operator shall be solely responsible for any and all additional expenses, including taxes levied, reporting and/or testing requirements, incurred after award of this O&M Agreement, except as specified herein.

11. **Annual Inflation CPIU Pricing Adjustment:** After the initial year of the Agreement, and with KUB authorized written approval, pricing schedules may be adjusted once per calendar year effective on the anniversary date of the Agreement based on the previous month's "All Items" line item of the Consumer Price Index-Urban (CPI-U) data available for reference at www.bls.gov. If a CPIU adjustment is made, Operator will issue updated pricing sheets and said updated pricing sheets shall indicate the year period for the pricing to be in effect.

12. **Compliance with Laws, Rules, and Regulations:** The Operator shall comply with all state, federal and local laws and regulations (including but not limited to the Occupational Safety and Health Act, environmental and immigration laws and regulations, and all applicable codes and standards which govern the Work. The Operator shall have and maintain in force at all times and upon request shall furnish to the OWNER proof that it has all licenses that are required to do the Work. It shall be the Operator's responsibility to obtain permits and schedule for any items necessary to complete the work. The Operator agrees to maintain a drug and alcohol-testing program for all employees performing the Work under this Agreement and shall replace any such employee who refuses testing or fails a test immediately at the Operator's expense without impeding the progress of the Work. The Operator agrees to comply, and require all of its subcontractors and employees to comply, with the

terms and conditions of the KUB Firearms and Weapons Policy, as that policy may be amended from time to time and available on request, and agrees, immediately upon KUB's request, to remove from KUB's premises and the Work, any person who violates this policy and any firearms, ammunition or other weapons in their possession or under their control. Operator also agrees that all employees and subcontractors will comply with KUB Customer Service Policy and KUB's Tobacco-Use Policy, available on request.

13. **Safety Standards and Required Use of PPE:** Operator shall conform to the same safety standards as denoted in the Construction Agreement Specification 00700, Section 6.13 as excerpted below, with "Operator" substituted for the term "CONTRACTOR" and "KUB" substituted for "OWNER":

"6.13 *Safety and Protection*

A. CONTRACTOR shall be solely responsible for initiating, maintaining and supervising all safety precautions and programs in connection with the Work. CONTRACTOR shall take all necessary precautions for the safety of, and shall provide the necessary protection to prevent damage, injury or loss to:

1. all persons who may be affected by the Work;

2. all the Work and materials and equipment to be incorporated therein, whether in storage on or off the Site; and

3. other property at the Site or adjacent thereto, including trees, shrubs, lawns, walks, pavements, roadways, structures, utilities, and Underground Facilities not designated for removal, relocation, or replacement in the course of construction.

The presence on Site of OWNER, DESIGN ENGINEER and/or the Resident Project Representative in no way relieves CONTRACTOR of CONTRACTOR's safety obligations. In accordance with generally accepted construction practices, the CONTRACTOR will be solely and completely responsible for safety conditions at the Site, including but not limited to the safety of all persons and property during performance of the Work. This requirement will apply continuously throughout the performance of the Work and is not be limited to normal working hours.

B. CONTRACTOR shall comply with all applicable Laws and Regulations relating to the safety of persons or property, or to the protection of persons or property from damage, injury, or loss; and shall erect and maintain all necessary safeguards and shall comply with all mandatory PPE requirements for such safety and protection. Applicable Laws and Regulations governing the work include but are not limited to OHSA, TOSHA, NEC, ANSI, and NFPA. CONTRACTOR shall notify owners of adjacent property and of Underground Facilities and other utility owners when prosecution of the Work may affect

them, and shall cooperate with them in the protection, removal, relocation, and replacement of their property. All damage, injury, or loss to any property referred to in paragraph 6.13.A.2 or 6.13.A.3 caused, directly or indirectly, in whole or in part, by CONTRACTOR, any Subcontractor, Supplier, or any other individual or entity directly or indirectly employed by any of them to perform any of the Work, or anyone for whose acts any of them may be liable, shall be remedied by CONTRACTOR (except damage or loss attributable to the fault of Drawings or Specifications or to the sole acts or omissions of OWNER or DESIGN ENGINEER or DESIGN ENGINEER's Consultant, or anyone employed by any of them, or anyone for whose acts any of them may be liable, and not attributable, directly or indirectly, in whole or in part, to the fault or negligence of CONTRACTOR or any Subcontractor, Supplier, or other individual or entity directly or indirectly employed by any of them). CONTRACTOR's duties and responsibilities for safety and for protection of the Work shall continue until such time as all the Work is completed and OWNER has issued a notice to CONTRACTOR in accordance with paragraph 14.07.B that the Work is acceptable (except as otherwise expressly provided in connection with Substantial Completion).

C. CONTRACTOR shall comply with OWNER's separate requirement to have all persons on the work site wear at least a minimum of Personal Protective Equipment (PPE) conforming to the requirements listed in section (6.13.C.1) at all times and CONTRACTOR shall meet all PPE requirements listed in this section (6.13.C).

1. Minimum Required PPE (PPE): Minimum required PPE consists of the appropriate class reflective vest standard for the type of work under contract, American National Standards Institute (ANSI) approved safety glasses with side shields, American National Standards Institute (ANSI) approved hard hat and safety-toed boots which are over the ankle and a minimum of six inches high. In cases of conflict PPE required by regulatory agencies shall prevail otherwise Minimum required PPE shall be worn at all times.

2. Alternate or Additional PPE: Contractor shall perform a Job Hazard Analysis for each task of the contracted project. Contractor shall present a copy of the Job Hazard Analysis to OWNER for review or approval upon request. Contractor shall ensure all alternate or additional PPE identified in the Job Hazard Analysis is used as required and meets all of the conditions specified in Sections 6.13.B and 6.13.C.

3. Required use of PPE: The minimum PPE requirement extends to all work site personnel including but not limited to Contractor's workforce, supervision, suppliers, vendors, inspectors, truck drivers, equipment operators, rental company employees, guests, and subcontractors and any other personnel associated with the work who are present at the work site, and who are outside of an enclosed equipment cab, enclosed vehicle cab,

office trailer, toilet facility, or other designated area (6.13.C.4) which is not considered part of the work itself. Contractor shall direct all non-essential personnel and the general public to remain outside of the areas of the work site where work is in progress at all times.

4. Contractor may, at Contractor's discretion, designate and cordon off or otherwise clearly mark parking areas, break areas, and other non-work areas within the work site where PPE is not required. Such areas shall have unobstructed access for entry and exit of the worksite and be clear of the work in progress. The work in progress includes but is not limited to any area where work is partially complete, work has started, work is not finished, restoration is not finished, material storage and laydown areas, staging areas, and equipment.

5. Contractor Requirement to Stop Work: Contractor shall not allow work to continue if PPE is not available and not used by all persons associated with the work.

6. Authority of Owner to Stop Work and Clear the Work Site: Owner shall have the authority to enforce Contractor's use of KUB required PPE up to and including Owner or Owner's representative(s) authority to stop work and require Contractor's on-site supervision to require Contractor's workforce, supervision, suppliers, vendors, inspectors, truck drivers, equipment operators, rental company employees, guests, or subcontractors to don required PPE before resuming work. Failure of Contractor to comply with the PPE requirement shall be considered a breach of contract. Contractor shall not be allowed additional work days, monetary compensation, or time for completion of the project resulting from work stoppage due to inadequate PPE.

7. Maintenance of PPE: Contractor shall ensure that all PPE whether supplied by Contractor or supplied by others, being used on the work site meets all industry standard requirements and is in good working order at all times. PPE used by persons on the work site shall have no functional defects. PPE requiring calibration, testing, or certification shall have copies of the latest such calibration, testing, or certification available on site and such calibration, testing, or certification shall not be expired. Owner shall not be responsible for supplying PPE to Contractor.

8. Use as Designed: All PPE shall be used as designed. No part or parts of the PPE shall be altered or defeated in use. PPE shall be properly sized, fitted, and adjusted for each person.

14. **Dispute Resolution:** Any dispute related to this O&M Agreement that the parties are unable to resolve through informal high level discussion or negotiations shall be resolved by either party bringing a cause of action in a Knox County state court that possesses appropriate jurisdiction. Both parties waive any right to a jury trial and waive their rights to any punitive or extra-contractual damage claims. Nothing contained herein shall be interpreted to eliminate or limit the rights and protections afforded KUB as a municipal utility created pursuant to the Charter of the City of Knoxville, Tennessee, and the laws of the State of Tennessee.

15. **Recitals:** The recitals set forth above are hereby incorporated into and made a part of the O&M Agreement.

ARTICLE II. OPERATIONS TERMS AND CONDITIONS

1. **Acceptance of CHP Facility by Operator Upon Execution of Agreement:** Except as otherwise agreed by both parties in writing, and pursuant to Article I. Paragraph 1., **Term of Agreement**, herein, Operator fully accepts the KUB CHP Facility as fully functional, in full working order, with all equipment performing to specifications as manufactured, installed, tested, debugged, and commissioned as appropriate and in accordance with manufacturer's and construction contractor's standards and in accordance with the construction contract requirements. Operator's execution of this agreement is Operator's approval of the CHP Facility as completed and ready for service and execution of Operator's responsibilities under this agreement.

The Operator has thoroughly examined and carefully studied the Site of the Work and the Contract Documents and has identified any and all conflicts, errors, ambiguities, and discrepancies to KUB in writing and the written resolution thereof by KUB is acceptable to the Operator; and the Operator has determined that it can deliver a fully complete maintenance and operations program which is functional for its intended purpose within the Contract Price structure and in accordance with the Contract Documents and this Agreement.

2. **Proposed Scope and Pricing:** Unless amended by both parties in writing, Operator's scope of work under this agreement shall be governed in part by Operator's _____ proposal, _____. Based on the CHP Facility performance and use profile over time parties reserve the right to negotiate amendment(s) adjusting the Operator's scope of work, maintenance intervals, and pricing.

2.1 **General**

2.1.1 **Site Visits.** Site visits shall be made as determined by the contractor.

2.1.2 **Emergency Site Visit Rates.** When an emergency site visit occurs, all such services shall be delivered by Operator at no additional cost to KUB. Such rate includes travel, minimum of one trained service tech, loaded service truck including standard tooling, diagnostic equipment, laptop with access to internet, cell phone, common spare parts, and consumables.

Emergency site visits are subject to response time as noted herein. Response time is defined as the time from initiation of the emergency site visit notification to arrival on site.

2.1.3 Operator's service technician shall be based within a 4-hour driving distance from the CHP Facility.

2.1.4 **Location of CHP Facility:** The sole location for Operator's work under this agreement is:

Kuwahee WWTP
2015 Neyland Drive
Knoxville, TN 37916

3. **Monitoring:** Facility monitoring shall be provided 24/7/365 by means acceptable to KUB.

4. **Scope and Pricing for Corrective Maintenance:** Per Appendix IX, Contract Pricing.

5. **Hours of Operation:** Other than for scheduled maintenance, pre-approved by KUB, the intended hours of operation for the **KWWTP CHP Facility** are 24/7/365. KUB in its sole discretion reserves the right to close the facility at any time for reasons including but not limited to: Equipment malfunction, Force Majeure, Public Safety, Security, Interruption or reduction of supply utilities including curtailments (Natural Gas, Electric, Communications services), Street Access, or any other reason which prevents the normal and intended operation of the facility. Operator and KUB shall make every reasonable effort to keep the **KWWTP CHP Facility** open for use.

5.1 **Extended Closure of KWWTP CHP Facility:** Should there be an occurrence of an extended full closure or partial closure and such closure is deemed by either party to adversely affect itself and all or portions of the Operator's scope of work are not needed or may be modified to better suit the affected party then parties shall agree to negotiate an amendment, either permanent or temporary to this agreement as appropriate.

5.2 **CHP Facility Operations Monitoring and Notifications:** Operator shall provide 24/7/365 monitoring service. The monitoring service shall be sufficient to provide indication that all systems are functioning within design parameters and that all safety systems are in place and functioning at any time. The CHP monitoring system shall provide email and text notifications within fifteen (15) minutes and shutdowns in a timely manner such that safety is maximized and damage to assets or loss of gas is minimized.

6. **Target Power Production:** The Contractor is required to provide a minimum of 11,250,000 kWh per year from the combined output of the two engines. Heat generation performance will not need to be continually analyzed, once performance is demonstrated to the acceptance of KUB.

6.1 **Annual Liquidated Damage:** If the power production isn't met for a specific year, the Contractor's O&M payment will be deducted by the cost of the additional electricity KUB had to purchase. The cost per kWh used in this liquidated damage will be equal to 110% of KUB's energy charge rate. The current KUB energy charge rate is 6.66 cents per kWh; therefore, the current liquidated damage would be 7.326 cents per kWh. The liquidated damage price per kWh will change with the KUB energy charge rate.

6.2 **Contract Term Liquidated Damage:** KUB will be penalized by TVA if it does not produce an average of 11,250,000 kwh per year of power. If at the end of the first 8-year O&M contract term, the Contractor has produced less than 90,000,000 kWh (11,250,000 kWh per year over 8 years), KUB will reduce the final payment by $0.49 for every 100 kW's not produced. For example, if after 8 years, the Contractor only produces 89,000,000 kWh, the final payment will be reduced by $4,900.

7. **Major Equipment Upgrades, Additions, Changes, or Removals:** Parties acknowledge that the scope of work contained herein and Operators pricing schedules have been built around the installed configuration and anticipated use profile at the time of initiation of this agreement. It is anticipated that a major engine overhaul will occur after 60,000 operating hours, which will occur within the 8-year O&M contract for each engine. The cost of a major engine overhaul, for each engine, should be included in the price of the 8-year O&M contract.

8. **Unrelated Future Site Changes or Additional Use of Site by KUB:** KUB reserves the sole right to modify or use the existing site parcel or portions thereof at its own expense for other purposes associated with or not associated with the existing CHP Facility. This includes but is not limited to development of additional facilities, other facilities, use for materials storage, stockpiling materials and parking. Any additional use of the real property or existing CHP Facility shall not interfere with the use of the existing CHP Facility as intended under this agreement and shall be in full compliance with any laws, permits, rules, and codes for which KUB shall be fully responsible for.

9. **Advertising and Publicity:** Operator shall not engage in any advertising or publicity regarding the KUB CHP Facility without the express written consent of KUB. This includes but is not limited to informational or pricing related signage on or around the property, print, radio, and television media interfacing, social media, electronic or website based media, and use in Operator's own

printed or electronic sales media. Operator may initiate written request to use photos and references of the KUB site in Operator's own advertising literature or for industry seminars or conferences and the request may be approved upon review by KUB with such approval not to be unreasonably withheld. KUB in its sole discretion may produce and publish and distribute its own advertising and publicize the CHP Facility as it sees fit.

10. **Site Communications:**

10.1 **Internet Connection(s) and Phone:** At Operator's expense, Operator shall obtain and maintain the required internet service(s) and phone as needed on site

10.2 **Contact List**

KUB Main Office	524-2911, Fax 594-7667
Mailing Address:	P.O. Box 59017, Knoxville, TN 37950-9017
Shipping Address:	445 S. Gay St., Knoxville, TN 37902-1109

Emergency Telephone Numbers

Tennessee One-Call System (locate before digging)	811
KUB Electric (repair, other problems)	558-2600
KUB Gas (repair, other problems)	558-2205
KUB Water & Waste Water (repair, other problems)	558-2114
KUB Streetlights & Private Lights (outage, repair)	558-2560
BellSouth Telecommunications (repair)	557-9000 ext. 9873
Comcast Cable TV (repair)	524-1840
CSX Railroad (locate, repair)	523-0263
Electrical Inspector - City of Knoxville	215-2998
Electrical Inspector - State of Tennessee	558-2509
Fire, Police, Sheriff, or State Patrol (emergency only)	911

10.3 **Reporting and Monitoring:** Operator will deliver to KUB the following data including but not limited to:

- Power Generation (Monthly-each generator)
- Biogas and natural gas Volume of usage (Monthly-each generator)
- Station level availability – each generator
- Equipment performance parameters including runtime hours – each generator
- Listing of maintenance activities and tasks – each generator

If the data is not available real-time through SCADA or a web-based interface, then the data must be delivered in an electronic format at least monthly to the primary contact as named by KUB.

10.4 **Status Meetings:** KUB and Operator will hold quarterly status meetings for the first year of service at the KUB facility located at 4505 Middlebrook Pike, Knoxville, TN 37921. The date and time of the meetings shall be mutually agreed upon by KUB and Operator. The frequency of the status meetings will change to semi-annually for the second and remaining years of the contract.

11. **Site Utilities:**

11.1 **Electric Utility Service:** KUB shall be responsible for paying the Electric Utility usage bill and for performing repairs, maintenance or modifications at and upstream of the pad mounted transformer. Notwithstanding the foregoing, Operator is responsible for damages it incurs in accordance with paragraph I.8. herein. Operator shall make every effort to ensure electric systems remain in good working order, controls are appropriately programmed, and shall notify KUB as appropriate such that electric consumption is not wasted.

11.2 **Gas Utility Service:** KUB shall be responsible for paying the Gas Utility usage bill and for performing repairs, maintenance or modifications at and upstream of the gas regulator station. Notwithstanding the foregoing, Operator is responsible for damages it incurs in accordance with paragraph I.8. herein. Operator shall make every effort to ensure gas systems remain in good working order, and shall notify KUB as appropriate such that gas consumption is not wasted.

11.3 **Water Utility Service:** KUB shall be responsible for paying the Water Utility usage bill and for performing repairs, maintenance or modifications at and upstream of the water meter. Notwithstanding the foregoing, Operator is responsible for damages it incurs in accordance with paragraph I.8. herein. Operator shall make every effort to ensure the water system remains in good working order, and shall notify KUB as appropriate such that water consumption is not wasted.

12. **Safeties and Shutdowns:** Operator shall maintain functionality of and not defeat or bypass any safety nor defeat or bypass any shutdown equipment during normal unattended operations without the express permission of the Original Equipment Manufacture ("OEM") and informing KUB. Bypassing safety or shutdown or exceeding operating parameters whether for operations or for testing shall not be done unless in accordance with manufacturer's guidelines. Operator must inform KUB of any intended unmanned operation of the site when safety or shutdowns are bypassed or compromised. KUB reserves the right to close the site or independently temporarily start or man the site if operation is needed with compromised safeties or shutdowns. This includes but is not limited to failure in part or whole by the control system or remote communications.

ARTICLE III. MAINTENANCE TERMS AND CONDITIONS

1. **Equipment to be serviced:**
   - Gas Compressors
   - Moisture Removal
   - H2S Removal
   - Siloxane Removal
   - Gas Meters

- Engine Generators
- Hot Water Circulation System
- All other miscellaneous components

2. **Specific Maintenance to be Performed by Operator:**

2.1 **Preventative Required Maintenance by Operator:** Operator shall perform all equipment vendor recommended Preventative Required Maintenance for all originally installed CHP equipment including but not limited to equipment listed above, in accordance with the approved O&M Manual. Preventative Maintenance documentation must be submitted to KUB annually and made available upon request. The Operator will be required to operate and maintain the facility in compliance with best industry practices.

2.2 **Corrective Maintenance:** This is defined as maintenance performed to identify, isolate, and rectify a fault so that the failed equipment, machine, or system can be restored to an operational condition within the tolerances or limits established for in-service operations. Any corrective maintenance required due to neglected preventative maintenance or improper operation is the responsibility of the Operator.

3. **Operator's Warranty on its Work:** Operator shall warrant its materials and labor for all service and maintenance work that it or its subcontractors perform. The time period and terms and conditions for the Materials and Labor warranty shall be the greater of: a) The manufacturer's standard parts warranty as applicable to the part or system being serviced or replaced or b) One year, whichever is greater. Notwithstanding the foregoing, the Materials and Labor warranty shall expire upon replacement or further related repairs to the warrantied parts and a new warranty related to the new repair shall start. This warranty shall apply to any parts or labor supplied under this agreement for which KUB has made compensation to Operator including but not limited to the regular scheduled Option 1 services or other specific work as agreed upon by KUB and Operator.

Operator warrants and guarantees to KUB all services and products to be provided and that work and products will be of good quality, and in conformance with the Contract Documents. All work not conforming to these standards may be considered defective by KUB and shall be reworked at the Operator's expense.

4. **Knowledge Transfer**: KUB and its authorized representatives shall, at all times, have access to and be permitted to observe, inspect and review all Work performed hereunder and any relevant written records of the Operator related to the Operator's Work subject to the execution of any appropriate non-disclosure agreement. Said non-disclosure agreement is enforceable to the extent permitted by Tennessee's Open Records Law. The Operator is solely responsible for the standard and quality of the Work done by it and its employees or agents under this agreement and is doing the Work as an independent contractor. In the interest of both parties KUB shall be allowed to shadow the Operator's Technician without interference to Operator in order to learn the basics and be able to assist in remotely communicating particulars with Operator. This should be helpful preceding Operator's scheduled and unscheduled site visits.

4.1 KUB technician to shadow Operator during planned service visits (72 hours notice).

4.2 KUB technician to shadow Operator during corrective maintenance (with 8 hours notice), if available.

4.3 KUB technician to shadow Operator during emergency response, if available.

ARTICLE IV. ADDITIONAL TERMS AND CONDITIONS

1. **Operator Furnishes all Labor, Tools and Materials:** Unless otherwise stated in the RFP, Proposal, or this Agreement, during the term of this Agreement the Operator shall furnish all supervision, labor, tools, equipment, consumables and transportation necessary for the timely and accurate completion of the Work. Operator further represents that it is and will remain throughout the term of this O&M Agreement licensed in Tennessee to perform its obligations under this O&M Agreement.

2. **Ownership of Real Property and Physical Assets:** Unless otherwise stated in separate agreement between KUB and Third Party, KUB is the sole owner of the real estate, its improvements and all physical assets associated with the site or equipment.

3. **Nondiscrimination:** KUB is an equal opportunity employer and as such requires that its suppliers not discriminate on the basis of race, color, sex, religion, or ethnic origin. Operator acknowledges this provision. KUB encourages the use of small business, minority, and women owned business enterprises.

4. **Title VI:** Operator shall comply with the requirements of all federal statutes relating to nondiscrimination, including but not limited to, Title VI of the Civil Rights Act of 1964, which prohibits discrimination on the basis of race, color, sex, or national origin ("Title VI"). No person on the grounds of race, color, or national origin shall be excluded from participation in, denied benefits of, or be otherwise subject to discrimination in the performance of the proposal. Operator shall upon request, show proof of such nondiscrimination.

5. **Choice of Law:** This Agreement shall be governed by and construed with the laws and regulations of the State of Tennessee, cities, counties, townships and other municipalities within the KUB service area.

6. **Statutory Disqualification:** Operator represents to the best of their knowledge that neither it nor any of its officers, directors, shareholders, members or partners has been convicted or plead guilty or nolo contendere to any violation of the Sherman Anti-Trust Act, mail fraud, or other state, or federal criminal violation in connection with a contract let by the State of Tennessee or any other state or any political subdivision of the State of Tennessee.

7. **Conflict of Interest:** Operator represents to the best of their knowledge that no commissioner or officer of KUB or other persons whose duty is to vote for, let out, oversee, or in any manner supervise any work on any contract for KUB has a "direct interest" in the Operator or in the work which is subject to this agreement.

8. **Copyright, Trademark, Service Mark, or Patent Infringement:**

A. Operator shall, at its own expense, be entitled to and shall have the duty to defend any suit which may be brought against KUB to the extent that it is based on a claim that the products or services furnished infringe a copyright, trademark, service mark, or patent. Operator shall further indemnify and hold harmless KUB against any award of damages and costs made against KUB by a final judgment or a court of last resort in any such suit.

B. If the products or services furnished under this agreement are likely to, or do become, the subject of such a claim of infringement, then without diminishing Operator's obligation to satisfy the contract, Operator may at its option and expense:

1) Procure for KUB the right to continue using the product or services
2) Replace of modify the alleged infringing products or services with other equally suitable products or services that are satisfactorily to KUB, so that they become non-infringing.
3) Remove the products or discontinue the services and cancel any future charges pertaining thereto.
4) Provided, however, that Operator will not exercise options b.i., or b.ii. are impractical.

9. **Property of KUB:** Any materials, including reports, computer programs, and other deliverables created under the Contract Documents are the sole property of KUB. The Operator is not entitled to a patent or copyright on those materials and may not transfer the patent or copyright to anyone else. The Operator shall not use or release these materials without the prior written consent of KUB.

10. **Force Majeure:** No party shall have any liability to the other hereunder by reason of any delay or failure to perform any obligation or covenant if the delay or failure to perform is occasioned by *force majeure,* meaning any act of God, storm, fire, casualty, flood, earthquake, embargo, civil disturbance, acts of terrorism, governmental regulation, or causes similar nature beyond its control.

11. **Possession of Weapons:**

The Operator agrees to comply, and require all of its subcontractors and employees to comply, with the terms and conditions of the KUB Firearms and Weapons Policy, as that policy may be amended from time to time and available on request, and agrees, immediately upon KUB's request, to remove from

KUB's premises and the Work, any person who violates this policy and any firearms, ammunition or other weapons in their possession or under their control.

12. **KUB Customer Service Policy:** Operator also agrees that all employees and subcontractors will comply with KUB Customer Service Policy, available on request.

13. **Means and Methods:** The Operator shall be solely responsible for and shall have control over the means, methods, techniques and procedures for doing the Work.

14. **Independent Contractor:** The Operator is an independent contractor and neither Operator nor any of its employees shall be deemed to be agents or employees of KUB.

15. **Operator's Workforce:** The Operator agrees to maintain a professional workforce at all times. Operator and its Subcontractors shall maintain current documentation related to the training, certification, and legal status (if applicable) of its employees and shall make documentation available to KUB for review upon request. The Operator shall enforce good order and discipline among their employees and any other persons performing the Work. Operator employees performing the Work shall present a neat appearance and shall treat KUB's employees and customers in a polite manner. The Operator shall not employ unfit persons or persons not skilled in the specific tasks of the Work. The Operator, at his expense, shall promptly replace employees or Subcontractors who do not meet these minimum requirements without impeding the progress of the Work.

16. **Search:** All persons, packages, and vehicles on KUB property are subject to being searched. Routine unannounced searches by KUB may be conducted. Refusal by Operator, its employees, Subcontractors and agents to submit to random searches will be grounds for removal from KUB property and prohibited access in the future. All vehicles leaving the KUB facilities are subject to being searched.

17. **Traffic:** Traffic regulations are to be observed at all times. Proper traffic control procedures and City of Knoxville permits, etc. are to be followed.

18. **Sub-Contracting:**

18.1 Use of Subcontractors**:** Operator may only use sub-contractors that have received prior written approval by KUB.

18.2 Operator's Responsibility for Subcontractors: The Operator shall be fully responsible to KUB for all acts and omissions of the Subcontractors performing or furnishing any of the Work just as the Operator is responsible for Operator's own acts and omissions. Operator shall be solely responsible for coordinating the Work with any Subcontractors performing any of the Work under direct or indirect contract with Operator.

18.3 Subcontractor Communications: Operator shall require all Subcontractors performing or furnishing any Work to communicate with KUB, through Operator.

18.4 Subcontract Agreement: All Work performed for Operator by a Subcontractor will be pursuant to an appropriate agreement between Operator and Subcontractor which specifically binds the Subcontractor to the applicable terms and conditions of the Contract Documents for the benefit of KUB. Operator shall have its own representative on site or otherwise available to communicate with the KUB while work is being performed by Subcontractors.

19. **Relationship of Parties:** The Operator shall be an independent contractor. Neither party shall be deemed to be the employee or agent of the other party to the Agreement.

20. **Drug and Alcohol Testing:** The Operator agrees to maintain a drug and alcohol-testing program for all employees performing the Work under this Agreement and shall replace any such employee who refuses testing or fails a test immediately at the Operator's expense without impeding the progress of the Work.

21. **Default by Operator:** (Including but not limited to) Should the Operator:

(a) fail or refuse to begin or, once begun, to diligently proceed with the Work after execution of agreement; or

(b) assign or sublet this Agreement or any part thereof without prior written consent of KUB; or

(c) violate any provisions of this Agreement; or

(d) allow any officer, director, shareholder or partner of Operator to have any relationship with KUB which would be violative of the conflict of interest provisions of T.C.A. § 6-54-107 and/or §12-4-101.

then in any of such events, KUB may immediately take one or more of the following actions: (I) terminate this Agreement; (ii) require the Operator to discontinue the Work immediately; (iii) sue the Operator for damages suffered by KUB, including consequential damages, and (iv) seek and obtain whatever equitable relief by way of injunction or specific performance that may be available. Seeking any one or more of the above remedies will not be a waiver of any other remedy available to KUB. The Operator shall pay the cost and expense of KUB's enforcement of its rights hereunder, including but not limited to reasonable attorney's fees.

22. **Tax Liability:** Unless otherwise agreed by both parties or as stated herein, the Operator is responsible for any and all tax liabilities, which may be imposed upon the Work, or any materials used therein under the sales or use tax laws of the State of Tennessee. It shall be the Operator's responsibility to determine if taxes are due on the Work or materials installed under this Agreement.

23. **Drafter of Agreement:** Neither party, nor its respective counsel, shall be deemed the drafter of this Agreement, and all provisions of this Agreement and the Contract Documents shall be construed in accordance with the fair meaning, and not strictly construed for or against either party.

24. **KUB Records:**

24.1 **Records Property of KUB**: Any KUB furnished records shall remain the sole property of KUB. Operator shall not sell, loan or otherwise convey KUB records to any other party without the written permission of KUB. Should it appear that the work intended, or any of the matters relative thereto are not sufficiently detailed or explained by the records furnished the Operator, the Operator shall request from KUB such further information as may be necessary and the Operator shall conform to the same as a part of this O&M Agreement. If additional information is available KUB will provide a copy of the information to the Operator. Upon termination of this O&M Agreement, the Operator shall return the original set and all copies of records as were provided by KUB.

24.2 **Record Retention:** Unless otherwise specified herein, Operator agrees to maintain records to support all work performed and all items of work billed to KUB and shall retain such records for a period of three (3) years after work has been paid for by KUB. The Operator shall keep such records at its corporate headquarters location. At the end of each one-year term of the Agreement and upon KUB request the Contractor shall deliver a copy of all records to KUB's Representative. KUB may from time to time request specific records for examination or auditing purposes. Operator shall comply with such requests in a timely manner.

25. **KUB's Right to Self Perform:** KUB reserves the right to use its own forces to perform the Work for its own purposes at any time. Nothing herein shall be deemed to require KUB to guarantee a minimum amount of work to the Operator.

26. **Operator's and Subcontractor's Vehicles:** Each of the Operator's vehicles utilized in the performance of the Work shall be clearly identified with the Operator's name, address and phone number on each side.

27. **Operator's and Subcontractor's Personnel:** Operator personnel shall be proficiently trained on the procedures, techniques, communicative skills and record keeping required for performance of the Work. Each of the Operator's personnel will be in contact with the public and will display appropriate professional appearance and demeanor. Each of the Operator's personnel will have a name badge or other recognizable insignia visibly displayed on their person. The Operator agrees to take appropriate corrective action in any situation where an Operator's employee does not display professionalism or courtesy during interaction with the public, governmental authorities, other contractors, KUB personnel, etc. KUB reserves the right to require the Operator to cease the use of persons for performance under this Agreement who in the opinion of KUB are not professional or courteous in their contact with the public or doesn't demonstrate proficiency in performing the Work.

28. **Coordination with Third Parties:** As necessary, KUB may be required to coordinate the priority and timing of the Work to meet KUB's obligations to cooperate with

governmental authorities, private industry, and others in meeting the needs of its customers and the public in a timely and unobtrusive manner. KUB's Representative will communicate the requirements of such coordination to the Operator as required to facilitate completion of the Work in the time frame required. Operator may be required to perform Work on weekends or off peak hours to minimize the impact on KUB customers.

29. **Right of Inspection:** Any right of inspection hereby given KUB does not give or imply the right to control the method or manner in which the Work shall be performed and gives KUB no control over the Operator's employees or agents in the performance of their work under this Agreement. Under no circumstances shall any of the Operator's employees or agents be considered employees or agents of KUB, for any purposes whatsoever.

30. **Headings:** Headings provided in this Agreement are solely for the convenience of the parties, and shall not in any manner affect the meaning or interpretation of this Agreement.

31. **Complete Agreement:** This Agreement constitutes the final, complete, and entire written agreement of the parties and supersedes all previous communications, representations, agreements, promises, statements, proposals and specifications, whether written or oral, by or between the parties.

32. **KUB and Operator are Independent:** KUB and the Contractor hereby certify that they are independent parties, acting as independent contractors and independent employers. Nothing herein shall be construed to create a partnership, joint venture, or agency relationship between KUB and the Contractor, and neither party shall have the authority to bind the other party in any respect.

33. **Third Party Rights:** Nothing contained in this Agreement shall be construed as creating rights in third parties and the parties hereby express their intent that this O&M Agreement is not intended to benefit in any manner third parties.

34. **Tort Liability Act:** Nothing contained in this Agreement or in bond or in any certificate or policy of insurance or in any provision of indemnity shall be construed to constitute a waiver by KUB of any provision, substantive or procedural, of the Tennessee Governmental Tort Liability Act, as amended, or of any other provision of federal, state, or local law affording KUB protection from or limitation of tort or other liability.

35. **Invalidity, Illegality or Unenforceability:** The invalidity, illegality or unenforceability of any provision of this Agreement, or the occurrence of any event rendering any portion of this Agreement void, shall in no way affect the validity or enforceability of any other portion or provision of this Agreement. Any void provision shall be deemed severed from this Agreement and the Agreement shall be construed and enforced as if this Agreement did not contain the particular provision held to be void. The parties agree to amend this Agreement if necessary to replace any stricken provision with a provision that comes as close as possible to the intent of the stricken provision.

SECTION 00515B

OPERATIONS AND MAINTENANCE AGREEMENT

36. **Definitions:** The defined terms used in this O&M Agreement shall have the same meanings as set forth in the KUB RFP, unless otherwise indicated in this O&M Agreement.

IN WITNESS THEREOF, the parties have executed this instrument in duplicate, effective the date indicated in the first paragraph of this Agreement.

Knoxville Utilities Board (KUB)

Attest:

_____
(Witness)

By:_____
Michelle W. Wilson

Its: Acting Procurement Manager

_____
(Company Name)

Attest:

_____
(Witness)

By:_____
(Signature)

Print Name _____

Its:_____
(Print Title)

SECTION 00515B
OPERATIONS AND MAINTENANCE AGREEMENT

Exceptions to Agreement (Section 00515B)

The Proposer hereby declares that the following list states any and all variations from and exception to the requirements of the Agreement and that, otherwise, it is the intent of the Proposer that the work be performed in strict accordance with the Contract Documents. The Proposer acknowledges that the listing of any exception, which is unacceptable to KUB, will have the effect of voiding the proposal.

SECTION 00515B

OPERATIONS AND MAINTENANCE AGREEMENT

The Proposer hereby accepts the Agreement (00515B) described herein except for the list of exceptions described immediately above.

Date:_____ Signed:_____

Title:_____

End of Agreement

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SECTION 01465
EQUIPMENT TESTING AND STARTUP

PART 1 GENERAL

1.01 SCOPE OF WORK

A. Provide a competent field services technician of the manufacturers of all equipment furnished under Divisions 13, 15, and 16 to supervise installation, adjustment, initial operation and testing, performance testing, final acceptance testing and startup of the equipment.

B. Perform specified equipment field performance tests, final acceptance tests and startup services.

1.02 RELATED WORK

A. Operation and Maintenance Data is included in Section 01730.

B. Performance and acceptance testing and startup requirements are included in the respective sections of Divisions 13, 15, and 16.

1.03 SUBMITTALS

A. Submit name, address and resume of proposed field services technicians at least 30 days in advance of the need for such services.

B. Submit, in accordance with Section 01300, detailed testing procedures for shop tests, field performance tests and final acceptance tests as specified in the various equipment sections. Submittals shall include the following:

1. Test procedures shall be submitted at least 30 days in advance of the proposed test dates and shall include at least the following information:
    a. Name, classification, model and serial number of equipment to be tested, including reference to specifications section number and title.
    b. Testing schedule of proposed dates and times for testing.
    c. Summary of power, lighting, chemical, water, sludge, gas, etc., needs and identification of who will provide them.
    d. Outline specific assignment of the responsibilities of the Contractor and manufacturers' factory representatives or field service personnel.
    e. Detailed description of step-by-step testing requirements, with reference to appropriate standardized testing procedures and laboratory analyses by established technical organizations (e.g., ASTM, WPCF Standard Methods, etc).
    f. Samples of forms to be used to collect and record test data and to present tabulated test results.

2. Copies of test reports upon completion of specified shop, performance and acceptance tests. Test reports shall incorporate the information provided in the test procedures submittals and modified to reflect actual conduct of the tests and the following additional information:
    a. Copy of all test data sheets and results of lab analyses.
    b. Summary comparison of specified test and performance requirements vs actual test results.

c. Should actual test results fail to meet specified test and performance requirements, describe action to be taken prior to re-testing the equipment.

3. Copies of the manufacturer's field service technician's report summarizing the results of his/her initial inspection, operation, adjustment and pre-tests. The report shall include detailed descriptions and tabulations of the points inspected, tests and adjustments made, quantitative results obtained, suggestions for precautions to be taken to ensure proper maintenance, and the equipment supplier's Certificate of Installation in the format specified herein.

1.04 REFERENCE STANDARDS

A. American Water Works Association (AWWA)

B. ASTM International

C. Water Environment Federation (WEF)

D. Standard Methods for the Examination of Water and Wastewater (Latest Revision)

E. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.05 QUALITY ASSURANCE

A. Field service technicians shall be competent and experienced in the proper installation, adjustment, operation, testing and startup of the equipment and systems being installed.

B. Manufacturers' sales and marketing personnel will not be accepted as field service technicians unless they can prove their qualifications.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 PRELIMINARY REQUIREMENTS

A. After installation of the equipment has been completed and the equipment is presumably ready for operation, before it is operated by others, the manufacturer's field service technician shall inspect, operate, test and adjust the equipment. The inspection shall include at least the following points where applicable:

1. Soundness (without crack or otherwise damaged parts).

2. Completeness in all details, as specified and required.

3. Correctness of setting, alignment and relative arrangement of various parts.

4. Adequacy and correctness of packing, sealing and lubricants.

B. The operation, testing and adjustment shall be as required to prove that the equipment has been left in proper condition for satisfactory operation under the conditions specified.

C. Upon completion of this work, the manufacturer's field service technician shall submit a signed report of the results of his/her inspection, operation, adjustments and tests.

3.02 WITNESS REQUIREMENTS

A. Shop tests or factory tests may be witnessed by the Owner and/or Owner's representatives, as required by the various equipment specifications.

B. Field performance and acceptance tests shall be performed in the presence of the Owner, the Owner's designed personnel and/or Owner's representatives.

3.03 STARTUP AND ACCEPTANCE OF EQUIPMENT AND SYSTEMS

A. General Requirements

1. Successfully execute the step-by-step procedure of startup, normal operation, shutdown, and performance demonstration specified herein.

2. The startup and performance demonstration shall be successfully executed prior to Substantial Completion and acceptance by the Owner of the facility and its related systems.

3. All performance tests and inspections shall be scheduled at least 10 working days in advance or as otherwise specified with the Owner and the Engineer. All performance tests and inspections shall be conducted during the work week of Monday through Friday, unless otherwise specified.

B. Preparation for Startup

1. Upon completion of the facility and all its related systems, all piping and tanks shall be flushed with potable water and hydraulically checked for leaks, cracks, and defects. They shall also be disinfected in accordance with AWWA Standard where required for potable water use.

2. All mechanical and electrical equipment shall be checked to ensure that it is in good working order and properly connected. Preliminary run-ins of the various pumps, blowers, and other remaining equipment shall be made. All systems shall be cleaned and purged as required. All sumps, tanks, basins, chambers, pump wells and pipelines which are hydraulically checked shall be drained and returned to their original condition once the water testing is complete.

3. All instruments and controls shall be calibrated through their full range. All other adjustments required for proper operation of all instrumentation and control equipment shall be made.

4. Perform all other tasks needed for preparing and conditioning the facility for proper operation.

5. No testing or equipment operation shall take place until it has been verified by the Engineer that all specified safety equipment has been installed and is in good working order.

6. No testing or equipment operation shall take place until it has been verified by the Engineer that all lubricants, tools, maintenance equipment, spare parts and approved equipment operation and maintenance manuals have been furnished as specified.

C. Facilities Startup

1. Startup period shall not begin until all new facilities and equipment have been tested as specified and are ready for operation. The Owner shall receive spare parts, safety equipment, tools and maintenance equipment, lubricants, approved operation and maintenance data and the specified operation and maintenance instruction prior to the startup. All valve tagging shall also be complete prior to this startup.

2. Demonstrate a seven consecutive 24-hour day period of successful operation of the facility as a prerequisite of Substantial Completion and Acceptance.

3. In the event of failure to demonstrate satisfactory performance of the facility on the first or any subsequent attempt, all necessary alterations, adjustments, repairs and replacements shall be made. When the facility is again ready for operation, it shall be brought on line and a new test shall be started. This procedure shall be repeated as often as necessary until the facility has operated continuously to the satisfaction of the Owner and Engineer, for the specified duration.

4. The Owner will furnish all operating personnel (other than vendor's or subcontractor's service personnel) needed to operate equipment during the final test period; however, said personnel will perform their duties under Contractor's direct supervision. Until performance tests are completed and units and systems are accepted by the Owner as substantially complete, the Contractor shall be fully responsible for the operation and maintenance of all new facilities.

5. The Owner will provide all necessary chemicals and electricity. However, the Contractor shall provide all necessary personnel of the various construction trades, i.e., electricians, plumbers, etc, and field service personnel of the major equipment suppliers on an 8 hour per day basis at the facilities and on a 24 hour per day basis locally during the startup period. Major equipment suppliers shall include, but not be limited to, the following:
   a. Instrumentation and Control Equipment
   b. All Pumping Equipment
   c. Gas Treatment Equipment
   d. Generator Equipment

6. Do not, at any time, allow the facility to be operated in a manner which subjects equipment to conditions that are more severe than the maximum allowable operating conditions for which the equipment was designed.

EQUIPMENT SUPPLIER'S CERTIFICATE OF INSTALLATION

Owner _____

Project _____

Contract No. _____

EQUIPMENT SPECIFICATION SECTION _____

EQUIPMENT DESCRIPTION _____

I _____, Authorized representative of
(Print Name)

_____
(Print Manufacturer's Name)

hereby CERTIFY that _____
(Print equipment name and model with serial no.)

_____

installed for the subject project has (have) been installed in a satisfactory manner, has (have) been tested and adjusted, and is (are) ready for final acceptance testing and operation on :

Date_____

Time_____

CERTIFIED BY: _____
(Signature of Manufacturer's Representative)

Date:_____

END OF SECTION

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SECTION 13239
COMBINED HEAT AND POWER SYSTEM

PART 1 GENERAL

1.01 SCOPE OF WORK

A. This Section covers the requirements of the Combined Heat and Power (CHP) system being provided.

B. Furnish all detailed design, labor, materials, equipment and incidentals, and install, operate and maintain two digester gas/natural gas-fueled, engine-driven generator sets. These units shall be CHP units with paralleling equipment and appurtenances and required supporting systems for the Knoxville Utility Board (KUB). Each CHP system shall include but not be limited to the items specified in Article 1.04, "COMBINED HEAT AND POWER; QUANTITATIVE SYSTEM DESCRIPTION", in this Section.

C. The Contractor shall require the manufacturers or their representatives to furnish installation assistance, start-up operation, field test, operator training, and operation and maintenance manuals.

D. Contractor shall coordinate with the Owner (KUB) to provide all necessary performance, operating and fuel data to apply for the necessary emissions permits.

E. Contractor shall coordinate with the Owner (KUB) to provide all necessary performance, operating and fuel data to apply to the natural gas and electrical utilities and comply with their restrictions.

F. The engine driven generators shall be synchronous and have nominal prime power ratings (site rated) from 840 kW to 1,200 kW with 480 Volt, three phase, 60 Hertz output. The alternator shall be four wire, wye connected, neutral grounded, complete with excitation system and controls.

G. The engine shall have a dual fuel blending system, and will be able to adjust the fuel ratio from 100% biogas to 100% natural gas, without the shutting down the engine, and without a de-rate of the electrical output of the system.

H. Provide all project work in conformance with the National, State and Local building, and associated mechanical, plumbing, fire, and energy codes, ordinances, and regulations applicable to the project work area.

I. Work included under the "Scope of Work" of this CHP Section shall include but not be limited to the following work items:

1. Labor and material to design, procure, furnish, deliver, unload, install, test and place in satisfactory operation, the CHP system described, herein.

2. Equipment, tools and services necessary to maintain and service the specified equipment.

3. Provide services and systems including any incidental work not shown, or not specified but which can reasonably be inferred as belonging to the various systems and necessary in good practice to provide complete and fully operational systems.

J. Provide 480V Switchgear, controls and appurtenances.

K. It shall be the Contractor's responsibility to ensure the performance and design intent of the complete system as specified herein and as shown on the contract drawings. This responsibility includes, but is not limited to, providing the following:

1. The specified system exhaust emissions

2. The TVA required kWH's of generated electricity per year over the 12-year (8 plus 4) life of their contract.

3. The specified electrical efficiency and thermal performances

4. The specified radiated and discharged noise levels:

    a. Exhaust system

    b. Engine and turbocharger cooling radiator fans

    c. Engine noise, outside of the unit enclosure

5. The specified total exhaust flow pressure drop or equal sum of component pressure drops does not exceed the engine manufacturer's recommended maximum.

6. The specified structural loading

7. The specified unit availability

8. Labor and material for the manufacturer's recommended maintenance items and service intervals to maintain 90% availability for the duration of the eight (8) year agreement period and four (4) year extension option with KUB.

9. The systems described in this Section and on the drawings are preliminary to delineate scope and are for bidding purposes only. This Contractor shall confirm the performance of the equivalent system components working as a complete system during the design phase.

1.02 RELATED WORK

A. The areas of work, which are related to this Section are shown in the following Sections:

1. Specification Sections

Number	Title
13240	Packaged Biogas Treatment System
13306	I&C Application Engineering Services
13311	I&C Digital Hardware and Software
13321	I&C Fiber Optic Cabling and Equipment
13330	I&C Control Panels, Enclosures and Panel Equipment
13340	Instruments
15505	HVAC – Piping
15541	Centrifugal Pumps
16000	Electrical - General Provisions
16110	Raceways, Boxes Fittings and Supports
16120	Wires and Cables
16191	Miscellaneous Equipment
16470	Panelboards
16600	Underground System
16660	Grounding System
16950	Electrical System Testing and Settings

2. Drawing Number

Number	Title
C-1	Combined Heat and Power Equipment Layout Plan
C-2	National Fire Protection Association Area Classification Plan
C-3	Combined Heat and Power Equipment Topography and Drainage Plan
C-4	Yard Piping Plan
C-5	Railroad Zone of Influence Plan and Profiles I
C-6	Railroad Zone of Influence Plan and Profiles II
E-1	Electrical Site Plan
E-2	One Line Power Diagram Modifications
ED-1	Electrical Details
APPENDIX A	KUB Standard Details
APPENDIX B	KUB Standard Details
I-1	Instrumentation Legend
I-2	P&ID H2S and Moisture Removal
I-3	P&ID Siloxane Removal
I-4	P&ID Engine Generator 1
I-5	P&ID Engine Generator 2

1.03 ENGINEERING SERVICES

A. Detailed engineering services shall be provided by the Contractor, the Contractor shall retain a licensed professional engineer to perform the services. The engineer shall be licensed at the time the work is done and in the State in which the project is located. If the State issues discipline specific licenses, the engineer shall be licensed in the applicable discipline. In addition, the engineer shall be experienced in the type of work being provided.

B. Execute all engineering work according to the applicable regulations for professional engineers, to include signing, sealing and dating documents. When project document submittals are required by a professional engineer, also include a copy of the current wallet card or wall certificate indicating the date of license expiration.

1.04 COMBINED HEAT AND POWER; QUANTITATIVE SYSTEM DESCRIPTION

A. The Combined Heat and Power (CHP) system shall include but is not limited to the following major components, which are specified in the Section:

1. Two (2) gas engine-driven synchronous generators or alternators, each with:
   a. One (1) on-container fuel system piping and appurtenances fuel train for conditioned digester gas.
   b. One (1) on-container fuel system piping and appurtenances fuel train for natural gas.
   c. One (1) factory-installed system to automatically blend both digester and natural gas fuels.
   d. Fuel carburetion system (for digester gas and natural gas), which may be part of a fuel/air control system.
   e. Automatic control valves, including the secondary fuel pressure regulator and solenoid valve.
   f. One (1) engine lube oil makeup tank with level regulator on a separate stand.
   g. One (1) heat recovery system to recover all available thermal energy in the jacket water (high-temperature cooling circuit) and exhaust at full load into a plant hot water loop, assuming a minimum hot water loop temperature to the CHP system of 160 degrees F, and a maximum hot water temperature leaving the CHP system of 180 degrees F. A bypass duct for the exhaust and “critical grade” exhaust silencer shall be provided with each unit.
   h. One (1) dual-circuit radiator or two (2) radiators to reject the engine water jacket, lubricating oil and turbocharger after-coolers (one high-temperature cooling circuit); the second-stage turbocharger after-coolers (one low-temperature cooling circuit). All radiators shall have a low noise, 67 dBA maximum sound pressure level at 25feet distance.
   i. One (1) back-fire relief valve on the exhaust system.
   j. One (1) electric motor or engine-driven circulation pump for the “high-temperature” cooling glycol/water (serving the engine water jacket, oil cooler and first-stage intercooler).
   k. One (1) electric motor or engine-driven circulation pump for the “low-temperature” cooling glycol/water (serving the second-stage intercooler).
   l. Two (2) expansion tanks with level sensors, sight glasses, and drain valves for the two-closed-circuit engine water jacket an intercooler cooling loops.
   m. Engine/generator structural/acoustical container base with a vibration isolator system between the engine/generator unit support rails and each foundation. Each engine/generator shall have its own foundation, isolated and poured separately and designed as an inertia block. Each containerized engine/generator shall be thermally and acoustically insulated to limit radiated unit noise to 65 db(A) at a distance of 32.5 feet (10 meters).
   n. Container mounted, factory-piping, wiring and valves.
   o. Engine mounted electric starter with battery and battery charger.
   p. One (1) prewired control panel including: paralleling/synchronizing equipment, power distribution for all ancillary equipment (including waste heat dump radiators, heat

exchangers and emission control equipment), control equipment for all ancillary equipment, engine control equipment, generator control equipment, and communication equipment. This Contractor shall be responsible for all interconnecting wiring and field testing of wiring not provided by the unit manufacturer.

q. Two Emergency Shut-off Valves, one for each gas train.

r. Two flame arrestor assemblies one for each gas train, each consisting of a flame arrestor and thermic valve. These shall be provided according to their manufacturer's recommendations.

2. Supplementary structural steel to support the exhaust gas heat recovery heat exchangers, radiators and vertical stacks.

3. High temperature cooling water (HTCW) pumps, low temperature cooling water pumps (LTCW), container piping, air separators, expansion tanks and accessories associated with reclaiming the engine heat for process heating and cooling the engine.

4. Miscellaneous accessories as specified hereunder.

5. Thermal and acoustical insulation for piping, duct systems and equipment.

6. Vibration and expansion joints for piping, duct systems and rotating equipment.

7. A complete monitoring and control system consisting of PLCs and HMI's with all necessary programming and graphic development.

8. Communication to the SCADA system using the Allen-Bradley, or equivalent Ethernet IP protocol.

9. Services of a manufacturer's representative.

B. The engine controls shall be panel mounted NEMA 1A steel cabinet integral to the container. The system and components shall be assembled, tested, and shipped by the engine manufacturer or his authorized factory representative. Engine power and control panels shall be in a small electrical compartment at one end of each of the containers.

C. The engine generator shall be manufactured by Caterpillar Inc., Manheim, Germany distributed by Carolina Cat or GE Jenbacher, Jenbach, Austria, distributed by Nixon Power. No equals will be considered for this equipment. The minimum acceptable nominal output shall be 840 kW, the maximum acceptable output shall be 1,200 kW. Units offered at ratings in excess of their published ratings are not acceptable and will not be approved.

1.05 COMBINED HEAT AND POWER; PERFORMANCE AND OPERATIONAL SYSTEM DESCRIPTION

A. Furnish all labor, materials, and equipment to install, place in operation, and field test two containerized internal combustion engine generator units and required supporting systems.

B. Engines shall be capable of being fueled by digester gas, natural gas, or a blend of the two. Engine/generators shall be nominally rated from 840 kW to 1,200 kW burning digester gas, as shown on the Drawings and as specified herein. Each engine generator shall have the capability

to be operated between the ranges of 50% to 100% load, and can fluctuate the composition of the fuel between 100% biogas and 100% natural gas, without shutting down or incur a resulting power output de-rate.

C. Each engine generator shall have the ability to be operated solely on natural gas fuel, without any de-rate on the power output, when the Packaged Biogas Treatment system specified in Section 13240 is offline for maintenance.

D. All equipment and controls specified in this Section shall be new and be considered part of the engine generator package. The Contractor shall be responsible for furnishing the package in its entirety as specified herein and shown on the Drawings.

E. External piping and wiring connections to the engine generator set shall be furnished and installed under other related sections. The engine generator package shall be complete in all respects and shall include all equipment and controls necessary for a fully operational cogeneration system.

F. Treated biogas shall be delivered to the internal combustion engines through the Packaged Biogas Treatment as described in Section 13240 and the engines shall be designed to operate based on the gas quality listed therein. The internal combustion engine generator system manufacturer or supplier shall review the design and performance requirements of the biogas conditioning and compression system and certify that the design of the system meets or exceeds the biogas properties required for successful engine operation and said certification shall be submitted with the bid documents. The internal combustion engine generator system manufacturer or supplier shall furnish a pressure regulator as part of the fuel gas train to ensure adequate delivery pressure to the engine.

G. The engine generator systems shall be configured to generate power for the facility in parallel with utility supplied power. Each internal combustion engine generator system shall consist of a gas engine, synchronous generator, sufficient quantity of lifting lugs to allow for safe rigging of the container onto its equipment pad, control system, and all other incidental equipment/systems to comprise for a fully functional and operational system.

H. Provide a two-year Factory Warranty as described within this Section.

I. The entire system, including the engine controls, engine and exhaust heat exchangers, intercooler, natural gas train, digester gas train, battery charger, and electrical equipment shall be the responsibility of this Contractor. The system and components shall be assembled, tested, and shipped by the engine manufacturer or his authorized factory representative.

J. The engine manufacturer shall supply all testing apparatus, labor, and laboratory services as required to perform all required field exhaust air emission testing to satisfactory demonstrate to the Owner and Engineer that the actual exhaust air emissions from the engines are in compliance with the emission limits defined under paragraph 1.06 B (9) of this Section. The engine manufacturer shall submit his exhaust air emission test protocol to the Engineer for approval prior to conducting any field testing. Should the field exhaust air emission testing reveal that the engines are in non-conformance with the emission limits defined under paragraph 1.06 B (9), the engine manufacturer shall supply all materials, labor, and equipment to install the necessary corrective actions and measures to modify the engine exhaust and fuel systems to bring the engines exhaust air emissions into compliance with this Specification.

Once corrective actions and measures are completed, the engine manufacturer shall perform additional field exhaust air emission testing to demonstrate compliance with this Specification.

1.06 SUBMITTALS

A. Submit in accordance with Section 01300 the following:

1. A performance affidavit is required for the equipment specified in this section and shall include the following:
   a. Generator Output - kW, power factor (PF), voltage and rpm.
   b. Brake Mean Effective Pressure (BMEP) at rated load.
   c. Recommended service intervals including but not limited to oil changes, top and bottom overhauls, and valve adjustments.
   d. Required digester gas and natural gas inlet pressures.
   e. Energy balance calculations.

2. Shop drawings, catalog cuts, internal wiring schematics and other materials required to completely describe the systems and equipment being furnished.

3. Assembly drawings with identification, description and dimensions for each separately installed sub-assembly or piece of equipment and associated piping and electrical connection schematics.

4. Scaled electronic drawings in AutoCAD 2016 format which include equipment elevations and side views, enclosure floor plan, overall footprint details and dimensions. The electronic drawings shall also be provided on a CD-ROM.

5. Equipment base drawings indicating the size and location of bolt holes for anchorage, and location of conduit stub-ups.
   a. Details of anchorage of the equipment to the foundation including anchor bolt type, size, material, embedment depth, and minimum edge distance.
   b. Summary of maximum vertical and horizontal reactions at each anchor bolt considering all applicable loads and load combinations.

6. Performance specifications of all items of equipment.

7. Control panel layout drawings showing interior and exterior views, dimensions, paint finish specifications and component bill of materials.

8. Complete electrical, instrumentation, control and wiring diagrams in sufficient detail to allow installation of instrumentation and controls and electrical components. Additionally, provide the requested PLC and HMI files as listed below. Specifically, the following is required:
   a. Complete instrumentation loop drawings and control schematics, presented in conformance with ISA Bulletin S5.1, latest edition and NFPA 79, latest edition.
   b. Complete electrical circuit schematics, including all generator control, alarms and power to motors, accessories, instruments, etc. Schematics shall include all termination points in each control panel. All wiring shall be identified by numbers and every termination point shall be assigned a number. Termination point number (including wire number) shall appear on the schematics for each wiring termination shown.

c. Complete external electrical interconnection diagrams for wiring between control panels and engine terminal boxes.
d. Complete PLC memory map for "points" that will be monitored by the SCADA system. List shall be in Excel format and coordinated with the KUB.
e. Complete printout set of all HMI graphics that will be provided as part of the control system for the engine generator and accessory systems.
f. Complete memory map of all signals required by the generator control system that must be provided by the SCADA system. Vendor shall coordinate signal needs with the KUB.

9. Details of the proposed battery charger and starting battery, including cold cranking amps and ampere hour rating.

10. Information on the proposed jacket water treatment including Material Safety Data Sheets.

11. Details of the paralleling system generator control panel and requirements of the local electrical utility for paralleling operation, and as required for the system proposed.

12. Details of the jacket water heater and jacket water treatment.

13. The generator set shall meet NSPS 40 CFR 60 Subpart JJJJ for Biogas and Natural gas applications.

14. Backpressure analysis to ensure the pressure drop of the exhaust system and components does not exceed the engine maximum allowable backpressure. Analysis shall be conducted by the Contractor, with the engine supplier providing the component backpressures for the equipment within their scope.

15. Contractor shall furnish a 3rd party testing firm to conduct a frequency band noise analysis for the proposed generator set showing separate analyses for the following:
    a. Engine exhaust noise and for engine mechanical noise inside the container, in dbA
    b. Engine exhaust noise outside, in dbA, at a distance of 3 ft, 50 ft, and at the nearest property line, from the outlet of the stack
    c. Radiator fan noise, in dbA, at a distance of 3 ft, 50 ft, and at the nearest property line, from the radiator
    d. Standard sound power level data sheet for the factory test to be performed on the engine/generator unit and radiator(s) during their testing phase
    e. The above data shall be collected and measured at 3 ft and 50 ft distances from each stack's and radiator's the outdoor design location. This data will be used to generate a baseline noise level before the CHP system is operated.
    f. The above data shall be collected and measured at the nearest property line from each stack's and radiator's outdoor design location. This data will be used to generate a baseline noise level before the CHP system is operated.
    g. This baseline data will be used as the target noise levels for the installed CHP systems.
    h. Sound testing shall be made with both engine/generators operating at 100% load.
    i. KUB reserves the right to witness the testing and will be given at least 7 calendar days' notice of the test.

16. Description of and reasons for any deviations from the specification as written.

17. Sample test data sheet for the factory test to be performed on the unit and a sample field test data sheet.

18. Manufacturer's certified shop test record of the engine driven generator unit performed in accordance with Paragraph 2.08. The final test record shall confirm the generator set performance as specified in this Section.

19. Draft copy of the warranty specified in Paragraph 1.10.

20. Certificate of Compliance for Seismic Design of Non-Structural Components and Systems in accordance with ASCE 7, Section 13 and the IBC, for the generator assembly and accessory components attached to the generator assembly, demonstrating that the equipment and its mounting system and anchorage have been tested or analyzed to withstand specified seismic demands.

21. Submit for review a drawing indicating locations of all anchor bolts or other points of attachment and a table indicating the vertical (upward and downward) and horizontal (inward and outward) reactions in kips at each point of attachment for all individual load components (including, but not limited to, dead, live, snow, ice, collateral, wind, and seismic loads) and for all required load combinations for allowable stress design per the 2012 International Building Code, and, by reference, the International Building Code and ASCE/SEI 7. Reactions shall be vertical and horizontal only. No bending moments will be allowed at the individual points of attachment.

B. Design Data

1. Submit design data for engine, generator, exhaust and accessories in format indicated in Paragraphs B2 through B10 (For rated kW capacity).

2. Fuel consumption for digester gas at 550 BTU / scf (LHV) and 650 BTU/ scf (HHV) at 50 percent, 75 percent and 100 percent of rated load.

3. Fuel consumption for natural gas at 1000 BTU/ scf at 50 percent, 75 percent and 100 percent of rated load.

4. Engine Data
   a. Manufacturer
   b. Model
   c. Number and arrangement of cylinders
   d. RPM
   e. Bore x stroke
   f. Maximum power at rated rpm
   g. BMEP at rated kW (including any parasitic loads and generator efficiency)
   h. Piston speed, fpm
   i. Make and model of governor
   j. Make and model of over-speed shutdown device
   k. Maximum allowable engine exhaust back pressure (inches H_2O)
   l. Engine cold cranking
   m. Method of operation and control sequences for blending natural and digester gas for engine operation.

n. The allowable range of proportions for blending natural and digester gas for engine operation.

5. Generator Data
   a. Manufacturer
   b. Model
   c. RPM
   d. Rated KVA (Prime)
   e. Rated KW (Prime)
   f. Voltage
   g. Temperature rise above 104 degrees F ambient
      1) Stator by thermometer degrees F
      2) Field by resistance degrees F
      3) Class of insulation degrees F

6. Generator efficiency including excitation losses and at 80 percent PF
   a. Full load percent
   b. Three-quarters load percent
   c. Fifty load percent

7. Guaranteed fuel consumption rates for both digester gas (at 600 BTU/CF) and natural gas (at 1000 BTU/CF):
   a. Full load, scfm
   b. Three-quarters load, scfm
   c. Fifty percent, scfm

8. Generator unit and accessories
   a. Weight of container mounted unit
   b. Overall length
   c. Overall width
   d. Overall height
   e. Exhaust pipe size
   f. Overall length, width, height and weight of waste heat dump radiators

9. Target Engine Exhaust Emissions with one engine operating on digester biogas:
   a. At full load with wet exhaust gas flow at 11,056 lbs/hr:

NOx	0.6 grams/BHP-hr or less
CO	3.00 grams/BHP-hr or less
PM	0.15 grams/BHP-hr or less
NMHC	0.20 grams/BHP-hr or less
NMNEHC	0.20 grams/BHP-hr or less
VOC	0.2 grams/BHP-hr or less

   b. Provide maximum values and gas flow at 50% and 75% load.

10. Heat Recovery Equipment data, guaranteed heat recovery rates at loads varying from full to 50% load:
    a. Manufacturer
    b. Model

c. Thermal Energy Available at varying load
   1) Full load
   2) Three-quarters load
   3) Fifty percent
d. Weight of any skid mounted unit not incorporated into the container.
e. Overall length
f. Overall width
g. Overall height
h. Connection sizes

11. Air flow required for combustion and ventilation based upon inlet air temperature of 102 degrees F.

12. Heat rejected to lubricating oil and intercooler.

13. Pressure drops of process/heating fluid-side of the de-coupling heat exchangers and Exhaust-Gas heat exchangers at their design flows.

14. Furnish four copies of the manufacturers certified shop test record of the complete engine driven generator unit. The final test record shall confirm the generator set performance required in Paragraph 2.01 below.

15. Furnish four copies of the certified field exhaust air emission tests.

C. In addition, the following shall be submitted with the shop drawings:

1. Elementary diagrams of the engine/generator control panel and remote devices.

2. Engine/generator control panel layout and material lists of components and detailed written sequence of operation.

3. Paralleling / Synchronization equipment layout and material lists of components and detailed written sequence of operation.

4. Foundation drawings, indicating size and location of anchor bolts and seismic restraints

5. Complete details of the main circuit breaker and auxiliary circuit breaker showing location, dimensions, ratings, and enclosure details.

1.07 REFERENCE STANDARDS

A. Design, manufacture and assembly of elements of the equipment herein specified shall be in accordance with but not limited to published standards of the following, as applicable:

1. American Gear Manufacturers Association (AGMA)

2. American Institute of Steel Construction (AISC)

3. American Iron and Steel Institute (AISI)

4. American National Standards Institute (ANSI)

5. American Petroleum Institute (API)
6. American Society of Mechanical Engineers (ASME)
7. ASTM International (ASTM)
8. American Welding Society (AWS)
9. American Bearing Manufacturers Association (ABMA)
10. British Standards Institution (BS)
11. Canadian Standards Association (CSA)
12. Deutsches Institut Fuer Normung (DIN) (German Institute for Standards)
13. Factory Mutual Engineering and Research Corp. (FM)
14. Institute of Electrical and Electronics Engineers (IEEE)
15. International Society of Automation (ISA)
16. International Standards Organization (ISO)
17. National Electrical Code (NEC)
18. National Electrical Manufacturers Association (NEMA)
19. National Fire Protection Association (NFPA)
20. Occupational Safety and Health Administration (OSHA)
21. Society of Automotive Engineers (SAE)
22. Society for Protective Coatings (SSPC)
23. Underwriters Laboratories, Inc. (UL)

B. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.08 QUALITY ASSURANCE

A. The engine-generator sets shall be the standard product, as modified by these specifications, of a manufacturer authorized distributor regularly engaged in the production of this type of equipment and having satisfactory experience in supplying units as herein specified. The units to be furnished shall be built from components which have proven compatibility, reliability and are coordinated and prototype tested to operate as a unit. The units shall be designed, constructed, delivered, field tested and operated in accordance with the best practices and methods. A factory trained and certified service provider for the engine shall provide engine

servicing and maintenance and maintain a permanent organization and supply of spare parts in place at the time of the bid within 120 miles of the project site.

B. The units shall be designed and installed in accordance with NFPA 37, Standard for Use and Installation of stationary Combustion Engines and Gas Turbines, except as modified by these Specifications.

C. All mechanical equipment shall be designed and built for continuous, prime power service at any and all points within the specified range of operation without overheating or excessive vibration or strain, and to require only that degree of maintenance generally accepted as applicable to the specific type of equipment required. All parts and components shall be designed and built for interchangeability so that replacement parts may be installed without any additional fitting or machining.

D. Components of mechanical and electrical equipment shall be the products of manufacturers who can produce evidence of their ability to promptly furnish all interchangeable replacement parts as may be needed at any time within the expected life of the equipment.

E. The manufacturer shall have suitable testing facilities adequate for performing the shop tests and inspections specified herein. Submit a description of the manufacturer's testing facilities. The descriptive matter shall contain illustrative photographs, drawings and such other matter as may be requested.

1.09 MAINTENANCE

A. The engine manufacturer’s recommended maintenance for the eight-year plus four-year contract period shall be performed by the Contractor per the separate Operations and Maintenance Agreement provided in the Request for Proposal.

1.10 WARRANTY

A. Furnish a written two-year warranty from the equipment manufacturer, written to the Owner. This warranty shall cover all equipment furnished under this Section. This equipment shall operate as a prime power unit, continuously, for at least 7,884 hours per year (availability: 90% of 8760 hours per year). The warranty shall extend from the date of acceptance of the equipment and shall include all parts, labor, and transportation for replacing any defective components of the equipment as furnished.

1.11 UNIT PERFORMANCE

A. The steady state voltage regulation shall be within plus or minus 1.0 percent from zero load to full-rated load. Upon application of a 15 percent load or removal of a 10 percent load in one step, the recovery to steady state operation shall be within ten seconds in accordance with ISO 8528-5.

B. Stable or steady state operation is defined as parallel operation with the frequency variation not exceeding plus/minus 0.25 percent (0.15 Hz) and voltage variation plus or minus one percent of their mean value for constant load from zero load to full rated load. A rheostat shall provide a minimum of plus or minus five percent voltage adjustment from rated voltage.

C. Unit Performance shall be no less than the following:

1.	Min. Gross Electrical Output	840 kW
2.	Design Electrical Efficiency, min	36% based on HHV of fuel
3.	Fuel Input to CHP	7.8 - 9.6 MMBtu/hr HHV
4.	Recoverable Heat by CHP, MMBtu/hr	3.9 MMBtu/hr HHV
5.	Design Thermal Efficiency, min	40% HHV
6.	Design Combined Efficiency, min	80% HHV for 50 to 100% of operating capacity

1.12 PROJECT/SITE REQUIREMENTS

A. The engine generator is to be installed as an outdoor unit within a container. The container shall have ventilation fans and automatic temperature controls to limit the maximum summertime temperature in the facility. All equipment provided under this section and intended for installation with the container shall be designed for an ambient temperature of 102 degrees F. The altitude at the project site will not be in excess of 642 feet above sea level.

B. All structures, supports, and anchors for the generator unit shall be designed for all gravity loads, dynamic loads, and seismic forces and shall conform to all applicable requirements of the State Building Code.

PART 2 PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

A. The complete gas engine generator system shall be capable of the following performance when rated at the following conditions:

1. Altitude - Approximately 642 ft above sea level.

2. Ambient Temperature Ranges:
   a. Average high: 88° F
   b. Average low: 27° F
   c. Maximum high: 102° F
   d. Minimum low: -20° F

3. Fuel-Each Engine shall be fully capable of operating on digester gas, utility delivered natural gas, or a blended mixture of the two. Operation of the fuel blending shall be automatic, not requiring operator assistance, and shall be able to operate from 100% biogas to 100% natural gas without requiring engine shutdown. The engine shall have the same rated electrical output on 100% biogas and 100% natural gas fuel scenarios (no electrical output de-rate due to fuel type).
   a. Sewage sludge digester gas with particulate matter down to 3-micron size removed, supersaturated moisture removed and with a high heating value (HHV) of 600 BTU per scf. Conditioned biogas shall be delivered to the engines from the Packaged

Biogas Treatment System having the properties listed in Section 13240. Digester gas pressure at inlet to engine gas regulator shall be no higher than 5 psig.

4. Performance
   a. Operation - Continuous (7,884 hours/year; 90% availability), under full (100 percent) load

5. Output
   a. Nominal 1,680 to 2,400 kW minimum using digester gas; electrical power at 480 volts, 60 Hertz, 3 phase with PF of 0.8 minimum.

6. Raw Engine Air Emissions with engines operating on digester biogas as specified in paragraph 1.06.B.9.

7. Acoustics
   a. Each containerized engine generator system shall not exceed an air-borne or radiated noise level of 65 db(A) at a distance of 32.5 feet (10 meters) from the container.
   b. The table below shows the allowable sound pressure level after treating the engine exhaust (reference 20 micro pascals per octave band) and includes the dBA at 1 meter.

	Octave Band Center Frequency Sound Pressure Level								
Noise Source	63	125	250	500	1000	2000	4000	8000	Sum Level dBA
Exhaust Noise with Attenuation dB (linear)	89	91	83	86	87	86	83	75	92 dBA

   c. Equipment supplier shall provide actual data for the equipment submitted. If the exhaust does not meet the required criteria after the sound attenuation treatment, and the noise level of the equipment is found to be the cause, the equipment supplier shall be responsible for the modifications required to correct the condition.

2.02 EFFICIENCY GUARANTEE

A. The engine generator manufacturer shall guarantee that, at the time of start-up, each engine/generator will achieve the thermal and electrical efficiencies submitted for this particular project and approved by the Engineer. This guarantee includes efficiencies at 100%, 75% and 50% engine/generator loads burning digester and natural gas. If any engine/generator unit fails to achieve its corresponding guaranteed efficiency, as submitted and approved, the manufacturer will rebate the KUB. This rebate shall be based on the revenue difference between the electricity generated at the actual efficiency and the submitted and approved efficiency level. The actual efficiencies will be based on the full-load operation of the engine/generator during the field testing period using digester gas. The rebate will be determined at the time of the testing based on the deficient amount of electricity generated at full-load operation for 7,884 hours per year for a period of twelve (12) years at a rate of $0.07/kWh.

2.03 FUEL GAS SYSTEM

A. Design

1. The fuel gas system will consist of both a digester gas service complete with fuel conditioning and a utility grade natural gas supply. The engines shall be designed to operate on a blend of digester gas and natural gas, with digester gas being the primary fuel source. The engine system manufacturer shall supply dual fuel gas trains to allow the system to operate on both. Dual fuel blending shall be automatic, not requiring operator assistance.

2. The natural gas delivery system shall consist of an electric shutoff valve equipped with status position contact (closed or open) and a pressure regulator. Downstream of the gas delivery system shall be a normally closed dual electric shutdown valve and a metering valve. The system shall be controlled by the engine control panel.

3. Both digester gas and natural gas services shall include a flame arrester assembly on each individual fuel supply.

4. All operations described as Digester Gas shall be fully applicable to natural gas. On a loss of digester gas for any reason, the engine shall be able to automatically switch to natural gas operation with no operator action required.

5. The necessary connecting piping from the digester gas treatment system connection to the engine shall be furnished and installed by the Contractor. Furnish for installation in the gas supply piping, a 2-in diameter gas pressure gage with a scale of 0 to 30-in of water complete with petcock, an electric (DC) solenoid operated shut-off valve, a low gas supply pressure switch, a Y-type dry fuel strainer, and a State Building Code approved flexible connector to the engine fuel supply connection.

6. For all loading conditions, the control panel shall continuously adjust the position of the supply valves to ensure steady operation at the demanded loading.

7. All parts of the fuel system shall meet the approval of, and be installed in complete compliance with, all applicable local, State and Federal codes, laws and regulations.

B. Normal Operation

1. Normal operation will be for engines to operate at full load, or to meet the electrical demands on the KWWTP power loop it is feeding into, whichever is lesser. This operation will be fueled primarily by a biogas, with supplemental natural gas blended in to achieve full load.

2. If digester gas booster discharge pressure is within the normal pressure range of 1.0-3.0 psig and engine-generator start is initiated; the digester gas solenoid valve and the common normally closed dual solenoid shutdown valve will open. Engine-generator will then crank, start and run and automatically synchronize with utility power. Upon a shutdown command the digester gas solenoid valve will close, shutting down the engine and disconnecting the paralleling breaker from the utility.

3. The amount of natural gas added will be determined by the shortage of biogas to operate the engine at full load (or to meet its loop's power demand). If the digester gas supply pressure dips below the set point of 1.0 psig, conveying that the engine demand exceeds the fuel supply, natural gas will be added to keep the engine operating at full load. Conversely, if the biogas header pressure exceeds the set point of 3.0 psig, the fuel supply exceeds the engine demand and the natural gas added to the fuel supply decreases.

C. Natural Gas Only Option

1. If treated biogas is not available, such as when the gas conditioning system is offline, the engines shall be able to fire using natural gas as the sole fuel. As biogas becomes available again, the engine will start blending biogas per the process described in the "Normal Operation" paragraph above.

2.04 EXHAUST SYSTEM

A. Miscellaneous Equipment

1. Hearing Protection
   a. Contractor shall provide ten circumaural hearing protection devices MSA Noisefoe Mark IV ear muffs or equal shall be furnished for the protection of operating personnel. Provide with high impact plastic window type cabinet, suitable for wall mounting.

2.05 AUTOMATIC OIL LEVEL REGULATOR AND TANK

A. Furnish with each engine a lubricating oil maintenance system consisting of a lube oil make-up tank and automatic lube oil maintenance valve on the engine. The lube oil make-up tank will be manually filled. The system shall be as furnished by Ren or equal.

2.06 ENGINE COOLING LOOP

A. General

1. The engine cooling system shall be provided with expansion tank(s) for each cooling loop with a level sensor, drain valve, a pressure relief valve sized for maintaining a safe pressure, one dual sensor thermowell, and one mixing valve for controlling the high temperature of the coolant by diverting the flow of coolant through the process heat exchanger with a motor-driven circulating pump.

2. The system shall have flow indicators, check valves, shutoff/ isolation valves, engine heat exchanger, thermometer wells and visual thermometers to indicate coolant temperature entering and exiting heat exchangers, electronic 3-way valves for bypassing the engine heat exchanger on low coolant temperature, stainless steel flexible joints at inlet and outlet of the lube oil heat exchanger, remote pad-mounted heat rejection dual circuited radiator, and piping, drains, and accessories as required for engine control, monitoring, shutdown and alarms.

3. The design of the engine cooling loop shall be the responsibility of the Contractor's Engineer and approved by the engine manufacturer.

4. The engine coolant shall be a glycol/water mixture with demineralized water containing corrosion inhibitors and coolant additives with concentration as recommended by the engine manufacturer. Engine manufacturer shall provide a pre-mixed glycol/water mixture for the entire HTCW and LTCW cooling loops that extend to the remote engine radiators.

5. Flow Indicators, Temperature Indicators and Pressure Relief Valves – provide flow and temperature indicators and relief valves for each engine loop as needed with 4-20 mA output for control of mixing valves.

B. Engine Coolant Pump

1. A high temperature cooling water pump and a low temperature cooling water pump shall be provided to circulate engine coolant through each engine, cogeneration heat exchanger, and waste heat dump radiator.

2. A coolant booster pump, if required, shall be provided as an in-line pump for circulation of coolant. This pump shall supplement the engine driven coolant pump as required by the engine manufacturer.

C. Process Heat Exchanger

1. The high temperature cooling water loop on each engine shall be provided with a process heat exchanger (CHP Heat Recovery heat exchanger). Heat exchanger shall be a plate and frame type, complete with mounting feet, with NBRP clip-on gaskets. The plate and frame sides of the heat exchanger shall be constructed in accordance with the ASME Code for Pressure Vessels for a working pressure of 150 psig. Design operating temperature for the plate and frame sides of the heat exchanger shall be 300°F. Inlet and outlet shall have bolt studs for flanged connections. Provide ASME pressure relief valve. Capacity shall be based on a heat transfer surface fouling factor of 0.002. The plant side of the heat exchanger will be water; the engine side of the heat exchanger will be 50/50 propylene glycol/water mixture.

2. Unit shall have thermal or pressure relief in the heat recovery line to avoid over pressurization when isolated.

D. Exhaust Gas Heat Recovery Units

1. Each engine shall be provided with an exhaust gas heat recovery unit with bypass and motor operated diverting valves and be furnished as a factory assembled module. Unit shall incorporate a design suitable for hot water service.

2. Exhaust adapters shall be stainless steel with ANSI 150 lb Type 316 stainless steel flanges. Provide stainless steel flexible connector on engine side of unit.

3. Unit configuration shall be horizontally mounted on the roof of the container or skid mounted separate to the container. Access hatches shall be removable for cleaning of unit and fin tube module removal.

4. Hot water piping connections shall be ANSI 150 lb flanged.

5. The system shall be designed, constructed and tested in accordance with the ASME Pressure Code, Section VIII Division I. The heater coils shall bear the ASME "U" stamp for un-fired pressure vessels.

6. Shell (water-side) shall be constructed with S235JR (USA, ASTM: A 284 GR C, D or SAE 1015) hot-rolled steel. Tubes and tube sheets (exhaust gas-side) shall be constructed of AISI Type 316L stainless steel.

7. Unit shall be factory or field insulated for outdoor installation.

8. Base-frame and other components shall be field painted with hard finish enamel.

9. Unit shall include a drain connection.

10. Unit shall include a thermal relief valve in the heat recovery line to avoid over pressurization when isolated.

11. A pressure relief valve for relieving hydrostatic pressure shall be provided on each unit housing. The capacity of the safety valve shall be at least 1.5 times the heat transfer rate. The pressure relief valve shall meet the requirements of the ASME Boiler and Pressure Vessel Code, Section VIII. Valve shall be manufactured by Watts or equal.

E. Remote Waste Heat Dump Radiators

1. Each engine shall have one (1) dual-circuit or two (2) waste heat dump radiator(s) mounted remotely from the engine. Radiator shall be of horizontal design.

2. Each radiator shall reject the engine water jacket, lubricating oil and turbocharger inter-coolers (one high-temperature cooling circuit); the second-stage turbocharger inter-coolers (one low-temperature cooling circuit).

3. Radiator shall include multiple separate fans for cooling. Fans will cycle based on temperature through the cores.

4. Radiator shall be galvanized steel construction on individual support legs suitable for mounting on a concrete equipment pad.

5. Radiator shall be IEA Industries Model or Guntner and, or equal.

F. System Accessories

1. Pipe-Work. Complete internal cooling water pipe-work of the CHP module including, bends, fittings, flanges, screws and gaskets. The pipe-work shall be carbon steel and shall be factory primed, painted and insulated and shall be pressure and functional tested before shipment.

2. Exhaust Pipe-Work. The exhaust pipe-work including bends, fittings, and flanges shall be primed and insulated and shall be pressure and functional tested.

3. Each high temperature and low temperature cooling circuit shall be furnished with the following accessories:
   a. One (1) circulation pump having a 3 phase, 480 volt, 60 Hz motor;
   b. One (1) 3-way motor operated mixing valve for continuous control;
   c. One (1) electronic temperature sensor;

2.07 GENERATOR

A. General

1. The generator shall be synchronous type, 3 phase, conforming to ANSI Standards for Rotating Electrical Machinery and to NEMA Standards for Motors and Generators (NEMA Standard Publication, latest revision). Temperature rise shall be 220 degrees F continuous.

2. The rotor shall be statically and dynamically balanced and shall have an integral cooling fan. The generator shall have grease lubricated anti-friction ball bearings with conveniently located grease fittings. A means of preventing overgreasing of bearings shall be provided.

3. Each generator shall conform to the following ratings:

a.	Rated Output	840-1,200 kW
b.	Rated Voltage	480 volts
c.	Rated Frequency	60 cycle
d.	Rated Speed	1800 rpm maximum
e.	Efficiency	96 percent minimum at 0.8 PF
f.	Power Factor	0.80 minimum
g.	Rated Current	157 amps minimum at 0.8 PF
h.	Synchronous Speed	1800 rpm
i.	Temperature Rise	220 F for continuous power
j.	Insulation	Class H

4. The data for the generator for the ratings outlined above plus information for the following shall be tabulated in one location on the generator shop drawing submittal:
   a. Nominal efficiency
   b. Generator manufacturer
   c. Model No
   d. Frame number
   e. Shop painting

B. Sub-base and Vibration Isolators

1. The engine generator unit and accessory equipment shall be mounted on a full subbase fabricated of structural steel. Polymer or cork pad vibration isolators shall be supplied. Mounting holes for the isolators shall be located in the subbase by the engine manufacturer to insure equal distribution of weight on the isolators. Unit isolation system shall be seismically restrained.

C. Engine/Generator Control Panel

1. Each engine/generator system shall include an engine/generator control panel.

2.08 SIGNALS FOR REMOTE INDICATION AND CONTROL

A. Provide output signals via Ethernet from the generator control panels for remote indication of conditions in the plant-wide SCADA system as shown on the P&IDs for the cogen system. Provide an Ethernet protocol converter, if required, to be compatible with the existing plant-wide supervisory control and data acquisition (SCADA) system. Provide a fiber optic switch or media converter, and patch panel and patch cables, within the control panels as required for connection to the existing plant SCADA system.

2.09 SURFACE PREPARATION AND SHOP PAINTING

A. The engine generator set and associated equipment shall be shop primed and finish coated in accordance with the manufacturer's standard practice prior to shipment. One quart of touch up paint shall be supplied by the manufacturer.

2.10 SHOP TEST

A. Shop test each complete engine driven generator unit and the generator control panel prior to shipment. Submit the complete certified test record. The tests shall demonstrate that each unit will operate successfully and meet the specified operational requirements. The manufacturer shall furnish all instruments, filters, fuel gas, electric power and load banks for the test.

B. The shop test shall include operation on a reactive load bank at 0.8 power factor at rated continuous load. During operation, test and record voltage and frequency regulation, and voltage and current balance to confirm compliance with this Section. Load shall be adjusted, starting with one-hour intervals each at 1/2 load, and 3/4 load followed by the remaining two-hours at full load. Perform tests to demonstrate transient response from half load to full load, half load to three-quarter load, and three-quarter to full load. Test each of the automatic alarm and shut-down devices and record the settings at which the automatic devices actually alarmed and/or stopped the engine. Submit copies of the shop test record.

C. During the factory test, take readings and record results for each of the following:

1. Time

2. Ambient air temperature of the Engine Room.

3. Outdoor air temperature.

4. Load:
   a. Volts for each phase
   b. Amps for each phase
   c. Kilowatts
   d. Frequency
   e. Power Factor
   f. Generator RPM

5. Engine jacket water temperature

6. Engine jacket water pressure

7. Engine exhaust gas temperature at the outlet of the turbocharger

8. Engine lubricating oil pressure

9. Engine lubricating oil temperature

10. Engine RPM

11. Natural gas flow rate and pressure at each steady load and transient load situation

D. Shop test the alternator in accordance with IEEE Standard 115. Testing shall include the following:

1. Cold resistance of all windings

2. Insulation resistance of all windings

3. Polarity of field coils

4. High potential on all windings

5. Open circuit saturation

E. KUB representatives reserve the right to witness all factory testing and shall be notified in writing at least 30 calendar days prior to anticipated factory testing. KUB and its representatives understand the date is subject to change and it is expected those attending will make adjustments to their schedule to accommodate a change in schedule.

F. The complete certified factory test data log shall be provided to the Engineer and Owner. The unit(s) being tested will not ship unless all parties agree that it has been successfully tested.

PART 3 EXECUTION

3.01 INSTALLATION

A. The engine manufacturer shall provide the services of a qualified factory representative to check the installation of the generator unit to ensure a proper installation, conduct the field test specified herein, and to instruct the Contractor’s personnel in the operation and maintenance of the equipment. This is included in the services pre-purchased by the Contractor.

B. The engine-generator container base shall be mounted on a flat concrete base and leveled to provide equal bearing for all supports as work of this section. Anchors shall be in accordance with the manufacturer's recommendations. Anchor bolts shall be Type 316 stainless steel and be provided by the Contractor.

C. Installation shall include furnishing all required coolant and lubricants.

3.02 EQUIPMENT START-UP

A. After installation and manufacturer's representative check of the installed equipment, operate the unit to demonstrate its ability to operate continuously without vibration, jamming, leakage or overheating and to perform specified functions.

B. Comply with manufacturer's operating and maintenance instructions during start-up and operation.

C. Promptly correct improper installation of equipment.

D. Cooperate with supplier of equipment at time of start-up and in making of all final adjustments necessary to place equipment in satisfactory working order. Start-up shall not commence without the presence of the manufacturer's representative.

3.03 FIELD TEST

A. Upon completion of the installation and as soon as conditions permit, the engine driven generator and associated electrical circuits and controls shall be tested in the presence of the Contractor's Engineer by the Contractor and the service representative for the manufacturer of the engine driven generator unit to assure that the system functions as specified. Before conducting the on-site field tests, the Contractor shall submit to the Engineer for approval, a copy of the proposed test data log sheet.

1. Prior to scheduling the test, notify the Engineer in writing that all requirements and provisions of the Contract Documents have been fulfilled, that all apparatus has been cleaned, properly adjusted and is ready for operation and that the Operation and Maintenance Manuals described in Paragraph 1.03, have been submitted.

2. The manufacturers' representatives shall make such changes in wiring or connections and such adjustments, repairs or replacements necessary to make the circuit, device or control system function as specified and otherwise comply with the Contract Documents.

3. If the engine-generator system fails to fulfill the performance requirements of this specification, corrective action shall be taken and the system retested to assure full compliance. All expenses associated with the field tests, including any corrective action, shall be borne by the Contractor. The engine-generator system supplier shall have 30 days to remedy any failure or performance requirements.

B. Physical Checkout

1. The manufacturer's representative shall physically inspect the system components individually after they have been installed by the Contractor to determine if the components have been installed as specified and are ready for field and functional testing. The testing shall be in accordance with the recommendations of the manufacturer's representative and shall include at a minimum the following:
   a. Apply electric power to individual components to determine continuity of power supply and signal systems. Equipment shall not be energized without the permission of the Engineer.
   b. Coordinating with the Contractor to pressure and leak test digester and natural gas and jacket cooling piping systems provided by the Contractor.

c. Perform dry running tests where possible to confirm rotation and function.
d. Verify construction is in accordance with the approved manufacturer's drawings, and that the equipment and all auxiliaries are ready for operation.
e. Verify fuel, coolant and lubrication systems are complete, clean and filled with the proper grades of fuel, coolant and lubricants.

2. Prior to scheduling the Initial Field Test, notify the Engineer in writing that all requirements and provisions of the Contract Documents have been fulfilled, that all apparatus shall be clean, properly adjusted and ready for operation and that the Instruction Manuals, parts lists and record drawings described in Paragraph 1.03 have been submitted.

C. Initial Field Test

1. The Engineer and Owner shall be given the opportunity to witness all field testing and shall be notified in writing 21 calendar days prior to anticipated field testing. Written test procedures shall be provided by the engine generator system supplier and approved by the Owner/Engineer. The Owner/Engineer understands the date is subject to change and it is expected those attending will make adjustments to their schedule to accommodate a change in schedule. The Initial Field Test comprises of a complete system test where the system comprises of the engines and gas conditioning system as specified in Section 13240.

2. Prior to initiating the Initial Field Test, verify with the Owner and Engineer that sufficient digester gas has been stored in the gas holder to allow operation of the engines under varying loads for the durations specified herein.

3. The Contractor shall provide a portable resistive and reactive load bank, with loads sufficient to exercise each engine and generator to 100% of the specified kW. Provide all temporary connecting cables, metering equipment, and other equipment or devices required to collect the specified data. Collected data shall comply with the efficiency data shown in Paragraph 1.11, C. During the test, take and record the same readings as outlined under Item 7, below, at fifteen-minute intervals.

4. Coordinate completion of the Initial Field Test with the Owner and Engineer to ensure availability of the plant hot water loop installed by the Contractor.

5. The Initial Field Test shall utilize the resistive load bank to operate the engine generator under the following conditions.
   a. One hour @ 50 percent of specified kW at 0.80 PF utilizing digester gas.
   b. One hour @ 75 percent of specified kW at 0.80 PF utilizing digester gas.
   c. Two hours @ 100 percent of specified kW at 0.80 PF utilizing digester gas.
   d. Perform tests to demonstrate transient response from half load to full load.
   e. Perform tests to demonstrate transient response from half load to three-quarter load.
   f. Perform tests to demonstrate transient response from three-quarter to full load.

6. During the initial hour of the 50% load operating test, the remote waste heat dump radiator will be used to remove heat from the jacket cooling loop. During the second hour of 75% load operating test, the process hot water loop will be used to remove heat from the jacket cooling loop with the remote waste heat dump being used as required. This process will be repeated during the 100% load operating test to document satisfactory operation of the remote waste heat dump radiator with and without the process hot water loop. Test will be

conducted utilizing digester gas and again utilizing natural gas at the maximum natural gas rating.

a. When operating at 100% load, show how the 160-degree F plant hot water supply is able to capture all of the recoverable heat (jacket water and exhaust gas) while not exceeding 180 degrees F.

7. The following engine parameters shall be read and recorded at 15-minute intervals throughout the 4-hour test for digester gas and 4-hour test for natural gas:
   a. Coolant temperature and flow at each monitoring point shown on the P&ID
   b. Digester gas fuel consumption (flow rate) and pressure at each steady state and transient load situation.

8. All safety systems and controls shall be demonstrated and recorded, including:
   a. Functioning of the high temperature coolant shutdown by lowering cooling system temperature shutdown setpoint.
   b. Overspeed Shutdown - record speed at which overspeed trip operates; must be set to operate at no more than a 10 percent overspeed condition.
   c. Low Oil Pressure Shutdown - Establish minimum safe operating pressure.
   d. Shutdown for low coolant temperature, high lube oil temperature and low oil pressure shall be tested by synthetic actuation.
   e. Shutdown for low digester gas pressure.

9. Any adjustments required shall be made in the devices to make the operating values correspond to those recommended by the engine manufacturer and as recorded during the stop test

D. Operational Test (Commissioning Period)

1. Upon successful completion of the Initial Field Test and after approval is received from the utility to parallel the engine generator with the grid, an Operational Test shall be completed. Operating hours and loads will need to be coordinated with KUB operating personnel to provide consistent and high enough electrical loads. This is required to perform all the specified performance, emission and sound testing.

2. When running on digester gas, the Contractor will need to coordinate with KUB to match the plant's gas production to the engine/generator operation.

3. The Operational Test period is to be two calendar days with the engines operating continuously (24 hours per day). If problems develop during the 2-day period requiring replacement of parts or major adjustments, the Operational testing period stops and restarts after corrections are made.

4. During the Operational Test period provide a manufacturer's representative at the site during normal working hours. The manufacturer's representative shall be equipped and ready to provide emergency repairs, adjustments, and corrections to the equipment and systems at all times.

5. During the commissioning period, Owner will be responsible for all normal operational costs. The Contractor shall pay the costs of all necessary repairs or replacements, including labor and materials, required to keep the portion of the plant being commissioned, operational.

6. In accordance with TVA's Minimum Requirements Document, Energy Conservation Measures, the Operational Test shall demonstrate compliance with the Performance requirements in Paragraph 1.12.C

7. This Contractor shall work with the manufacturer's representative and their sound consultant to conduct sound level testing to take and record octave band sound pressure level readings with the engine-driven generator using the station load available at the time the field tests are conducted. These readings shall be within the limits permitted by this specification as called out in Paragraph 2.01, "Acoustics".

8. This Contractor shall work with the manufacturer's representative and their emission testing consultant to conduct emissions testing and operating the engine driven generator using the station load available at the time the field tests are conducted. These readings shall be within the limits permitted by this specification as called out is Paragraph 2.01.A.6.

END OF SECTION

SECTION 13240
PACKAGED BIOGAS TREATMENT SYSTEM

PART 1 GENERAL

1.01 SCOPE OF WORK

A. This Section describes the functional requirements for a packaged biogas treatment system to be furnished and installed under this Contract.

B. The biogas treatment system vendor shall be responsible for design of the system to meet the performance and functional requirements of this Section, supply and delivery, and providing assistance to the Contractor including installation support, training, start-up, field testing, commissioning, and performance testing. The biogas treatment system vendor shall be responsible for all mechanical and instrumentation and controls within each equipment skid and to all termination points as described in this Section and as shown on the Preliminary Drawings. The biogas treatment system vendor shall be a subcontractor to the Contractor, who will be responsible for the final design.

C. The Contractor shall be responsible for installation of the packaged biogas treatment system including all pre-assembled skids provided by the biogas treatment system vendor. The Contractor shall be responsible for all mechanical and instrumentation and controls interconnections between skids and remote control panels. The Contractor shall be responsible for all heat tracing and insulation of biogas equipment and piping that may be required..

D. Equipment List:

Item	Equipment No.
H_2S Scrubber 1	SSR-1000-1
H_2S Scrubber 2	SSR-1000-2
CHP Gas Compressor Skid – Filter and Compressor	T-1100-1, B-1100-1, B-1100-2
CHP Heat Exchanger Skid – Re-Heat Gas to Gas Heat Exchanger and Gas to Glycol Heat Exchanger	EX-1100, GGC-1100
Siloxane Scrubber 1 (Bid Alternate)	SSR-2100
Siloxane Scrubber 2 (Bid Alternate)	SSR-2200
Particulate Filter	T-2300
Chiller Skid (Chiller, Recirculation Pumps)	GC-1200, P-1200-1, P-1200-2
Main Control Panel	Gas Conditioning Control Panel (ACP-1100)

E. Design Requirements and Operating Conditions

1. Equipment shall be specifically designed and selected for continuous duty for moisture removal, particle removal, hydrogen sulfide removal, siloxane removal, compression and handling of biogas (digester gas). The biogas treatment system vendor shall provide written certification that all equipment being supplied under this Section is suitable for use in this service.

2. The approximate composition and characteristics of the digester gas at the inlet to the biogas treatment system is indicated as follows:

Item	Value
Methane Content Range	55-65 percent
Carbon Dioxide Content Range	35-45 percent
Hydrogen Sulfide (average)	120 ppmv
Hydrogen Sulfide (maximum)	1000 ppmv
Siloxanes (average)	3,500 ppbv, 3.6 mg/m^3 (total as Si)
Siloxanes (maximum)	4,500 ppbv, or 5.0 mg/m^3 (total as Si)
Inlet Temperature (minimum)	70-100 degrees F
Moisture	Saturated (system shall be capable of saturating the biogas prior to the H2S vessels)
Digester gas pressure	5 in w.c. in digester, 1-2 psi after compressor

3. Supports for all vessels and equipment shall be designed to meet the seismic requirements required by applicable local and national codes.

4. The system shall have capacity to treat the following flow range:
   a. Minimum flow: 200 scfm
   b. Average flow: 280 scfm
   c. Maximum flow: 475 scfm

5. Headloss through new piping and equipment that will not be supplied as part of the packaged biogas treatment system will be determined by the Contractor during final design. This headloss shall be included by the biogas treatment system vendor when sizing the CHP gas compressors to be provided under this Section.
   a. Work being performed under a separate contract will be adding digester gas compressor upstream of the gas conditioning system. The compressor is currently designed to boost the digester gas pressure from 5 inches of water column to 2 psi. The Contractor shall confirm the digester gas pressure to the gas conditioning system during final design.

6. The minimum and maximum ambient outdoor design temperatures at the location of the project site are -20 degrees F and 102 degrees F, respectively. The average annual minimum and maximum ambient outdoor temperatures at the location of the project site are 27 degrees F and 87 degrees F, respectively. The system shall be capable of meeting the performance requirements specified in Paragraph 1.01 F while operating in any ambient temperature between the minimum and maximum design temperatures. Insulation of all external components shall protect against freezing for the expected minimum ambient temperatures. Contractor shall supply and install all insulation.

7. All vessels and pre-assembled skids shall be sized and configured in such a way to fit within the footprint of the concrete pads shown on the Preliminary Drawings for this equipment.

8. H_2S removal vessels shall be designed for Maximum Allowable Working Pressure of 5 psig, 1 psig vacuum, and shall be suitable for installation in an outdoor environment.

9. Siloxane removal vessels shall be designed for a Maximum Allowable Working Pressure of 10 psig and shall be suitable for installation in an outdoor environment.

F. Performance Requirements

1. The biogas treatment system shall treat and supply biogas to the following levels as measured downstream of the particulate filters (the outlet port of the biogas treatment system equipment). The system shall be capable of achieving the specified performance requirements under all flow conditions. In both cases the system shall meet these requirements with the following equipment out-of-service: one H_2S scrubber, one biogas compressor filter, one biogas compressor, one siloxane scrubber.

Item	Value
Outlet Pressure	3.0 - 5.0 psig at discharge of final filter
Hydrogen Sulfide	50 ppmv (maximum)
Siloxanes	200 ppbv total siloxanes for compounds D3, D4, D5, L2, L3, L4 and L5, or approximately 1.08 mg/m^3 as Si
Particulate Removal	99.0% reduction of all particles 3 microns and larger
Discharge Temperature Range	80 to 100 degrees Fahrenheit

2. Vertical interconnecting piping shall be minimized to the extent practical. Isolation valves installed on vertical segments pipe shall also be minimized to avoid instances where condensate may accumulate in segments of piping that are removed from service for extended periods. For all such locations where vertical segments of pipe are included and are provided with isolation valves or other means of restricting biogas flow, additional condensate drain system(s) in accordance with Paragraph 2.07 shall also be provided.

3. All Ethernet (IP) addresses shall conform to the KUB SCADA Network addressing scheme. Identify each Ethernet device to be provided and submit a request for an Ethernet address assignment for each network device to be provided.

G. Each compressor shall be driven at variable speed by a dedicated variable frequency drive controller. The Contractor shall require the compressor and motor manufacturer to coordinate his/her design with the supplier of the variable frequency drives.

H. Electrical motors furnished as part of the work of this Section shall be as specified in Section 16150.

1.02 QUALITY ASSURANCE

A. References:

1. This Section contains references to the documents in PART 2 of this Section. They are a part of this Section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this Section as if referenced directly. In case of conflict between the requirements of this Section and those of the listed documents, the requirements of this Section shall prevail.

2. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether or not the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
ANSI/ASME B16.5 ASME	Pipe Flanges and Flanged Fittings ASME Code for Pressure Piping, B31
IBC	International Building Code
API 1104	American Petroleum Institute
NFPA 820	National Fire Protection Association Standard for Fire Protection in Wastewater Treatment and Collection Facilities
NEC	National Electric Code

B. Experience and Qualifications

1. The biogas treatment system shall be furnished by a single manufacturer or vendor to be responsible for proper selection of components, their manufacture and assembly and the proper functioning of the complete units.

2. Each component of the biogas treatment system shall be the standard product, modified as necessary to meet the specified performance requirements of this Section, of a manufacturer regularly engaged in the production of this type of equipment. The component to be furnished shall be of proven quality and correct application to this work and shall be designed, constructed and installed in accordance with best practices and methods. Each component and ancillary equipment items furnished under this Section shall be new and unused, and the product of a manufacturer having a successful record of manufacturing and servicing the equipment.

3. The biogas treatment system shall be furnished by a vendor that is qualified and experienced in biogas treatment. The biogas treatment system vendor shall have at least 10 years of experience in the design, application, and supply of WWTP digester gas treatment systems and shall submit a list of not less than 10 operating packaged biogas treatment installations at WWTPs (H_2S removal, biogas conditioning and siloxane removal) in the United States as evidence of meeting the experience requirement. Provide a minimum of 10 references with contact information including e-mail and phone number. Application and flow system rate for each reference shall be listed.

4. Vendor shall provide audited financial statement for the prior fiscal year.

5. Vendor must follow ASME B31.3 Process Piping Standards. All welds must be pressure tested, 100% visually inspected and verification of the procedure utilized shall be provided. All piping must be passivated. Vendor must provide complete inspection reports for Owner review upon request.

6. Vendor shall build Industrial Control Panels to UL 508A/698A, NEMA 4X stainless steel.

1.03 PROJECT/SITE REQUIREMENTS

A. All equipment and instruments located outdoors and within 5 feet of biogas (digester gas) process pipes and all components of the biogas handling equipment shall be listed and labeled for use in an NEC Class 1 Division 1 area.

B. All equipment and instruments located outdoors and between 5 and 10 feet from biogas process lines and biogas handling equipment shall be listed and labeled for use in an NEC Class I Division 2 area.

C. To assure unity of responsibility, the motors and supporting base for the gas compressors shall be furnished and coordinated by the compressor manufacturer. The General Contractor and compressor manufacturer shall assume responsibility for the satisfactory installation and operation of the entire compression system including compressors, motors, VFDs, controls and supporting base as specified.

1.04 SUBMITTALS

A. Submit, in accordance with Section 01300, shop drawings and product data, to establish compliance with this Section. Submittals shall include the following:

1. Drawings showing location of anchor bolts, location, size and connection method including specification designation for all external piping connections, dimensions and weights for all biogas treatment system components.

2. Descriptive literature, manufacturer catalog cut sheets, specifications, materials of construction for all biogas treatment system components.

3. Detailed schematic and wiring diagrams showing piping and wiring connections with sizes required and location for the controls of all biogas treatment system components.

4. Seismic calculations for all skids, vessels, and equipment. All calculations shall be stamped and signed by a professional structural engineer licensed in the State of Tennessee.

5. Manufacturer’s installation, operation and maintenance manuals, bulletins, and spare parts list for all biogas treatment system components.

6. Equipment list identifying all equipment, instruments, and ancillary components to be supplied by the biogas treatment system vendor. For equipment, instruments, and ancillary components that are pre-assembled and shipped on a skid package, the equipment list shall identify the specific skid package that they are pre-installed upon. Equipment, instruments, and ancillary components that are to be shipped loose shall be identified as such. All equipment, including automated condensate drain valve systems, shall be accompanied by a certification from the biogas treatment system vendor (or its manufacturer for individual components) stating that use of the equipment in the intended application with biogas treatment systems conforming to the requirements of Paragraphs 1.01.D and 1.01.E is appropriate.

7. Wiring diagram showing all electrical external connections.

8. Complete I/O list and program listing for all PLCs and control panels supplied under this section. Include a complete PLC memory map of all monitoring and control signals that will be transferred between the GASCP and the facilities existing SCADA system.

9. Program listing, logic diagrams, functional block diagrams, memory map and other documentation as required to demonstrate that all equipment supplied under this Section can be operated properly and in accordance with the performance requirements of this Section, manufacturers' normal equipment operating requirements and proper system safety requirements.

10. Network communication diagram, demonstrating the biogas treatment control system architecture, (e.g. interconnection between equipment skids and control panels). Detail type of media connection and communication protocols being used.

11. Provide a hard copy and soft copy to the Owner of the PLC documentation. Soft copy will be provided in a memory stick and/or CD media. PLC documentation includes logic diagrams showing all address numbers, rung reference numbers, all preset register values, detailed commentaries describing the purpose of each rung, tables or schedules listings all utilized I/O addresses, internal relay addresses, and timer, counter, and register addresses and values, and the date of the latest revision. Provide a hard copy and soft copy to the Owner of all Operator Interface programming and graphics as applicable.

12. Performance tables for all variable speed motors provided under this Section.

B. Design Data

1. Layout drawings for all pre-assembled skids showing exact equipment locations and dimensions including all biogas and condensate handling equipment, piping, and appurtenances.

2. The biogas treatment system vendor shall furnish technical calculations verifying the performance of the proposed system, including the chosen media(s) to be installed in fixed bed media vessels. These technical calculations shall include media exhaustion rate as a function of SCFM flow, face velocities, and media definitions. Media definitions shall include the carbon tetrachloride (CTC) numbers for carbon media, density, and media sizing.

3. H_2S Scrubbers: Certified pressure drop calculations when full of media.

4. Coalescing Filters (CHP Gas Compressor Filters): Volume of moisture removed from biogas stream, pressure drop, design flow rate, maximum and minimum flow rate.

5. CHP Gas Compressors: Rotational speed at full load, frequency, voltage, number of phases, full load current, enclosure designation, NEMA code design letter, efficiency, horsepower rating, temperature rise, bearing life rating and method of lubrication, blower curve with operating point designated on the curve and motor performance sheets.

6. CHP Gas Cooling Heat Exchanger(s): Inlet and outlet temperatures, flow rates, pressure drops, heat rejection, heat transfer coefficients, and weight and volume of moisture condensed. Provide calculations showing the derivation of the U values used.

7. Chillers: Design heat rejection, flow rates, pressure drops, motor horsepower, assumed ambient temperature, COP at the identified conditions in this Section, the integrated part load value (IPLV) for the heat exchanger, and motor performance sheets.

8. Siloxane Scrubbers: Certified pressure drop calculations when full of media.

9. Particulate Filter: Pressure drop when the filter is 90 percent utilized, removal efficiency.

C. Test Reports

1. A test report documenting the performance of all components included in the biogas treatment system for all tests described in PART 3 of this Section.

D. Standard Operating Procedures

1. The biogas treatment system vendor shall provide written procedures for safely removing from and returning to service all equipment listed in Paragraph 1.01.D including all segments of interconnecting piping upstream and downstream without interrupting continuous service for remaining equipment. The biogas treatment system vendor shall provide recommendations for safely maintaining and/or purging any portions of piping that may remain out of service to accommodate equipment maintenance.

E. Detailed Control System Submittal Requirements

1. This submittal shall provide complete documentation of the proposed hardware (Programmable Logic Controllers (PLCs), input/output (I/O) modules, remote IOs (ROI), Operator Interface Terminals (OITs), computers, communication equipment, cables, peripherals, etc.). A complete Bill of Materials (BOM) listing all hardware equipment shall be provided. The submittal shall include the following:
   a. System Block Diagram
      1) A complete schematic system block diagram(s) showing the interconnections between major hardware components.
      2) The block diagram shall reflect the total integration of all control devices in the system and any OIT locations. Location of all components shall be clearly identified with appropriate cross-references.
      3) The diagram shall reference all interconnecting cabling requirements for digital components of the system including any data communication links.
      4) The block diagram shall reflect the integration of the manufacturer's control system in the plant wide SCADA system. Location and division of responsibility shall be clearly identified.
   b. Data Sheets
      1) A data sheet for each hardware component listing all model numbers, options, auxiliary and ancillary devices that are being provided.
      2) The data sheets shall be provided with an index, proper identification and cross-referencing. They shall include, but not be limited to, the following information:
         a) Product (item) name used herein
         b) Manufacturer's complete model number
         c) Location of the device
         d) Input/output characteristics
         e) Range, size and graduations

f) Physical size with dimensions, enclosure NEMA classification and mounting details
g) Materials of construction of all components
h) Power supply device sizing calculations where applicable

c. System Input/Output List
1) The Control System Hardware submittal shall contain a complete system Input/Output (I/O) list for equipment connected to the control system under this Contract. The I/O list shall be submitted in a Microsoft Excel readable electronic file format on a CD-ROM and an 8-1/2-in by 11-in hard copy. The I/O list shall include, but not be limited to, the following information:
a) Tag number(s)
b) Description
c) Physical location
d) Physical point address
e) I/O type
f) Range state
g) Engineering Units
h) Alarm limits
2) Where multiple mechanical components are provided for process redundancy, their field connections to I/O modules shall be arranged such that a failure of a single I/O module will not disable all mechanical components of the redundant system.

d. Control Panel Layout and Wiring Drawings
1) Panel Layout Drawings: Drawings shall be furnished for all panels, consoles, and equipment enclosures specified. Panel assembly and elevation drawings shall be drawn to scale and detail all equipment in or on the panel. Panel drawings shall be 11"x17" minimum in size. As a minimum, the panel drawings shall include the following:
a) Interior and exterior panel elevation drawings to scale.
b) Nameplate schedule.
c) Conduit access locations.
d) Panel construction details.
e) Cabinet assembly and layout drawings to scale. The assembly drawing shall include a bill of material on the drawing with each panel component clearly defined. The bill of material shall be cross-referenced to the assembly drawing so that a non-technical person can readily identify any component of the assembly by manufacturer and model number.
f) Fabrication and painting specifications including color (or color samples).
g) Submit construction details, NEMA ratings, intrinsically safe barrier information, gas sealing recommendations, purging system details, etc. for panels located in hazardous locations or interfacing to equipment located in hazardous areas.
h) Heating and cooling calculations for each panel supplied indicating conformance with cooling requirements of the supplied equipment and environmental conditions. Calculations shall include the recommended type of equipment required for both heating and cooling.
i) Submit evidence that all control panels shall be constructed in conformance with UL 508 and bear the UL seal confirming the construction. Specify if UL compliance and seal application shall be accomplished at the fabrication location or by field inspection by UL inspectors. All costs associated with

obtaining the UL seal and any inspections shall be borne by the manufacturer and included in the Project Bid Price.

2) Panel Wiring Diagrams: Panel wiring diagrams depicting wiring within and on the panel as well as connections to external devices. Panel wiring diagrams shall include power and signal connections, UPS and normal power sources, all panel ancillary equipment, protective devices, wiring and wire numbers, and terminal blocks and numbering. Field device wiring shall include the device ISA-tag and a unique numeric identifier. The diagrams shall identify all device terminal points that the system connects to, including terminal points where I/O wiring lands on equipment not supplied by the manufacturer. Wiring labeling used on the drawings shall match that shown on the Contract Documents or as approved by the Engineer. I/O wiring shall be numbered with rack number, slot number, and point number. Two-wire and four-wire equipment shall be clearly identified and power sources noted. Submit final wire numbering scheme. Panel drawings shall be 11" x17" minimum in size.

2. HMI Memory Map (PLC tags/addresses) Submittal
   a. This submittal shall contain a memory map of PLC registers submitted to the Engineer/Client no later than 30 days prior to the scheduled shipment of the vendor equipment to the site. Vendor shall contact and coordinate with the Engineer/Client to ensure compatible configuration of the vendor PLC(s) in order to match the facility SCADA network. Vendor shall configure the network addresses, IP addresses, and Subnet mask in their equipment to match the addresses determined by the client. Software communication shall be provided in contiguous registers. One set of registers shall be provided for writing discrete-type information, and one set shall be provided for reading discrete-type information. One set of registers shall be provided for writing floating-point information, and one set shall be provided for reading floating-point information.

1.05 WARRANTY

A. The Contractor shall obtain from the supplier of the biogas conditioning system a statement that the equipment shall be warranted from a period of one (1) year from the date of Substantial Completion, as defined under the General Conditions, to be free from defects in workmanship, design or material. If the equipment should fail during the warranty period due to a defective part(s), the part(s) shall be replaced and the equipment restored to service at no additional cost to the Owner.

B. The biogas treatment system as a whole shall be provided with a system warranty for a minimum of 12 months following successful field testing.

   1. All individual biogas treatment system components and equipment shall be provided with manufacturer’s standard warranties.

   2. Warranty certificates shall be submitted in writing and signed by an officer of the biogas treatment system vendor’s firm, as part of the submittal package.

PART 2 PRODUCTS

2.01 GENERAL

A. All components of the biogas treatment system shall have firmly attached to each component a stainless steel nameplate. The nameplate shall have engraved on it, at a minimum, the name of the manufacturer, the model number, the serial number and the equipment tag number. Drive motor nameplates shall include the name of the manufacturer, model number, serial number, volts, full load current, rated horsepower, service factor, full load rotational speed and temperature rating.

B. Equipment over 100 lbs. shall be supplied with lifting lugs.

C. The biogas treatment system vendor shall be Unison Solutions, Varec, Inc., LFG Specialties, Perennial, or approved equal.

2.02 H2S REMOVAL SYSTEM

A. The H_2S Removal scrubbers shall be designed for scavenger iron oxide based media such as SulfaTreat® or equivalent.

B. The H_2S Removal system shall include two hydrogen sulfide scrubber vessels (H_2S scrubbers), support frame for the scrubbers, and related appurtenances as shown on the P&IDs. The scrubbers shall sit on legs or a support frame. The Contractor shall directly mount the support frame(s) to a concrete pad and install the interconnecting piping.

C. The H_2S Removal system shall be located as shown the Preliminary Drawings.

D. H_2S Scrubber Vessels

1. The H_2S scrubbers shall be designed to accommodate iron-oxide granular media to meet requirements listed in this Section. Scavenger media that the hydrogen sulfide scrubber vessels shall accommodate are as follows:
   a. Media life shall be at least 6 months at the average hydrogen sulfide concentration and the average digester gas flow rate specified in Paragraph 1.01 E. Media life shall be based on one H_2S scrubber being out-of-service.

2. H_2S scrubbers shall be designed such that when one vessel's media is being replaced, the adjacent vessel can continue to treat the biogas.

3. H_2S scrubbers shall be welded Type 316L stainless steel, with dished tops, straight sides, and conical sloping or dished bottoms.

4. Each H_2S scrubber shall be provided with two tapped connections to accommodate purging with nitrogen gas. Purging ports shall be one-inch diameter and shall be provided with a ball valve.

5. Each H_2S scrubber shall be provided with a 2-inch quick connect coupling for purging with air or draining the tank with a hose during media change-out.

6. Each H_2S scrubber shall be provided with an automatic drain system to constantly maintain discharge of water collected. The drain system shall be sized assuming that only one H_2S scrubber is in operation and is being loaded with 100 percent of the anticipated biogas. The drain system shall meet the requirements of Paragraph 2.07.

7. Each H_2S scrubber shall be provided fully charged with media at startup. The media and H_2S scrubber shall be shipped separately. H_2S scrubbers shall not be shipped charged with media. The biogas treatment system vendor shall provide the initial charge of media. The Contractor shall install the media under supervision of the biogas treatment system vendor.

8. Each H_2S scrubber shall be provided with stainless steel ANSI/ASME B16.5 150-pound flanges on the inlet and outlet of each vessel for direct connection to the fiberglass piping.

9. Each H_2S scrubber shall be provided with a pressure vacuum relief valve with flame arrestor and plug valve on each vessel.

10. The H_2S scrubbers shall be identical to one another in physical dimensions, materials of construction and media capacity. The scrubber diameter shall be 8 feet. The maximum height shall be 20 feet or less above grade inclusive of the equipment pad, frame and scrubber.

E. H_2S Removal System Piping and Valves

1. Contractor shall provide and install all interconnecting piping and valves between the H_2S scrubbers. The above grade digester gas piping shall be schedule 10S, Type 316L stainless steel and shall be configured such that the H_2S scrubbers are operated in parallel as shown on the Preliminary Drawings. The piping shall be arranged to allow any H_2S scrubber to be isolated and taken out of service without affecting the operation of the remaining H_2S scrubbers. The biogas piping shall include sampling taps with shutoff valves at the upstream and downstream limits of the H_2S Removal skid.

2. Each H_2S scrubber shall be supplied with an inverted u-trap for automatic draining of each scrubber by gravity into the condensate manhole. Each inverted u-trap shall be designed to prevent gas from escaping the system. The inverted u-traps shall be installed in a heat-protected environment by the Contractor.

F. Support Frame

1. The H_2S scrubbers shall be supported on Type 316 stainless steel legs or a support frame designed by a Professional Engineer registered in the State of Tennessee. The frame and vessel system shall be designed to meet the requirements of the International Building Code.

G. Access Ladders

1. A ladder with safety cage shall be provided for access to each H_2S vessel cover. The ladder shall extend from the ground surface to the cover. The ladder shall be constructed of aluminum and shall meet all OSHA requirements.

2.03 CHP GAS CONDITIONING SKIDS

A. The CHP Gas Conditioning system shall include one biogas compressor skid, sized for the flow requirements of this Section. The compression skid shall be supplied with a coalescing filter prior to a rotary positive displacement or centrifugal blower. The CHP Gas Conditioning system shall have a CHP gas cooling heat exchanger skid. The CHP gas cooling heat exchanger skid shall be supplied with one dual core CHP gas cooling heat exchanger or a system of two shell-in-tube CHP gas cooling heat exchangers. All skids shall be provided with all necessary drains, required instrumentation, and interconnecting piping and valves.

B. All equipment and interconnecting piping on the CHP Gas Conditioning skids shall be delivered to the site pre-assembled on skids. The skids shall be mounted on a concrete pad by the Contractor. Interconnecting piping between the skids shall be provided and installed by the Contractor.

C. The skids shall be installed outside, to the West of the CHP engines as shown on the Preliminary Drawings.

D. Installation of the equipment, instrumentation, control valves, and interconnecting piping shall be in accordance with P&IDs.

E. Piping between the H_2S Removal system and CHP Gas Conditioning system shall be supplied by the Contractor.

F. Piping between the CHP Gas Conditioning system and the Siloxane Removal system shall be supplied by the Contractor.

G. The CHP Gas Conditioning skid shall be provided with flanged connections at both the upstream and downstream extremes of the skid mounted piping to facilitate connection of piping between skids (supplied by the Contractor).

H. CHP Gas Compressor Filters

1. The filter on the CHP gas compressor skid shall be constructed with a Type 304 stainless steel housing, casing and internals. The filter media shall provide 99 percent removal efficiency of droplets 3 microns and larger.

2. The filter package shall be equipped with an automatic drain system to constantly maintain discharge of water collected and prevent biogas from escaping the system. The drain system shall meet the requirements of Paragraph 2.07.

I. CHP Gas Compressors

1. The CHP gas compressors shall be sized based on the flow, turndown and discharge pressure requirements included in Paragraphs 1.01.D and 1.01.E.

2. The compressors shall be rotary lobe positive displacement blowers or centrifugal type with history of usage on biogas applications.

3. Compressors shall be belt driven with 460V, 60 Hz, 3 phase, TEXP, inverter duty rated motor.

4. Casings shall be cast iron.

5. Each compressor shall be equipped with inlet and discharge flex connectors and butterfly isolation valves.

6. Each compressor discharge shall be equipped with a silencer and a check valve.

7. Each compressor discharge shall be equipped with a pressure safety valve.

8. Digester gas compressors shall not exceed 80 dbA at a three foot radius from the compressor. Noise enclosures and inlet silencers shall be provided as a mitigation method to achieve the 80 dbA requirement.

J. CHP Gas Cooling Heat Exchanger(s) (mounted on Heat Exchanger Skid)

1. The CHP Gas Cooling Heat Exchanger shall be a dual core heat exchanger or a system of two shell-in-tube heat exchangers. The selected CHP Gas Cooling Heat Exchanger system shall have the following respective specifications.
   a. Dual core heat exchanger:
      1) Stage 1 - Gas to gas plate/fin core
         a) Materials of constructions shall be aluminum plate and fins
      2) Stage 2 - Gas to glycol fin/tube core
         a) Materials of construction shall be aluminum fins on Type 304L stainless steel tubes
      3) Mounted in single Type 304 stainless steel housing
      4) 150# ANSI B16.5 inlet and outlet connections
      5) All condensation generated during cooling will be removed inside the heat exchanger housing
      6) Level switch mounted on the housing to warn of drain failure
      7) RTD mounted on the housing to verify the coldest temperature that the gas reaches
      8) Automatic bottom drain system with strainer, no-gas-loss drain with level switch control, manual bypass and piping to constantly maintain discharge of water collected without allowing biogas to escape the system.
   b. Shell-in-tube heat exchangers:
      1) Pre-cooler/re-heater heat exchanger:
         a) Shell-in-tube unit to receive compressed biogas and pre-cool it using the 40° F chilled biogas as the cooling medium. The biogas is pre-cooled from 120° F to approximately 105° F, preparing it for delivery to the chiller heat exchanger while the 40° F chilled LFG is reheated to approximately 90° F for delivery.
         b) The wetted construction shall be of stainless steel.
      2) Glycol/biogas heat exchanger:
         a) Shell-in-tube unit to receive the compressed biogas from the Pre-cooler/Re-heater, and chill it to 40° F using the 35° F chilled glycol from the glycol chiller as the cooler medium. A moisture knockout filter or other means of removing moisture should be placed after the Glycol/biogas heat exchanger and the re-heater heat exchanger.
         b) The LFG wetted side construction shall be of Type 304 stainless steel.
         c) The glycol wetted side construction shall be of carbon steel.

K. Interconnecting Piping & Valves

1. All equipment provided on the CHP Gas Conditioning skids shall be pre-assembled (pre-piped, pre-wired, etc.) and connected by the biogas treatment system vendor in the factory prior to shipping in accordance with Drawings.

2. Piping shall be schedule 10S, Type 304L stainless steel upstream and downstream of the moisture separator or schedule 40 for pipe sizes less than 3-inches in diameter.

3. Interconnecting piping and instrumentation shall be in accordance with the P&IDs included with the Preliminary Drawings.

4. Piping and valving provisions shall be made to facilitate safely isolating and removing from service each independent piece of equipment and its associated upstream/downstream piping as required to allow uninterrupted operation of the remaining equipment in service. SOPs for safely removing and returning to service interim pipe segments shall be provided in accordance with Paragraph 1.04.

5. Biogas conditioning system shall be provided with recirculation line with modulating recirculation valve. Valve shall be a lug style butterfly valve, iron body with stainless steel disc and stem and FKM seat. Valve shall be supplied with a weatherproof, 120V, Type 7 Explosion proof actuator.

2.04 SILOXANE REMOVAL SYSTEM

A. The Siloxane Removal system shall include two siloxane scrubbers with support framing to be bolted directly to the equipment pad. All lead/lag piping, valves and piping appurtenances shall be supplied and installed by the Contractor. The scrubbers shall sit on a support frame to be mounted directly on a concrete pad as shown on the Drawings. The Siloxane Removal skid shall be located as shown on the Preliminary Drawings.

B. Siloxane Scrubber Vessels

1. Each siloxane scrubber shall be a custom fabricated, high-performance device that is designed for maximum siloxane removal at low pressure drops. The scrubbers shall be identical to one another in physical dimensions, materials of construction and media capacity. The scrubber diameter shall be five and a half feet. The maximum height shall be 10 feet or less above grade inclusive of the equipment pad, frame and scrubbers.

2. Siloxane scrubbers shall have 125-pound ANSI B16.5 flanges for direct connections to biogas piping. Siloxane scrubber vessels shall be fabricated from Type 304L stainless steel.

3. Siloxane scrubbers shall be provided with a system for safely purging flammable gases during bed replacement.

4. Siloxane scrubbers shall be provided with two tapped connections to accommodate purging with nitrogen gas. Purging ports shall be one-inch diameter and shall be provided with a ball valve.

5. Siloxane scrubbers shall be equipped with two access manways per vessel. One access manway shall be on the top of the vessel, and one access manway shall be on the side of the tank at the bottom. Each access way shall consist of a 24-inch diameter access hole and access cover with easy-open swing bolts, toggle bolts, or similar latches. Gasket materials shall be Buna-N or Viton.

6. Siloxane scrubbers shall be equipped with internal retention screens. Screens shall be removable to accommodate vessel servicing and contained completely within the interior of the vessel. All internal hardware shall be Type 304L, and shall be designed to be removable from the top or side hatch.

7. Each siloxane scrubber shall be provided with a manually operated drain at the bottom of the vessel.

8. Provide pressure relief valves to protect the scrubbers.

C. Siloxane Scrubber Support Frame

1. Each scrubber shall be supported on Type 304L stainless steel legs or a Type 304L stainless steel support frame designed by a professional structural engineer registered in the State of Tennessee. The frame and scrubber system shall be designed to meet the seismic requirements, outlined in Section 3 of the RFP document.

D. Access platform

1. The siloxane scrubbers shall be equipped with an access platform to provide access to the top access manway of both vessels. The platforms shall be equipped with handrails and shall meet all OSHA requirements.

2. A ladder with safety cage shall be provided for access to the elevated platform. The ladder shall extend from the ground surface to the access platform. The ladder shall be constructed of aluminum and shall meet all OSHA requirements.

E. Interconnecting Piping and Valves

1. All interconnecting piping and valves in the siloxane system shall be provided and installed by the Contractor. Piping shall be Type 304L stainless steel. Piping and valves shall be configured such that the siloxane scrubbers can be operated in series with a lead vessel and a polishing vessel. The piping and valve configuration shall be such that either of the vessels can be selected as the lead vessel. The design intent of the piping configuration is such that either vessel can be taken out of service without affecting the operation of the other siloxane scrubber.

2. As shown on the Preliminary Drawings the piping on the outlet of each siloxane scrubber shall include a biogas sampling tap with shutoff valve to facilitate manual grab sampling.

F. Siloxane Scrubber Media

1. The biogas treatment system vendor shall provide the initial charge of virgin activated carbon for each scrubber. The virgin activated carbon shall be produced from bituminous

coal. It shall be a pelleted carbon and shall be of a size to facilitate gas/media contact for siloxanes removal. No other media types are acceptable.

2. The scrubbers shall be provided with sufficient siloxane scrubber media to provide a 3-month bed life with one siloxane scrubber out of service at the average constituent concentrations and the average biogas flow rate specified herein.

3. Siloxane scrubber media shall be easily removed and refilled into the siloxane scrubbers. Design of the scrubbers shall be such that all tools required for removal of media and refilling media can be easily operated without causing the disassembly of any part of the Siloxane Removal skid, other than hatches and opening on the siloxane scrubbers.

4. All specialty tools required for the removal and refilling of siloxane scrubber media shall be provided by the biogas treatment system vendor.

5. Each scrubber shall be provided fully charged with media at startup. The media and the scrubber shall be shipped separately. The biogas treatment system vendor shall be responsible for providing the initial charge of the media. The media shall be installed by or under supervision of the biogas treatment system vendor.

2.05 PARTICULATE FILTER

A. Particulate filter shall remove all particles in excess of 3 microns.

B. Provide pressure indicator transmitter and pressure relief valve to protect the filters, as specified herein.

C. Filter shall accommodate purging and be provided with two tapped connections, one at the bottom of the vessel and a second at the top of the housing. Purging ports shall be 1-inch diameter and shall be provided with a ball valve.

D. Filter shall be provided with a manually operated drain valve.

E. Particulate filter shall be installed outside on an equipment pad adjacent to the siloxane vessels as shown on the Preliminary Drawings. Alternatively, the particulate filter can be co-located on the gas conditioning skid.

2.06 CHILLERS

A. The chiller system shall include one refrigerant dryer/chiller, consisting of: chiller condensers, chiller compressors, chiller evaporators (heat exchangers), chiller evaporation pumps, chiller cooling tanks and chiller unit pumps to reduce the dew point of the biogas and allow efficient removal of siloxanes. The chiller recirculation pump on each chiller skid shall be appropriately sized to recirculate the chilled water glycol/water solution from the cooling tank to the biogas cooling heat exchanger on the gas conditioning skid, via buried CGS/CGR prefabricated pre-insulated (PFPI) pipe, and back to the chiller tank.

B. The chiller skid shall be specifically adapted to biogas service and shall have been installed and successfully operated on a minimum of five biogas installations where digester gas is being chilled.

C. Chillers shall be appropriate for outdoor installation and shall be energy efficient with a minimum EER of 12.

D. Chiller coils, fins, and tubes shall be of marine grade aluminum or stainless steel.

E. All refrigerant piping shall be stainless steel or phenolic coated copper. Phenolic coating shall be Heresite or equal.

F. The biogas treatment system vendor shall coordinate the biogas cooling heat exchangers and the chillers to ensure that the equipment will meet the requirements for cooling biogas described herein.

G. The coolant supply and return piping between the biogas cooling heat exchanger and the chillers shall be provided by the Contractor. The Chiller skid shall be provided with flanged connections at the terminations of the coolant supply and return piping on the skid to facilitate connections with piping supplied by the Contractor.

H. Glycol circulated from the Chiller skid to the Biogas Conditioning skid shall be minimum 30% ethylene glycol.

I. The chiller system shall produce chilled water of no less than 34 degrees Fahrenheit.

J. The chiller system shall have a cooling Coefficient of Performance (COP) of no less than 3.0 at ambient temperatures between 60 and 100 degrees Fahrenheit and 34 degrees Fahrenheit chiller water temperature.

K. The chiller shall have an integrated part load value of at least 12.5.

L. The chiller system shall be provided with its own digital setpoint panel controller.

2.07 CONDENSATE DRAINS

A. Where a drain is specified, the drain shall meet the following requirements:

1. All drain systems shall be the product of a single manufacturer and shall be factory tested by the manufacturer in the presence of the Owner or their representative prior to shipping to the biogas treatment system vendor for installation on pre-assembled skids. The drains shall be designed and configured to eliminate gas releases to the atmosphere.

2. Electronics for automatic drain systems shall be explosion proof and Listed and Labeled for operation in Class 1 Division 1 classified areas. Electronics shall be rated for 120VAC, single phase power supply.

3. Portions of drain piping above ground or in a manhole shall be insulated and heat traced, or sheltered, in such a way as to prevent condensate from freezing in the pipe.

Drain Schedule

Equipment	Drain Type
H_2S Scrubbers	Inverted u-trap/gravity
CHP Gas Compressor Filters	Automatic
CHP Gas/PW Cooling Heat Exchanger	Automatic
Biogas Cooling Dual Core Heat Exchanger	Automatic
Siloxane Scrubbers	Manual ball valve
Particulate Filters	Manual ball valve

4. Manufacturers: Automatic condensate drains shall be as manufactured by Varec, Groth, or approved equal.

2.08 CONTROLS

A. The biogas treatment system vendor shall provide all instruments as indicated on the P&IDs.

B. Provide a marshalling junction box for each pre-assembled skid. All instruments and control wires, requiring external connection, shall be factory wired to the junction box, and terminated on terminal blocks. Junction box shall be NEMA Type 7, UL 886 approved. Low voltage components and wiring shall be separated from high voltage components and wiring as per NEC.

C. The chiller system shall be provided with its own digital setpoint panel controller to set the temperature differential and chilling loop temperature of the chiller compressors and the chiller unit pumps. Temperature indication of the glycol supply and return temperature shall be provided. The control panel for the chiller system shall be integral with and installed directly on the Chiller skid.

1. The Chiller Control Panel shall communicate to the Gas Conditioning Control Panel via hard wired contacts.
   a. Provide remote indication of chiller system running status.
   b. Provide remote indication of chiller system failure status.
   c. Provide remote indication of the chiller system energy usage (kWh).
   d. Provide remote indication of each HAND-OFF-AUTOMATIC selector switch position.

2. The local HAND-OFF-AUTOMATIC selector switch shall have the following functions:
   a. HAND position: Start-stop control from chiller control panel pushbuttons.
   b. OFF position: Chiller system off.
   c. AUTOMATIC position: remote dry contact closure shall start and stop the chiller system.

D. The Biogas Treatment System shall be provided with a NEMA 4X, UL508A labeled, stainless steel, free standing, PC/PLC based Gas Conditioning Control Panel (GASCP) and located under the canopy as shown on the Preliminary Drawings. All equipment provided under this Section shall be controlled by an Allen-Bradley Compact Logix PLC within the GASCP. The panel shall include all programming necessary for monitoring and control of the provided equipment. The GASCP shall have an Allen-Bradley PanelView Plus 7 (or latest version available upon

submission), or equal, nominal 12-inch diagonal size, operator interface terminal (OIT) for the monitoring and control of the equipment. The control system shall interface with the Plant SCADA system via Ethernet communications. The system shall transmit alarm, status and monitoring signals to the Plant SCADA system.

1. The gas conditioning equipment supplier shall include a small patch panel and ethernet switch with fiber ports or ethernet media converter in the GASCP. The Contractor will be running a 6-strand multimode cable with ST connectors between the GASCP and an existing PLC panel to connect to the plant SCADA system. See system architecture drawing.

2.09 SURFACE PREPARATION AND FIELD PAINTING

A. All non-stainless steel surfaces shall be primed and painted or galvanized in the shop as a part of the work under this Section. Surface preparation, shop priming and painting shall conform to the requirements of Division 9. Ferrous surfaces furnished shop primed shall be compatible with finish paint. Field painting is included in Section 09902.

2.10 SPARE PARTS

A. One removable cartridge for each H_2S monitor.

B. Two sets of seals for all pumps and compressors.

C. Two sets of all gaskets.

D. Two sets of all bearings.

E. One of each type and size switches and transmitters provided under this Section.

PART 3 EXECUTION

3.01 INSTALLATION

A. Contractor is to supply all anchor bolts, temporary lift equipment, power, water, labor and all other incidentals required for proper installation of the equipment.

B. Installation shall be in strict accordance with the biogas treatment system vendor’s recommendations and instructions, and the best practices of the trade, in the locations shown on the Preliminary Drawings. Anchor bolts shall be set in accordance with the manufacturer's installation drawings or template. Installation shall include connections required for cooling water, power and controls. Furnish all oil and grease lubricants grades in accordance with the manufacturer's recommendations and apply them ready for initial operation.

C. Field Quality Control: Manufacturer shall furnish an authorized field engineer to inspect, test, and adjust field assembled component and equipment installation including connections and control system programming modifications, as necessary, and to supervise field test performance. Manufacturer’s representative shall issue a standard form Certificate of Proper Installation (COPI) to the Owner confirming that the equipment has been installed in accordance with the manufacturer’s recommendations.

3.02 FACTORY TESTING

A. Factory Acceptance Testing (FAT) of the biogas treatment system monitoring and control system shall be performed as described under Division 13. Within 7-days following successful completion of the FAT, the biogas treatment system vendor shall provide to the Owner a complete, documented program listing of all application programs developed for monitoring and control of the biogas treatment system.

B. All pre-assembled skids shall be factory tested in the presence of the Owner or their representative prior to shipping to the jobsite. A factory testing plan and schedule shall be submitted to the project representative a minimum of 14 days in advance of the scheduled testing.

3.03 FIELD TESTING

A. Functional System Test:

1. Prior to placing the equipment into operation all equipment described in this Section shall be inspected, in the presence of the Project Representative and the biogas treatment system vendor, for proper connection, proper alignment, quiet operation and satisfactory performance by means of a functional system test in accordance with Section 01465. The biogas treatment system shall be operated under the full range of flow conditions expected in this installation, including a simulation of a loss of cooling water supply and low biogas system pressure. During the functional test, the mechanical elements shall be observed for excessive vibration and noise and for overheating. Furnish and install temporary electric metering equipment to allow observance of the power draw by the unit under the full range of operating conditions.

2. Upon completion of the functional system tests, the biogas treatment system vendor shall certify in writing that the installation is acceptable and will not invalidate any warranty provided for the equipment.

3. Blower motors and blowers shall be field tested for operating vibration and natural frequencies as specified in Section 01465.

4. Blower motors and blowers shall be field tested for operating noise levels.

B. Operational Test:

1. Upon successful completion of functional system testing, schedule and perform operational testing of the complete biogas treatment system in accordance with Section 01465.

C. Performance Test:

1. A performance test shall be conducted two months following beneficial use of the biogas treatment system and again nine months after beneficial use of the biogas treatment system to determine the level of treatment being achieved.

2. Performance test procedures shall be provided by the biogas treatment system vendor and approved by the Owner's Representative. Chemical analysis shall be provided by the biogas treatment system vendor.

3. The Owner may independently sample and analyze the biogas. If the Owner's sample analysis and the biogas treatment system vendor's analysis differ significantly, a subsequent sample shall be taken and sent to an independent laboratory for verification. If the subsequent analysis shows that the biogas treatment system is meeting the performance specifications of this section, then the Owner will pay for the subsequent sampling and biogas analysis. If the subsequent analysis shows that biogas treatment system fails to meet the performance requirements of this specification, then the biogas treatment system vendor shall pay for the subsequent sampling and biogas analysis.

4. Failure to meet the performance requirements listed in this Section shall be cause for replacement or repair at the biogas treatment system vendor's expense.

5. The biogas treatment system vendor may request monthly samples and biogas analyses prior to treatment to verify that the biogas is in compliance with the Design Requirements and Operating Conditions of this Section. All equipment and biogas analyses required for the monthly testing shall be paid by the biogas treatment system vendor. The Owner, at their sole discretion may conduct independent sampling and analyses and will pay for independent sampling and analyses except when failed tests result in additional testing. Additional sampling and analyses necessitated by previous test failures shall be paid by the Contractor.

3.04 TRAINING

A. The biogas treatment system vendor shall provide three 8-hour days of training services for this system in accordance with Section 01465. Training shall include methodology for obtaining biogas samples and preparation on chain of custody for sample taking in addition to full Operations & maintenance procedures for the biogas treatment system.

END OF SECTION

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SECTION 15250
THERMAL INSULATION

PART 1 GENERAL

1.01 SCOPE OF WORK

A. This Section specifies the basic materials and methods of installation for insulation for process equipment, piping, valves, and fittings as specified herein and where shown on the Drawings. Specific uses and applications are specified in the following Sections.

1. Specification Sections
   a. Section 13239 – Combined Heat and Power System
   b. Section 13240 – Digester Gas Treatment System
   c. Section 15541 – Centrifugal Pumps

1.02 RELATED WORK

A. System applications for insulations are specified in other Sections of Division(s) 11, 13 and 15.

1.03 SUBMITTALS

A. Submit, in accordance with Section 01300, the following for each insulation by System: manufacturer's product data showing conformance with this Section for all required insulations, jackets, covers, coatings, adhesives, fasteners, supports and appurtenances; and complete manufacturer's instructions for installation of all required items.

B. All submittals shall contain a statement that Sections defining specific insulation types and thickness and all other referenced Sections have been read and complied with. The certification statement shall specify the specific Sections and be made by all of the following that are applicable; the Contractor, sub-contractor and the vendor. The statement shall be an individual statement for each party involved, and shall be included with every submittal and resubmittal.

C. All materials deliveries must have accompanying manufacturer's certifications attesting to satisfactory results of product testing showing conformance with this Section.

D. For units that will be shipped exposed, provide a description of the protective packaging that will be used during transit.

E. In general, corrections or comments or lack thereof made relative to submittals during review shall not relieve the Contractor from compliance with the requirements of the drawings and specifications. Submittals are for review of general conformance with the design concepts of the project and general compliance with the contract documents. The Contractor is responsible for the final design conforming and correlating all quantities and dimensions, selecting fabrication processes and techniques of construction, coordinating the work of all trades, and performing the work in a safe and satisfactory manner.

1.04 REFERENCE STANDARDS

A. American Conference of Governmental Industrial Hygienists (ACGIH)

B. American Society for Testing and Materials (ASTM)

C. Leadership in Energy and Environmental Design (LEED)

D. National Fire Protection Association (NFPA)

E. Occupational Safety and Health Administration (OSHA)

F. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.05 QUALITY ASSURANCE

A. The insulation materials to be furnished under this section shall be essentially the standard products of manufacturers regularly engaged in the manufacture of insulation systems.

B. Several manufacturers are indicated as acceptable for each type of insulation in these specifications. The Insulation Sub-contractor shall be responsible for determining that all insulation supplied for the project is suitable for installation in the spaces indicated. The Insulation Sub-contractor shall also ensure that all materials used are compatible and in compliance with applicable codes and standards.

C. The Owner and Engineer reserve the right to sample and test any materials after delivery and to reject all components represented by a sample that fails to comply with the specified requirements.

1.06 DELIVERY, STORAGE, AND HANDLING

A. All materials shall be inspected for size, quality, and quantity against approved shop drawings upon delivery.

B. Delivery schedule of all equipment shall be coordinated with the Contractor. Equipment ready for shipment prior to the agreed on shipping date shall be stored without cost to the Owner by the manufacturer.

C. All equipment shipped that is exposed, such as on a flat bed truck, shall be protected during transit. The equipment shall be protected from moisture, road salt, dirt and stones or other materials thrown up from other vehicles. Electrical components shall be protected as above, but with special attention to moisture. The method of shipment protection shall be defined in the submittals.

D. All materials shall be suitably packed for shipment and long-term storage. Each package shall be labeled to indicate the project and the contents of each package. Where applicable, equipment numbers shall be marked on the container.

E. All materials shall be stored in a covered dry location off of the ground. When required to protect the materials they shall be stored in a temperature-controlled location.

F. Refer to Section 01610 for additional requirements.

1.07 DEFINITIONS

A. Particular terminology used under this Section is defined as follows. Not all terms listed below apply to this project.

1. Traffic Level and Personnel Level - Areas, including process areas, equipment rooms, boiler rooms and other areas where insulation may be damaged by normal activity and local personnel traffic. Area extends to eight feet above floor, walkways, platforms and stairs, and horizontally three feet beyond the edge of walkways, platforms, and stairs.

2. Exposed Piping - Piping visible from the floor level and includes all piping and ductwork in equipment rooms, boiler rooms, etc.

3. Concealed Piping - Piping not visible from the floor level and includes piping and ductwork above hung ceilings and in shaftways.

4. Ventilated Spaces - Areas supplied with outdoor air on a continuous or intermittent basis. The outdoor air may be heated and/or cooled or untreated.

5. Heated Spaces - Areas where heat is supplied to maintain a minimum temperature during the heating season.

6. Unheated Spaces - Areas where heat is not applied and there is no minimum temperature during the heating season.

7. Conditioned Spaces - Areas that are provided with heating and mechanical cooling.

8. Non-Conditioned Spaces - Areas that are not provided with mechanical cooling.

9. Indoor Piping - Piping within a building that is not exposed to the weather.

10. Outdoor Piping - Piping that is not within a building and which is exposed to the weather.

PART 2 PRODUCTS

2.01 GENERAL

A. All materials and integrated insulation assemblies furnished shall have flame spread ratings of not over 25 (fire resistive) and smoke developed rating of not over 50 as established by tests conducted in accordance with ASTM E84.

B. The toxicity of the solvents used shall not exceed a maximum allowable concentration of 200 ppm or the latest value published by the American Conference of Governmental Industrial Hygienists and OSHA.

C. Adhesives, coatings and vapor barrier materials shall be compatible with the insulation as recommended by the insulation manufacturer. Submit a certified statement attesting to the approval of the materials by the insulation manufacturer. Adhesives, sealants, mastics and coatings shall be manufactured by Foster; H.B. Fuller Construction Products; Childers or approved equal. Foster and Childers (CP) Numbers are listed below by adhesive/sealant/coating types.

1. Lagging adhesive/coating: 30-36, CP-50, AMV-1. (LEED IEQ 4.2 compliant as a coating).

2. Vapor barrier coating: 30-35, CP-30. (To meet LEED IEQ Credit 4.2, select water based, Foster 30-80, Childers CP-38)
   a. Permeance shall be 0.013 perms or less at 43 mils dry per ASTM E96, Procedure B.

3. Vapor seal lap adhesive: 85-20, CP-82. (To meet LEED IEQ Credit 4.1, select Foster 85-60).

4. Duct insulation adhesive: 85-20, CP-82. (To meet LEED IEQ Credit 4.1, select Foster 85-60, Childers CP-127).

5. Metal Jacketing/Flashing Sealant: 95-44, CP-76 (LEED IEQ 4.1 compliant).

6. Weather Barrier mastic (light gray): 46-51, CP-10-1. (LEED IEQ 4.2 compliant as a coating).

7. Cellular glass adhesive and joint sealant: Pittseal CW as recommended by the manufacturer.

2.02 INSULATION FOR HOT PIPING (TYPE I-1)

A. Hot piping systems include but are not limited to:

1. All exposed process air piping.

2. All exposed hot water piping, including CHP systems like Boiler Feedwater, Blowdown, and Condensate.

3. All exposed digester gas (DG) piping.

B. Insulation Material - Molded rigid fiberglass sectional pipe insulation rated to 850 degrees F. The insulation shall have a maximum “K” factor of 0.24 at 75 degrees F mean temperature. Insulation thickness shall be 2 inches except as indicated in the respective piping system specification.

C. Jacket

1. Indoor Piping - Jacket shall be kraft paper bonded to aluminum foil reinforced with fiberglass yarn and self-sealing lap.

2. Indoor Piping at Traffic Level - Jacket shall be kraft paper bonded to aluminum foil reinforced with fiberglass yarn and self-sealing lap with field applied 0.016-in thick aluminum jacket and aluminum draw bands.

3. Outdoor Piping - Jacket shall be factory or field applied 0.016-in thick aluminum, with aluminum draw bands.

D. Fittings Covers

1. Indoor Piping - Preformed aluminum covers.

2. Outdoor Piping - Preformed aluminum covers.

E. Acceptable manufacturers shall be Manville Corp., Certain-Teed, Owens-Corning Fiberglas, or equal.

2.03 INSULATION FOR COLD PIPING WITHOUT VAPOR BARRIER (TYPE I-2)

A. Cold piping systems without vapor barrier include but are not limited to:

1. Outdoor, exposed process piping 6 inches in diameter and smaller. Excludes process air piping and other process piping systems listed in Paragraph 2.02 above.

2. Outdoor, exposed plant water piping, including pump seal water piping.

3. Outdoor, exposed potable and protected water piping.

4. Outdoor, exposed process drains, including but not limited to odor control system drains.

B. Insulation Material - Molded rigid fiberglass sectional pipe insulation rated to 850 degrees F. The insulation shall have a maximum “K” factor of 0.24 at 75 degrees F mean temperature. Insulation thickness shall be 2 inches.

C. Jacket

1. Indoor Piping - Jacket shall be kraft paper bonded to aluminum foil reinforced with fiberglass yarn and self-sealing lap.

2. Indoor Piping at Traffic Level - Jacket shall be kraft paper bonded to aluminum foil reinforced with fiberglass yarn and self-sealing lap with field applied 0.016-in thick aluminum jacket and aluminum draw bands.

3. Outdoor Piping - Jacket shall be factory or field applied 0.016-in thick aluminum, with aluminum draw bands.

D. Fittings Covers

1. Indoor Piping - Preformed aluminum covers.

2. Outdoor Piping - Preformed aluminum covers.

E. Acceptable manufacturers shall be Manville Corp.; Certain-Teed; Owens-Corning Fiberglas or equal.

2.04 INSULATION FOR COLD PIPING WITH VAPOR BARRIER (TYPE I-3)

A. Cold piping systems with vapor barrier include but are not limited to:

1. Glycol.

B. Insulation Material - Molded rigid fiberglass sectional pipe insulation rated to 850 degrees F. The insulation shall have a maximum "K" factor of 0.24 at 75 degrees F mean temperature.

C. Jacket

1. Outdoor Piping - Jacket shall be kraft paper bonded to aluminum foil reinforced with fiberglass yarn and self-sealing lap with a maximum permeability of 0.02 perms with field applied 0.016-in thick aluminum jacket.

D. Fittings Covers

1. Outdoor Piping - Preformed aluminum covers

E. Acceptable manufacturers shall be Manville Corp., Certain-Teed, Owens-Corning Fiberglas, or equal.

2.05 INSULATION FOR HOT EQUIPMENT (TYPE I-10)

A. Insulation for hot equipment applications includes, but is not limited to:

1. Hot water pumps.

2. Heat exchangers.

B. Insulation Material - Fibrous glass semi-rigid board rated to 450 degrees F. The insulation shall have a minimum density of three pounds per cubic foot and a maximum “K” factor of 0.24 at 500 degrees F. Insulation thickness shall be 2 inches or as recommended by the equipment manufacturer.

C. Jacket shall be field-applied glass cloth.

D. Acceptable manufacturers shall be Owens-Corning Fiberglas, Manville Corp., Certain-Teed, or equal.

PART 3 EXECUTION

3.01 GENERAL

A. Do not apply insulation prior to testing and acceptance of piping, ductwork and/or equipment. Insulation shall not be applied to damp or frosty surface. Clean dust, dirt, grease and moisture from surfaces of pipe and ducts before applying insulation or insulation adhesives. Nameplates and equipment certification and data tags affixed to any piece of apparatus shall not be covered. Where two layers of insulation are used, stagger all joints both ways. Secure each layer independently. Continue insulation and jacketing through walls, partitions, floors and pipe sleeves except for partitions that are sealed with a mechanical seal.

B. The Contractor shall not install any equipment or materials until the Owner and Engineer have approved all submittals. If any equipment or materials are installed prior to approval of the submittals, it shall be at the Contractor’s risk.

C. Insulation, adhesives, coatings and vapor barrier materials shall be applied in accordance with manufacturer's recommendations. Do not apply these materials when ambient temperature is above or below the maximum and minimum ambient temperature respectively, specified as limits by the manufacturer.

D. All penetrations through a vapor barrier for hangers, instruments, etc, shall be sealed to provide a complete vapor barrier. The use of staples or other fasteners that penetrate the vapor barrier is not permitted.

E. Insulation systems that require a vapor barrier shall be installed with an intact vapor barrier that covers the entire pipe, duct, or piece of equipment to be insulated. All edges of insulation that do not about another piece of insulation shall have the vapor barrier extended, and sealed to the item being insulated. All penetrations through the insulation such as for thermowells, test ports, dampers, nameplates, or other items shall have the vapor barrier extend over the edges of the insulation and sealed to the item being insulated. Where items are mounted on ductwork a standoff shall be provided to protect the vapor barrier. The vapor barrier shall be sealed to the standoff.

F. For insulated items exceeding 100 square feet, or 20 feet in length, extend the vapor barrier to the item being insulated to reduce the area or length within a single enclosed area to the dimensions listed above.

3.02 INSTALLATION OF PIPING INSULATION

A. Pipe shields and pipe saddles shall be provided.

B. Preformed sectional insulation and jacketing shall be used where possible. The use of blanket insulation will be limited to fittings that cannot be insulated with sectional insulation. All joints on preformed and fabricated insulation shall be accurately fitted to eliminate voids. Voids shall be eliminated by refitting or replacing the insulation. End joints shall be firmly butted to adjoining sections of insulation.

C. Outdoor piping insulation shall be installed so as to keep the insulation dry. Joints shall be located to prevent the entrance of water. Breaks in jacketing caused by vertical connections or instruments shall be protected by hoods or cones. Where there are breaks in the jacket, plastic moisture barriers shall be provided under the jacketing to protect the insulation. Insulation and jacketing of valves shall be waterproofed. Insulation and jacketing of the valve shall be removable to allow servicing of the valve.

D. Vapor seal adhesive shall be used to seal seams and to butt sections on all cold piping if self sealing laps are not provided. The use of staples or any other fastening method that would penetrate the vapor barrier will not be permitted on cold piping systems. Staples may be used on hot piping systems where there is no potential for condensation.

E. Metal or plastic jacketing shall have its joints staggered from those of the insulation. Joints between jacketing and insulation shall be staggered a minimum of three inches.

F. Metal or plastic jacketing shall have a minimum three inch overlap on longitudinal joints and end joints. Longitudinal joints in horizontal piping shall have the outer lap of the joint pointed down to shed water. The end of the outer lap shall be located at the five or seven o'clock positions.

G. Where piping is provided with electric or steam heat tracing the insulation shall not be installed until the heat tracing has been tested and accepted. Insulation shall be sized to allow for the heat tracing line without deforming the insulation.

H. Where supports, anchors or guides are in direct contact with cold piping, insulate the item in contact a distance of four times the insulation thickness. Clamps and non-welded support devices shall be contained within the insulation. The space within insulating saddles at pipe hangers shall be filled with insulation.

I. On vertical risers exceeding 15-ft in height, provide intermediate support for the insulation. For carbon steel pipe, this support shall consist of angle clips or other suitable devices welded to the pipe at about 15-ft on centers and concealed by the pipe covering. On non-carbon steel piping, clamps or other non-welded devices shall be used.

J. Unless otherwise specified insulate all valves, control valves, fittings, pipe specialties and all other components that could be construed as being part of the piping system. Insulate valve bonnets to a point just below the stuffing box.

K. Bridge flanges, unions, and pipeline strainers with block or sectional insulation wired in place. Wire shall be black steel, annealed. Stop the pipe insulation a sufficient distance to allow removal of flange bolts without disturbing the pipe insulation and extend the block, at least two-in over the adjacent pipe insulation. Flange covers shall be designed for removal without damaging the pipe insulation. Fill voids with blanket insulation.

L. Where there are lines run between two different piping systems, e.g., make up water line between city water and chilled water, the interconnecting line shall be insulated the same as the system having the most rigid requirements. If one of the lines is not insulated the interconnecting line shall be insulated the same as the insulated line.

M. Where possible, all insulation shall be continuous through wall and floor openings and sleeves.

3.03 INSULATION FOR HOT PIPING (TYPE I-1)

A. Installation

1. Apply insulation in thicknesses indicated. Laps and joints shall be sealed using self-sealing laps or outward clinch staples. Laps in horizontal piping shall be at the top.

2. Where factory applied aluminum jacket is used for outdoor piping, factory supplied aluminum closures with sealing compound shall be used at all joints. Seams shall be located to shed water.

3. Where field applied aluminum jacket is used for outdoor piping or indoor piping at traffic level, the jacket shall be attached with aluminum draw bands located within 3-in of each joint and 24-in on center maximum. Jacket on outdoor piping shall have joints arranged to shed water.

4. Fittings shall be wrapped with blanket insulation to provide the same insulation value as required for straight piping. PVC fitting covers where specified shall be attached with tacks and taping to the adjacent pipe insulation. Aluminum fitting covers shall be attached by aluminum draw bands with joints located to shed water.

B. Insulation thickness shall be as specified in Paragraph 2.02.

3.04 INSULATION FOR COLD PIPING WITHOUT VAPOR BARRIER (TYPE I-2)

A. Installation

1. Apply insulation in thicknesses indicated. Laps and joints shall be sealed using self-sealing laps or outward clinch staples. Laps in horizontal piping shall be at the top.

2. Where factory applied aluminum jacket is used factory supplied aluminum closures with sealing compound shall be used at all joints. Seams shall be located to shed water.

3. Where field applied aluminum jacket is used, the jacket shall be attached with aluminum draw bands located within 3-in of each joint and 24-in on center maximum. Jacket piping shall have joints arranged to shed water.

4. Fittings shall be wrapped with blanket insulation to provide the same insulation value as required for straight piping. Aluminum fitting covers shall be attached by aluminum draw bands with joints sealed with sealing compound adhesive and located to shed water.

B. Insulation thickness shall be as specified in Paragraph 2.03.

3.05 INSULATION FOR COLD PIPING WITH VAPOR BARRIER (TYPE I-3)

A. Installation

1. Apply insulation in thicknesses indicated. Laps and joints shall be sealed using self-sealing laps or vapor barrier tape. Laps in horizontal piping shall be at the top. Seal ends of insulation sections at flanges, valves and fittings on 15-ft centers in straight pipe with vapor barrier coating that extends from vapor barrier jacket to the piping. All penetration of the vapor barrier shall be sealed vapor tight, including staples if used.

2. Where field applied aluminum jacket is specified the jacket shall be attached with aluminum draw bands located within 3-in of each joint and 24-in on centers maximum. Jackets on outdoor piping shall have joints arranged to shed water.

3. Fittings shall be molded fiberglass or mitered sections of pipe insulation to provide the same insulation value as required for straight piping. PVC fitting covers, where specified, shall be sealed with vapor seal adhesive. Circumferential edges shall be wrapped with vapor barrier tape. Where preformed aluminum fitting covers are specified a vapor barrier coating reinforced with glass cloth shall be applied directly to the insulation before installing the fitting cover. The vapor barrier shall be installed in accordance with the coating manufacturer's instructions. Aluminum fitting covers shall be attached with aluminum draw bands with joints located to shed water.

B. Insulation thickness shall be as specified in Paragraph 2.04.

3.06 INSTALLATION OF EQUIPMENT INSULATION - GENERAL

A. Equipment normally furnished with inspection splits shall be insulated in two sections so that a removable section can be removed without damage to the stationary section.

B. Manhole covers and access door covers shall be formed of built-up insulation and reinforced with aluminum jacketing so that the entire piece covering the manhole, or door, can be easily removed and replaced us a unit.

3.07 INSULATION FOR HOT EQUIPMENT (TYPE I-10)

A. Installation

1. Apply installation in thickness indicated. Cut insulation to fit the surfaces. Hold in place by means of lacing 14 gauge galvanized wire or 1/2-in by 0.015-in stainless steel band at a maximum of 12-in on center. Where required, provide welded studs, clips or angles as anchors for wires or bands. Fill joints and indentations with insulating cement. Cover entire surface with a 1/4-in coat of insulating cement and galvanized bead at corners. Finish with a second 1/4-in coat of insulating cement worked to a smooth hard surface. Do not cover nameplate, and neatly bevel edges of the insulation and coating at edges of all nameplates. When the cement is thoroughly dry, apply a brush coat of lagging adhesive to the entire cement surface. Embed into the wet coating a layer of glass cloth, overlapping all seams a minimum of two-in, smoothing out to avoid wrinkles. Apply a finish coat of lagging adhesive to entire surface.

2. Pump bodies shall be insulated in two sections so that the top half of the pump casing may be removed without disturbing the insulation on the lower half. The joint between the two sections of the insulation shall be filled with joint and sectional sealer, which can be removed when dismantling the pump.

B. Insulation thickness shall be as specified in Paragraph 2.05 or as recommended by the equipment manufacturer.

END OF SECTION

SECTION 15505
PIPING

PART 1 GENERAL

1.01 SCOPE OF WORK

A. Furnish and install all piping, valves, fittings and accessories to be used for the various systems as specified herein.

B. Furnish and install pipe hangers, supports, guides, shields, concrete inserts and anchor bolts for supporting piping.

C. The absence of pipe supports and details on the Drawings shall not relieve the Contractor of the responsibility for providing them.

D. Design, furnish and install seismic restraints and braces for all piping and accessories.

E. All piping, and equipment shown on the Drawings is intended to be approximately correct to scale, but figured dimensions and detailed drawings of the actual equipment furnished shall be followed in every case. The Drawings shall be taken in a sense as diagrammatic. Size of piping are shown, but it is not the intent to show every offset or fitting, nor every hanger or support, or structural difficulty that may be encountered. To carry out the intent and purpose of the drawings all necessary parts to make a complete working system ready for use shall be furnished without extra charge. The Contractor shall be responsible to coordinate the system installation and routing with the work of all trades.

1.02 RELATED WORK

A. Thermal insulation is included in Section 15250.

1.03 SUBMITTALS

A. Submit the following in accordance with Section 01300, for each of the piping system services furnished under this Section:

1. Piping system materials and assembly methods summary in tabular format listing the pipe materials, joining methods, pipe fitting types and materials, hanger types and materials with proposed hanger spacing. Include equipment catalog data or cut sheets for the piping system materials, identified with the applicable system service proposed for use.

2. Piping system valve schedules in tabular format, with catalogue data sheets showing materials of construction, flow characteristics; valve options or special trim to be furnished; and any special or precautionary handling or installation procedures. Valve schedules shall be organized by valve type; system service; size; pipe size and joint type.

3. Catalog cuts and data sheets for all piping specialties, such as traps, strainers, gauges, thermometers, vents, vacuum breakers, piping labels, flex connectors, test plugs, suction diffusers, expansion tanks, air separators and similar appurtenances. Clearly identify submittal items indicating the system services for which the submitted item is proposed for use.

4. Piping layout drawings, showing locations of all piping appurtenances and specialties including flow stations, circuit setters and valve banks for equipment piping isolation and control.

5. Typical piping details at coils, unit heaters, air handling units, heat exchangers, pumps and other major system components.

6. Confirmation that adequate protective packaging will be used during transit for all equipment shipped exposed.

B. In general, corrections or comments or lack thereof made relative to submittals during review shall not relieve the Contractor from compliance with the requirements of the drawings and specifications. Submittals are for review of general conformance with the design concepts of the project and general compliance with the contract documents. The Contractor is responsible for the final design conforming and correlating all quantities and dimensions, selecting fabrication processes and techniques of construction, coordinating the work of all trades, and performing the work in a safe and satisfactory manner.

1.04 REFERENCE STANDARDS

A. ASTM International

1. ASTM A53 - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.

2. ASTM A307 - Standard Specification for Carbon Steel Bolts and Studs, 60,000 psi Tensile Strength.

3. ASTM B32 - Standard Specification for Solder Metal.

4. ASTM B88 - Standard Specification for Seamless Copper Water Tube.

5. ASTM B306 - Standard Specification for Copper Drainage Tube (DWV)

6. ASTM A234 - Standard Specification for Piping Fittings of Wrought Carbon Steel Pipe.

7. ASTM A312 - Standard Specification for Seamless and Welded Austenitic Stainless Steel Pipe.

8. ASTM A395 - Standard Specification for Ferritic Ductile Iron Pressure-Retaining Castings.

9. ASTM A536 - Standard Specification for Ductile Iron Pipe.

B. American National Standards Institute (ANSI)

1. ANSI B16.18 - Cast Copper Alloy Solder Joint Pressure Fittings

2. ANSI B16.22 - Wrought Copper and Copper Alloy Solder Joint Pressure Fittings.

3. ANSI B16.29 - Wrought Copper and Wrought Copper Alloy Solder Joint Drainage Fittings (DWV).

4. ANSI B31.1 - Power Piping.

C. American Society of Mechanical Engineers (ASME)

D. American Institute of Steel Construction (AISC)

E. Pipe Fabrication Institute (PFI)

F. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.05 QUALITY ASSURANCE

A. All equipment of a given type included in this section shall be furnished by or through a single manufacturer or as specified on the schedules.

B. Inspection by the Engineer's representative or failure to inspect shall not relieve the Contractor of responsibility to provide materials and perform the work in accordance with the documents.

C. The piping manufacturer shall furnish an affidavit of compliance certifying that all materials used and work performed shall comply with the specified requirements. The Contractor shall provide copies of mill test confirming the type of material used in the various components.

D. The Owner and Engineer reserve the right to sample and test any materials after delivery and to reject all components represented by a sample that fails to comply with the specified requirements.

1.06 DELIVERY, STORAGE AND HANDLING

A. All materials shall be inspected for size, quality and quantity, against approved shop drawings, upon delivery.

B. Delivery schedule of all equipment shall be coordinated with the Contractor. Equipment ready for shipment prior to the agreed upon shipping date, shall be stored by the manufacturer, without additional cost to the Owner.

C. All materials shall be suitably packed for shipment and long-term storage. Each package shall be labeled to indicate the project and the contents of each package. Where applicable, equipment numbers shall be marked on the container.

D. All equipment shipped that is exposed, such as on a flatbed truck, shall be protected during transit. The equipment shall be protected from moisture, road salt, dirt and stones or other materials thrown up from other vehicles. Electrical components shall be protected as above, but with special attention to moisture. The method of shipment protection shall be defined in the submittals.

E. All materials shall be stored in a covered dry location off of the ground. When required to protect the materials, they shall be stored in a temperature-controlled location.

1.07 ENGINEER SERVICES

A. Detailed analysis and design engineering services related to the selection and placement of anchors, guides and expansion loops are to be provided by the Contractor. The engineer shall be licensed at the time the work is done and in the State in which the project is located. If the state issues discipline specific licenses, the engineer shall be licensed in the applicable discipline. In addition, the engineer shall be experienced in the type of work being provided.

B. All work is to be done according to the applicable regulations for professional engineers, to include signing, sealing and dating documents. When submittals are required by a professional engineer, in addition to state required signing and sealing, a copy of the current wallet card or wall certificate indicating the date of expiration shall be included with the submittal.

1.08 SPARE PARTS

A. Spare parts shall include all special items on the manufacturer's standard list of spare parts.

B. Furnish all special tools required for normal operation and proper servicing of the equipment.

C. Pack spare parts in containers suitable for extended storage without deterioration of the parts. Containers shall be clearly labeled designating contents, pieces of equipment for which intended and equipment identification numbers.

PART 2 PRODUCTS

2.01 PIPE AND FITTINGS

A. Chilled Water, Hot Water Heating and Engine Exhaust Gas and Cooling Water Piping.

1. Pipe shall be ASTM A53, Grade A or B Schedule 40 seamless. Fittings for piping 2-1/2-in and less shall be 125 lb cast iron screwed, 150 lb malleable iron screwed or forged socket welded. Fittings for piping three-in and greater shall be wrought carbon steel Schedule 40 butt weld. Elbows shall be long radius.

2. Flanges shall be 150 lb forged carbon steel flat face. Flanges for piping 2-1/2-in and less shall be socket weld and for piping three-in and greater shall be welding neck or slip on.

3. Unions for piping 2-1/2-in and less shall be 300 lb malleable iron ground joint and for piping 3-in and greater shall be flanges.

4. Nipples for piping 2-1/2-in and less shall be Schedule 40, ASTM A53, Grade A or B seamless and shall be a minimum of four-in long. Close nipples are not permitted.

5. Gaskets shall be full face 1/16-in thick compressed non-asbestos sheet packing with synthetic fibers and fillers and elastomeric binder suitable for use with glycol solution.

6. An acceptable alternate for piping 2-1/2-in and less is ASTM B88, Type L hard copper tubing. Fittings shall be soldered wrought copper ANSI B16.22 or pressure-sealed joints. Solder shall be 95 percent tin and five percent antimony per ASTM B32 Alloy 95TA.

B. Engine Exhaust Piping

1. Pipe shall be ASTM A53, Grade A or B Schedule 80 seamless. Fittings for piping 2-1/2-in and less shall be forged socket welded. Fittings for piping three-in and greater shall be wrought carbon steel Schedule 80 butt weld. Elbows shall be long radius.

2. Flanges shall be 150 lb forged carbon steel flat face. Flanges for piping 2-1/2-in and less shall be socket weld and for piping three-in and greater shall be welding neck or slip on.

3. Unions for piping 2-1/2-in and less shall be 300 lb malleable iron ground joint and for piping 3-in and greater shall be flanges.

4. Nipples for piping 2-1/2-in and less shall be Schedule 80, ASTM A53, Grade A or B seamless and shall be a minimum of four-in long. Close nipples are not permitted.

5. Gaskets shall be full face 1/16-in thick compressed non-asbestos sheet packing with synthetic fibers and fillers and elastomeric binder suitable for use with glycol solution.

2.02 VALVES

A. Where grooved pipe joints are approved for use, valves shall be equivalent, with grooved connections or with a flange to groove adapter provided as part of the valve assembly.

B. Figure numbers are given to give a pictorial description of the specified valve and to indicate the quality of valves specified. Similar types of other approved manufacturer's valves are acceptable.

C. Provide extended stems and lever handles to accommodate two-inch insulation thickness on ball and butterfly valves.

D. Chilled Water, Hot Water Heating, Condenser Water and Hot and Cold Glycol/Water Valves shall be in accordance with the table below:

Chilled Water, Hot Water Heating, Condenser Water and Hot and Cold Glycol/Water Valves									
Type	**Size Inches**	**Press Rating psig**	**Conn**	**Style**	**Stem**	**Body & Bonnet**	**Seat**	**Disc**	**Typical Valve Fig. No.**
Ball	3/4 to 2	300	Vic Press	Lever Oper	Brass	Forged Brass	TFE	Brass	Victaulic Series 589
Ball	2.5 to 6	800	Grv	Lever Oper	Chrome Plated	Ductile Iron	TFE	Carbon Steel	Victaulic Series 726
Gate	2.5 & less	200	Thd	ISRS	CuZn	Bronze Thd	Integral	Solid Wedge	Walworth Fig 5
Gate	3 to 12	200	Flg	OS&Y	Bronze	CI Bolted	Bronze	Solid Wedge	Walworth Fig 8726F
Globe	2.5 & less	400	Thd	ISRS	Bronze	Bronze Union	SS	SS	Walworth Fig 245P
Globe	3 to 10	200	Flg	OS&Y	Brass	CI Bolted	Bronze	Bronze	Walworth Fig 8906F
Check	2.5 & less	200	Thd	Swing	------	Bronze Thd	Integral	Bronze	Walworth Fig 406
Check	3 to 12	200	Flg	Swing	------	CI Bolted	Bronze	Bronze	Walworth Fig 8928F

Butterfly	3-in to 4-in	200	Threaded Lug	Lever Oper	SS	Ductile Iron	EPDM	316SS	Jenkins Fig.231BG
Butterfly	6-in to 12-in	200	Threaded Lug	Gear Oper.	SS	Ductile Iron	EPDM	316SS	Jenkins Fig.231BG
Ball	2-in & less	150	Solder Ends	Standard Port	Steel	Bronze Screwed	TFE	Chrome Plated	Apollo Fig 70-200
Gate	3-in & less	125	Solder Ends	ISRS	CuZn	Bronze Union	Integral	Bronze	Walworth Fig. 2SJ
Globe	3-in & less	150	Solder Ends	ISRS	Bronze	Bronze Union	Integral	Bronze	Walworth Fig. 955J
Check	3-in & less	125	Solder Ends	Swing	------	Bronze Screwed	Integral	Bronze	Walworth Fig. 406SJ

2.03 COMMON PIPING SPECIALTIES

A. All large piping specialties shall be provided with lugs, brackets or field supplied devices to allow the equipment to be firmly fastened to the structure. The lugs and brackets shall be sized to withstand the expected seismic loads for the area and type of application. Location of the attachment shall be based on the equipment being hung or base mounted as shown on the Drawings and the schedules.

B. Thermometers

1. Direct Mounting Location - Thermometer shall be installed as indicated on the Drawings and/or as specified herein.
   a. Type - Industrial thermometer, straight, angle or adjustable stem, mercury free type.
   b. Case - 9-in die cast aluminum with metallic blue-black finish or brass with suitable finish.
   c. Accuracy - Plus or minus one scale division.
   d. Scale - White background with jet black embossed figures and markings.
   e. Range - Per following table. For applications not listed in the following table, thermometer range shall be selected so that the normal operating temperature of the material being measured will fall approximately in the middle of the scale and shall read to the reasonably expected extremes of the system fluid temperature.

Fluid	**Location or Service**	**Range (degrees Fahrenheit)**
Water	Heating/Cooling Water	30 to 240

   f. Socket and Stem - Provide with 3/4-in NPT brass separable sockets with 2-3/4-in insertion length. Provide extension necks for sockets and stem lengths for insulated piping as follows:

Insulation Thickness	**Socket Extension Length**	**Thermometer Stem Length**
None (0-in)	0-in	3-1/2 inch
2-1/2 inch and less	2-1/2 inch	6 inch
3 inch to 4-1/2 inches	4-1/4 inch	8 inch

g. Acceptable manufacturers shall be Marshalltown Mfg. Co.; H.O. Trerice Co.; Palmer Instruments, Inc.; Moeller Instrument Co.; Weiss and Son, Inc.; U.S. Gauge, Inc. or equal.

C. Air Vents and Vacuum Breakers

1. Provide vacuum breakers upstream of traps for all steam modulating service and as shown on the Drawings.

2. Provide air vents at all hydronic system high points and as shown on the Drawings.

3. Equipment

	Size Inches	Press Rating	Connection	Body Material Type, Accessories and Model
Air Vents	All	150	Threaded	Float type with CI body, SS float and isolation cock. Armstrong No. 1-AV or equal
Vacuum Breakers	3/4 and less	-----	Threaded	Stainless steel construction; spring loaded adjustable ball valve. Velan Engineering Company or equal

NOTE: Delete system types that are not applicable.

D. Pipeline Strainers

1. General
   a. Provide a blowdown valve the full size of the strainer blowdown tapping, with a capped hose end connection for hydronic service and threaded NPT connection for steam and steam condensate service.
   b. If grooved pipe joints are used, furnish strainer with grooved connections or with factory installed grooved adaptors.
   c. Manufacturers: Leslie Co, Mueller Steam Specialty Co, Spirax Sarco, Inc, Armstrong International Inc, Yarway Co., Victaulic Co of America or equal

2. Applications

Service	Size	Press Rating	Connection	Body and Screen Material Types
General – All Duty	All	400 psig	Threaded /Flanged	Cast iron body “Y” type strainer. SS screen with 0.045-in perforations.
Hydronic Copper Tubing	3-in and less	250 psig	Threaded	Bronze body "Y" type strainer. Stainless steel basket with 0.045-in perforations.

E. Automatic 3-Way Control Valves

1. All automatic control valves shall be fully proportioning with modulating plug, unless otherwise specified. The valves shall be quiet in operation and fail in either normally open, normally closed, as specified in the event of control failure. All valves shall be capable of operating in sequence when required by the sequence of operation. Flow data shall coordinate with the shop drawings for equipment controlled. All control valves shall be

suitable for the pressure and temperature conditions and shall close against the differential pressure involved.

2. Valve construction shall conform to the requirements specified for the piping for the system. Thermal oil valves shall be rated for high temperature and shall have bodies and bonnets constructed of WCC steel. Valve control types and temperature ranges as shown in the Drawings.
   a. Valves shall have linear flow characteristics.
   b. Shut-off classification shall be Class IV for Standard Design and Class II for High Temperature Design as per ANSI/FCI 70-2.
   c. Valves plug style shall be balanced and metal seated.

3. Valve actuator and trim shall be furnished to provide the following minimum close-off pressure rating:
   a. Water Valves:
      1) Three-way: Shall meet the leakage classification specified previously between ports A and B at design flow or 100 percent of total system (pump) head.

4. Water Valves Sizing Criteria
   a. Three-way modulating service: Pressure drop equal to the pressure drop through the heat exchanger(load), or the scheduled pressure drop shown on the Drawings.

5. Water valves shall be single seated type, except where pressure and flow combination exceeds rating for commercial valve operators, double seated valves may be used.

6. Control Valves shall be equal to Emerson-Fisher, Design YD, three-way cage-guided valves, or equal.

F. Pneumatic Valve Actuators and Positioners

1. Pneumatic actuators shall be diaphragm type with easily replaceable, beaded, molded neoprene diaphragm.

2. Actuator housings may be molded or die-cast zinc or aluminum.

3. Actuator size and spring ranges selected shall be suitable for intended application.

4. Rate pneumatic actuators for a minimum 20 psig.

5. Actuators shall be selected in accordance with manufacturer's recommendations to provide sufficient close-off force and to provide smooth modulating control under design flow and pressure conditions.

6. Valve actuators shall provide close-off with the specified leakage at design system pressure and shall provide smooth modulation at design flow and pressure conditions.

7. On sequencing applications, actuators shall be sized for a maximum of 2 psi shift in nominal spring range. Spring ranges shall be selected to prevent overlap or positive postioners shall be provided.

8. All valves sequenced with other valves or control devices shall be equipped with pilot positioners.

9. Positive positioners are to have the following performance characteristics:
   a. Linearity: Plus/minus 10 percent of output signal span
   b. Hysteresis: 3 percent of the span
   c. Response: 1/4 psig input change
   d. Maximum pilot signal pressure: 20 psig
   e. Maximum control air supply pressure: 50 psig

10. Positive positioners shall be provided where required to provide smooth modulation or proper sequencing

11. Positive positioners shall be high capacity force balance relay type with suitable mounting provisions and position feedback linkage tailored for particular actuator.

12. Positive positioners shall use full control air pressure at any point in stem travel to initiate stem movement or to maintain stem position. Positioners shall operate on a 3 to 15 psig input signal unless otherwise required to satisfy the control sequences of operation. Positioners shall use an electronic input signal of 4-20 mA, DC with a maximum compliance voltage of 30 VDC.

13. Actuators shall be equal to Emerson-Fisher, 657 Direct Acting or 667 Indirect Acting diaphragm type, or equal.

14. Smart positioners shall be equal to Emerson-Fisher, 3582i Series, with filter regulators, or equal.

G. Electronic Valve Actuators:

1. Electronic actuators, less than 600 in.-lb. of rated torque, shall have ISO 9001 quality certification and be UL listed under standard 873, CSA C22.2 No. 24 and have CE certification. Electronic actuators used on valves shall be designed to directly couple and mount to a stem, shaft or ISO style-mounting pad. Actuator mounting clamps shall be a V-bolt with a toothed V-clamp creating a cold weld, positive grip effect. Single point, bolt or single screw actuator type fastening techniques or direct-coupled actuators requiring field assembly of the universal clamp is not acceptable.

2. Actuators shall be fully modulating/proportional, pulse width, floating/tri-state, or two-position as required and be factory or field selectable. Actuators shall have visual position indicators and shall operate in sequence with other devices if required. Proportional actuators shall be capable of digital communication, as built.

3. Where required by the control sequence, two sets of DPDT switches with fully adjustable set points shall be provided to activate panel indicators and provide signals for equipment operation.

4. Actuator shall have an operating range of minus 22 to 122 degrees F.

5. Proportional actuators shall accept a 0-10 VDC or 0-20 mA input signal, and provide a 2-10 VDC or 4-20 mA (with a load resistor) operating range.

6. Actuators shall be capable of operating on 24, 120 or 230 VAC or 24 VDC and Class 2 wiring as directed by the application. Power consumption shall not exceed 10 VA for AC, including 120 VAC actuators and eight watts per actuator for applications

7. NEMA 2 rated actuators shall be provided with a three foot (minimum), pre-wired, electrical cable. Actuators requiring removal of the actuator cover for access to wiring terminals, exposing electronics, printed circuit boards to damage, are unacceptable.

8. Actuators shall have electronic overload protection or digital rotation sensing circuitry to prevent actuator damage throughout the entire rotation. End switches to deactivate the actuator at the end of rotation or magnetic clutches are not acceptable.

9. For power-failure/safety applications, an internal mechanical spring return mechanism shall be built into the actuator housing. Spring return actuators shall be capable of CW or CCW mounting orientation. Spring return models >60 in.-lb. will be capable of mounting on shafts up to 1.05-in. diameter. Spring return actuators with more than 60 in.-lb. of torque shall have a manual override metal crank. Upon loss of control signal, a proportional actuator shall fail open or closed based on the minimum control signal. Upon loss of power, a non-spring return actuator shall maintain the last position.

10. Actuators using "on-board" chemical storage systems, capacitors or other "on-board" non-mechanical forms of fail-safe operation are unacceptable.

11. Actuators shall be capable of being mechanically and electrically paralleled to increase torque if required. Valves requiring greater torque or higher close off may be assembled with multiple low torque actuators. Dual mounted actuators using additional anti-rotation strap mechanical linkages or special factory wiring to function are not acceptable. Actuators in a tandem pair must be "off the shelf" standard actuators ready for field wiring.

12. Valve actuators will not produce more than 62 dbA when furnished with a mechanical fail-safe spring. Non-spring return actuators shall conform to a maximum noise rating of 45 dbA with power on or in the running or driving mode.

13. Proportional actuators shall be fully programmable. Control input, position feedback and running time shall be factory or field programmable. Diagnostic feedback shall provide indications of hunting or oscillation, mechanical overload, mechanical travel and mechanical load limit. Actuators shall also provide actuator service data, at a minimum, number of hours powered and number of hours in motion.

14. Where special classifications are shown on the electrical drawings valve actuators shall be provided with suitable enclosures.

15. NEMA 4X enclosures shall be as specified in Division 16 and shall have a shaft seal and all electrical connections shall be suitable for the space classification. Enclosure shall be UL listed.

16. Explosion-proof enclosure shall be suitable for Class I, II and III as specified in Division 16. A suitable shaft seal must be provided. Housing shall be cast copper fill aluminum with stainless steel fasteners and shall be UL listed. Housing shall be suitable for NEMA 4, 7, and 9.

2.04 HYDRONIC SPECIALTIES

A. Expansion Tanks, Air Separators, and Flex Connectors

Type	Size Inches	Pressure Rating	Connection	Service and Notes
Flexible Connectors	All	150	Flanged	Rubber flexible pipe with steel wire. Reinforcing FF Flg with retaining rings. Garlock 7250 Flexo-Matic Pipe or equal
Captive Air Bladder Type Expansion Tank	All	125	Scr	Carbon steel ASME Section VIII construction with replaceable heavy-duty rubber bladder, max. operating temperature: 240F. Tank shall be provided with charging valve, air connection, system connection and drain. TACO CA Series or equal factory painted.

B. Hydronic Flow Measurement and Flow Control Devices

1. Combination Flow Station and Balancing Valves
   a. For pipe sizes three-in and smaller furnish and install where shown on the Drawings and details, calibrated flow station/balancing valves equipped with readout valves suitable for the connection of a differential pressure meter. Valves shall be designed for a minimum 125 lb working pressure at 200 degrees F. Valves shall have an indexing pointer and calibrated nameplate to measure flow rate, based on pressure differential across valve and the degree of closure of the precision machined orifice. Valves shall be selected to provide a minimum meter reading of 1-ft of water column and a maximum meter reading of five-ft of water column in a fully open condition at the design flow rates shown on the equipment schedules. Valves shall be installed in strict accordance with manufacturer's instructions.
   b. Valves shall be Bell & Gossett, Type CBV; Sarco, Type MPP-G, Victaulic/TA Hydronics Style 787 (Threaded) or equal by Armstrong.

C. Triple Duty Valve

1. A triple duty valve may be used in place of the gate, balancing and check valve in a pump discharge. Triple duty valves shall have cast iron body and plug, bronze gland, stainless steel sleeve and brass clapper and seat. Valves for piping three-in and below are to be threaded and valves four-in and above are to be flanged.

2. The valve shall be suitable for horizontal or vertical installation and shall provide a bubble tight shut off. Provide positive memory stop feature to ensure returning to the original balance point after shutoff.

3. Triple duty valves shall be Bell & Gosset 3D series, Angle Pattern; Taco, "Plus One" Multi-purpose Valve or equal.

4. A grooved end triple duty valve assembly may be used in place of triple duty valve in a pump discharge. Triple duty valve assemblies shall be assembled of Vic® 300 butterfly valve with memory stop feature, assembled with Series 716 Vic-Check® or Series 779 Venturi-Check. Couplings used for assembly shall be of the same manufacturer as the grooved valves.

D. Pump Suction Diffusers

1. Where space conditions do not allow sufficient room for ten pipe diameters of straight run before a pump inlet, or where shown on the Drawings, a suction diffuser shall be provided. Suction diffuser shall have ductile iron or cast-iron body, cast iron or steel straightening vanes, bronze or stainless steel start-up strainer and stainless steel permanent strainer.

2. Suction diffuser shall have an integral flow straightening device, removable strainer, capped blowdown connection and adjustable support foot. Connections for all unit sizes shall be flanged or grooved. Provide inlet flange or upstream body tapping for installation of a pressure gauge. Provide removable threaded magnetic insert to collect ferrous materials at bottom of diffuser body.

3. Units shall be Bell & Gossett Suction Diffuser Plus; Taco, "SD" Series; Victaulic Series 731-D or equal.

2.05 HANGERS AND SUPPORTS

A. All of the equipment specified herein is intended to support the various types of pipe and piping systems. The details shown on the Drawings are intended to indicate the generally desired methods of support under normal conditions. Develop final details and any details associated with special conditions not already covered to meet the system conditions specified in the respective Division 15 pipe sections.

B. All pipe and tubing shall be supported as required to prevent significant stresses in the pipe or tubing material, valves, fittings and other pipe appurtenances and to support and secure the pipe in the intended position and alignment. Piping support systems shall include restraints as required by the applicable building codes to withstand seismic loading. Design shall be provided by a professional engineer hired by the Contractor as specified in other Sections. All supports shall be designed to adequately secure the pipe against excessive dislocation due to thermal expansion and contraction, internal flow forces and all probable external forces such as equipment, pipe and personnel contact. Any structural steel members required to brace any piping from excessive dislocation shall conform to the applicable requirements of Section 05500 and shall be furnished and installed under this Section.

C. The Contractor is responsible for determining expansion and contraction requirements. This data is to be used for design expansion compensation.

D. All pipe and appurtenances connected to equipment shall be supported in such a manner as to prevent any loads or strain displacement being imposed on the equipment. When manufacturers have indicated requirements that piping loads shall not be transmitted to their equipment, submit certification stating that such requirements have been complied with.

E. All hangers, supports and appurtenances shall be of approved standard design where possible and shall be adequate to maintain the supported load in proper position under all operating conditions. Except for hanger spring elements, the minimum working factor of safety for all hanger and support materials and equipment shall be as defined by MSS-58.

F. No work shall be installed using hangers or supports of other trades except where specifically shown on the Drawings as being furnished for HVAC work.

G. Provide all supplementary steel required to properly transmit the load to the building structural frame or floor and to meet the maximum spacing requirements. Supplementary (support) steel shall be in accordance with the AISC standards for Design, Fabrication and Erection of Structural Steel for Buildings.

H. All rods, clamps, hangers, inserts, anchor bolts, brackets and components for pipe supports shall be furnished with a hot dipped or electro-galvanized finish. Where field welding is required, cold-applied galvanizing may be used for touch-up of factory galvanized components. Interior clamps on plastic pipe shall be plastic coated. Supports for copper pipe shall be copper plated or shall have a 1/16-in plastic coating.

I. Expansion shields, where required, shall be two-unit self-drilling shell type.

J. Floor stands may be used on pipes running close to the floor. Application types for services shall be as shown in the following table or as indicated on the Drawings. Floor stands used on pipes covered with anti-sweat insulation or on hot lines, shall be the saddle type. Otherwise, they may be an adjustable welded pipe stanchion, or cast integral with the fitting.

Service	Pipe Size	Type
Water	6-in and smaller	Saddle type with adjustable pipe stanchion
All other piping	All	Saddle type with adjustable pipe stanchion
Engine cooling, heating hot water, Engine exhaust pipe	All	Adjustable pipe roll stand and base.

K. All pipe hangers shall conform to ANSI B31.1. All hangers shall be of the type to permit vertical adjustment after installation of piping.

L. A metal insulation shield shall be provided at all support points of insulated lines except where a pipe saddle is required. Secure shields with 1/2-in wide metal bands set 2-in from either end of the shield and locate one additional band in the middle of the shield. Shields shall be sized according to the following:

Nominal Pipe or Tube Size - Inches	Shield Length – Inches	Shield Gauge
1/2 to 3 (1/4 to 3-1/2 for tube)	12	18
4	12	16
6 (5 to 6 for tube)	18	16
8 to 14 (8 maximum for tube)	24	14
16 to 24 (NA for tube)	24	12

1. Lengths indicated are for strap hangers; where roller hangers are used, increase length to keep the rolling point of contact within the middle 1/3 of the shield length.

2. Materials: Shields and metal bands shall be galvanized steel except in special areas where shield materials shall match any special hanger materials specified for those locations. Shields on outdoor piping runs shall match the insulation covering material where metal, or shall be galvanized steel where the insulation jacketing is PVC.

3. Inserts: At pipe hanger locations provide high compressive strength rigid insulation inserts such as cellular glass, calcium silicate or expanded silica. The length of the insulation insert shall equal the pipe shield length.

M. Insulation protection saddles shall be provided on all hot lines which are supported by pipe roll or trapeze type hangers. Saddles shall be welded to the pipe and sized for the specified insulation thickness.

N. Attachments to Structure

1. Concrete inserts shall be malleable iron, cast iron, or steel of type required by load.

2. Clamps for fastening of hangers and supports to structural steel shall be as follows:
   a. Clamp shall be selected for the hanger load imposed.
   b. "C" clamps shall be used for 1-1/2-in and smaller pipe only. The use of "C" clamps for larger piping or other uses is not allowed. "C" clamps shall be malleable iron body with hardened steel cup point set screw, lock nut and retaining clip similar to Figure 87 of Anvil.
   c. Beam clamps shall be used on all members with double flanges. Clamp shall be positive locking type such that the load on the clamp will increase the grip on the beam. The load shall be suspended at the center of the flanges and shall not induce a moment load on the structural member. Clamps shall be similar to Figures 218, 228, 229, 292 of Anvil.
   d. Channel and angle clamps shall be positive locking type. The load shall be suspended below the vertical flange of the support member. Clamps shall be similar to Figure 235 of Carpenter Patterson.
   e. All clamps shall be galvanized.

O. Unless otherwise specified herein, pipe hangers and supports shall be standard catalogued components, conforming to the requirements of MSS-SP-58 and -69; and shall be as manufactured by Anvil International, Exeter, NH; Carpenter & Patterson, Inc., Woburn, MA; F&S Central, Brooklyn NY; Elcen Metal Products Co., Franklin Park, IL and Unistrut Northeast, Cambridge, MA or equal. A reference to a specific figure number of a specific manufacturer is for the purpose of establishing a type and quality of product and shall not be considered as proprietary. Items comparable in type, style, quality, design and performance shall be considered as equal.

P. All required pipe supports for which the supports specified in this Section are not applicable shall be fabricated or constructed from standard structural steel shapes, concrete and anchor hardware similar to items previously specified herein and shall be subject to the approval of the Engineer.

Q. Individual Pipe Hangers

1. General - Individual hangers shall be sized on the pipe O.D. for uninsulated pipe and on the O.D. of the covering for the insulated cold piping and insulated hot piping with insulation protection saddles. All insulated pipes must have saddle or protection shields to prevent deterioration due to movement of pipe and hanger. All individual hangers shall be of the types indicated as follows, unless otherwise designated on the Drawings.

Services	Pipe Size	Type
Water	6-in and smaller	Clevis
Drain lines	All	Clevis
All other piping	All	Clevis
Engine Cooling Water, Heating Hot Water, Generator Exhaust	All	Adjustable Yoke Pipe Roll or Pipe Slide Assembly

2. Clevis Pipe Hangers - Shall be adjustable carbon steel clevis.

3. Swivel Pipe Hangers - Shall be steel yokes with cast iron pipe roll.

4. Pipe Roll Pipe Supports - Shall be cast iron rolls with hot-dipped galvanized yokes of the type required for the specific installation.

5. Pipe Slides Assembly – Shall be structural tees with PTFE slides and plate bases.

R. Trapeze hangers shall consist of galvanized structural steel channel supported from galvanized threaded rod or attached to concrete walls, columns or structural steel support members as required to meet the intent of this Section. Channel shall be similar to F&S, Figure 710, rods, concrete inserts, "C" clamps, beam clamps, welded beam attachments and expansion shields shall be as specified above. Adjustable steel yoke shall be equal to: Anvil Figure 181.

S. Except as otherwise specified herein pipe anchors used for attaching pipe to trapeze or multiple pipe wall brackets shall be anchor or pipe chairs similar to F&S, Figures 158, 419, 160A, 160B as required. Material of construction shall be galvanized steel. Chair "U" bolts shall be tightened to allow freedom of movement for normal expansion and contraction except where pipe must be anchored to control direction of movement or act as a thrust anchor.

T. Hanger rods shall be hot rolled steel, machine threaded and galvanized after fabrication. The strength of the rod shall be based on its root diameter.

U. Where pipes are near walls, beams, columns, etc., and located an excessive distance from ceilings or underside of beams, welded steel wall brackets similar to Carpenter and Patterson Figure No. 69-68, 84 or 139 shall be used for hanging pipe. Brackets shall be galvanized. Where single pipes rest on top of bracket pipe supports, attachments shall meet requirements as specified under multiple pipe hangers.

V. Where piping is installed on top of a horizontal surface, pipe slide assemblies shall be provided. Assemblies shall be equal to Anvil. Figure 257; painted, carbon steel with PTFE bonded slide plates.

2.06 THERMAL EXPANSION OF PIPING

A. In general, thermal expansion of piping shall be compensated for by the use of flexible hose or flexible expansion joints. Flexible hose is to be used for lateral deflection and flexible expansion joints are to be used for axial displacement.

B. Flexible piping shall be flexible annular corrugated stainless steel hose. The hose shall be provided with an external stainless steel braid to minimize elongation under pressure. Hose 2-

1/2-in and smaller shall be threaded and hoses 3-in and larger shall be flanged. The manufacturer shall confirm the suitability of the flexible piping for the temperature and pressure of the systems.

C. Flexible expansion joints shall be spherical EPDM. Connections shall have multiple plies of corded fabric reinforcing. Connections shall be rated for 150 psi at 220 degrees F. For equipment with connections from 2-1/2 to 12-in, 90-degree bend connections can be used. Straight connections shall be double sphere. The manufacturer shall confirm the suitability of the connections for the temperature, pressure, and pipe contents for the systems. Provide pipe guides on each side of expansion joints to prevent misalignment and squirm.

D. If grooved pipe joints are used, expansion joints shall be equivalent with grooved connection and a grooved adaptor provided. Victaulic Mover Style 150 or equal.

2.07 PIPE SLEEVES AND SEALING MATERIALS

A. Unless otherwise shown, all pipe sleeves shall be Schedule 40 galvanized steel pipe conforming to ASTM A53. Where indicated, provide a 2-in minimum circumferential water stop welded to exterior of sleeve at its midpoint. Sleeves to be sealed by caulking shall be sized as required. Sleeves to be sealed with mechanical seals shall be sized in accordance with the seal manufacturer's recommendations. Sleeves for insulated piping shall be sized as required.

B. Sealant shall be a two part foamed silicone elastomer as manufactured by Dow Corning Co., Product No. 3-6548 silicone R.T.V.; 3M brand fire barrier products caulk C.P. 25 and 3M brand putty 303 or Flame-Safe fire stop systems Figure No. FS-500 Thomas & Betts Corp. Packing shall be a fire retardant pliable material, Figure No. 310 by Sealtite Co.; White Oakum WS-600 by American Manufacturing Co. or equal. Sealant bead configuration, depth and width shall be in accordance with manufacturer's recommendations.

C. Bonding compound shall be Sikadur Hi-Mod epoxy by Sika Corp., similar by Euclid Chemical Corp.; Master Builders Co. or equal.

D. Non-shrink grout shall be Masterflow 713 by Master Builders Co.; Euco N-S by Euclid Chemical Co.; Five Star Grout by U.S. Grout Corp. or equal.

E. Escutcheons shall be 16 gauge galvanized steel in dry areas, 16 gauge Type 316 stainless steel in wet and corrosive areas and chrome plated in finished areas. When a pipe has metal insulation jacket the escutcheon material shall match the insulation metal jacket material and be sized to the insulation outside diameter.

F. Mechanical seals shall be modular, mechanical type, consisting of interlocking synthetic rubber links shaped to continuously fill the annular space between the pipe and the wall opening. The elastomeric element shall be sized and selected per the manufacturer’s sizing procedure for use in temperatures ranging from -40 degrees F to 250 degrees F. The seal hardware such as pressure plates, bolts and nuts shall be Type 316 stainless steel. Two rows of links in series with each other shall be used in penetrations through below grade walls. Seals shall be Link Seal manufactured by PSI-Thunderline or equal.

2.08 LABELS

A. The name of the materials in each pipeline and alongside this an arrow indicating the direction of flow of fluids, shall be indicated on each pipe system. Labels shall not be located more than 26 linear feet apart and shall also appear directly adjacent to each side of any wall the pipeline breaches, adjacent to each side of the valve regulator, flowcheck, strainer cleanout and all pieces of equipment.

B. Labels shall identify the contents by complete name and the equipment number for the equipment served at least once in each space through which it passes and thereafter by generally recognized abbreviations, letters or numerals as approved. All labels are to include the nominal pipe size of the identified pipe. Identification label locations shall be determined by the Engineer but in general they shall be placed where the view is unobstructed and on the two lower quarters of pipe or covering where they are overhead. Label should be clearly visible from operating positions especially those adjacent to control valves.

C. Numbers and letters shall be die-cut from 3.5 mil vinyl film and pre-spaced on carrier tape. Adhesive and finish surface shall be protected with one piece removable liners. Color shall be white or black as approved depending on substrate color.

D. Letter size shall be as indicated in the following table:

Outside Diameter of Pipe or Covering	Size of Legend Letters
3/4-in to 1-1/4-in	1/2-in
1-1/2-in to 2-in	3/4-in
2-1/2-in to 6-in	1-1/2-in
8-in to 10-in	2-1/2-in
Over 10-in	3-in

E. The system for preparation and application of letters shall be Type B a.s.i./2 by ASI Sign Systems; Architectural Graphics Inc. or equal. Letter type shall be Optima Bold, upper case. Grid 2 spacing shall be employed. Arrow shall match as approved, letter type and size. The instructions of the manufacturer shall be followed in respect to storage, surface preparation and applications of letters.

F. Unit numbers indicated in equipment schedules shall be provided in vinyl film as specified above on all equipment using one-in high Optima Bold, upper case, Grid 2 spacing, white or black in color as approved depending on substrate. Unit numbers shall be mounted at eye level on machines where possible or at the upper most broad vertical surface of low equipment.

Contents of Pipe	Label
Cooling Water Supply	CLWS
Cooling Water Return	CLWR
Chilled Water/Glycol Supply	CHGS
Chilled Water/Glycol Return	CHGR
Hot Water Supply	HWS

Hot Water Return	HWR
Engine Exhaust	EE
Engine Exhaust Bypass	EEB
Digester Gas	DG
Digester Gas-Condensate	COND
Wastewater/Drain	DRAIN

2.09 VALVE IDENTIFICATION

A. Valve tags will be provided by the Contractor.

B. Prepare a valve schedule for all valves required for the work showing a number, the location, type, function and normal operating position, for each valve. The schedule shall be submitted to the Engineer for approval not less than 120 days prior to start-up.

C. Furnish tags for all valves required for the work. Valve tags shall be two-in diameter, 19 gauge, brass or plastic, with brass hooks suitable for attaching the tag to the valve operator. Tags shall be stamped or etched with the valve number and the information on the valve schedule coded in a system provided by the Owner. Submit two samples of the type of tag proposed and the manufacturer's standards color chart and letter styles to the Engineer for approval.

D. The Contractor shall install valve tags on all valves required for his work and deliver to each subcontractor for installation on all valves required for their work.

PART 3 EXECUTION

3.01 GENERAL REQUIREMENTS

A. Proceed with the installation of piping and supports only after all major building structural work has been completed and new concrete has reached its 28-day compressive strength.

B. Do not install any equipment or materials until receipt of Engineers written approval of all applicable submittals. If any equipment or materials are installed prior to approval of the submittals, it shall be at the Contractor's risk.

C. Finished metal surfaces subject to corrosion that are not galvanized or protected in some other way, shall be grease coated to prevent rust.

3.02 INSTALLATION OF HANGERS AND SUPPORTS.

A. All pipes, horizontal and vertical, requiring rigid support shall be supported from the building structure by approved methods. Supports shall be provided at changes in direction and elsewhere as shown on the Drawings or as specified herein. No piping shall be supported from metal stairs, ladders and walkways unless specifically directed or authorized by the Engineer.

B. All pipe supports shall be designed with liberal strength and stiffness to support the respective pipes under the maximum combination of peak loading conditions to include pipe weight, liquid weight, liquid movement and pressure forces, thermal expansion and contraction, vibrations and all probable externally applied forces. Prior to installation, all pipe supports shall be approved by the Engineer.

C. In certain locations, pipe supports, anchors, guides, and expansion joints may be indicated on the drawings. The Contractor shall be responsible to provide a complete system of supports, expansion joints, and anchors. Additional supports may be required adjacent to expansion joints, couplings, and valves.

D. Where flexible couplings are required at equipment, tanks, etc, the end opposite to the piece of equipment, tank, etc, shall be rigidly supported, to prevent transfer of system forces to the equipment. No fixed or restraining supports shall be installed between a flexible coupling and the piece of equipment.

E. Inserts for pipe hangers and supports shall be installed on forms before concrete is placed. Before setting these items, all Drawings and figures shall be checked which have a direct bearing on the pipe location. Responsibility for the proper location of pipe supports is included under this Section.

F. The installation of pipe support systems shall in no way interfere with the operation of the overhead bridge cranes, monorails, access hatches, etc.

G. Where piping is supported from the structure of a pre-engineered building the Contractor will coordinate the location of pipe hangers with the building supplier. Piping is to be supported only from members and locations as agreed to by the building supplier.

H. Hangers shall not be supported from roof decking or bulb tees. Provide supplemental steel where required to span between building structural elements.

I. Where hangers must be supported from concrete slabs, the required number and size of inserts shall be installed at their proper location prior to pouring of such slabs and continuous inserts shall be installed in the general pattern as shown on the structural slab drawings. Where continuous inserts are provided, threaded rod and nut compatible with the inserts shall be provided.

J. Expansion shields shall be installed so that the major loading is in shear. They shall not be used when the major load is in tension.

K. Drilling of building structural steel for attachment of hangers or supports is not permitted under any circumstances. Welding to building structural steel is permitted only where specified or specifically indicated on the Drawings. When special conditions arise, shop drawings and/or other descriptive information detailing proposed methods of welding hangers, supports, or anchors shall be submitted for written approval by the Engineer prior to welding.

L. Unless shown otherwise, supports shall originate at or transmit the load to the truss or joist panel points when hung from such members. Furnish supplementary supports where indicated on the Drawings to spread the load between joists and panel points.

M. Pipe runs in areas with steel construction shall be supported from the beams or joist with approved beam clamps unless otherwise shown on Drawings.

N. All vertical pipes shall be supported at each floor or at intervals of not more than 12-ft by pipe collars, clamps, brackets, or wall rests and at all points necessary to insure rigid construction. All vertical pipes passing through pipe sleeves shall be secured using a pipe collar.

O. Anchors and guides shall be installed in accordance with the details as shown on the Drawings or as otherwise required by good piping practice.

P. Suspended multiple pipes, running parallel in the same horizontal plane, which are adjacent to each other shall be suspended by trapeze type hangers or wall brackets.

Q. Pipes Supported from Below - Where piping is located in areas where it cannot be supported by hangers or where there is no structure above to hang from, provide support members from below. Support spacing and loadings shall be as previously described for pipe hangers. Pipe support structures shall be fabricated from structural steel square tube sections. Attachments to concrete structures shall be by inserts for concrete work where possible and by means of cinch anchors for existing concrete work. Attachments to structural steel shall be by means of locking clamps and fixtures. "C" or "G" type clamps without retaining strips are not acceptable. Where there is no available concrete or structural steel to attach to, the support member shall be provided with an adequate concrete foundation. Pipes supported by vertical members shall be supported by a bracket with saddles and clamps. Pipes supported by horizontal members shall be supported by the member if it is below the pipe or by hangers as previously specified if it is above the pipe. Supports shall be designed and detailed for each condition with Drawings submitted for review.

R. Pipe Support Spacing

1. Unless otherwise shown on the Drawings, provide support for all horizontal piping in accordance with the following maximum spans for straight pipe without fittings or accessories:

a. Steel Piping (Reference: ANSI B31.1)

Nominal Pipe Size Inches	**Maximum Span (Feet)**	
	Water Services	**Digester Gas or Exhaust Gas Service**
1	7	9
1-1/2	9	12
2	10	13
2-1/2	11	14
3	12	15
3-1/2	13	16
4	14	17
5	16	19
6	17	21
8	19	24
10	22	28
12	23	30
14	25	32
16	27	35
18	28	37

Nominal Pipe Size Inches	Maximum Span (Feet)	
	Water Services	Digester Gas or Exhaust Gas Service
20	30	39
24	32	42

b. Copper Tubing (Water filled)

Tube Size - Inches	Maximum Span (feet)
1-1/2 and smaller	6
2 and larger	10

3.03 INSTALLATION OF PIPING

A. Pipe and Fittings

1. Install piping in a neat manner with lines straight and parallel or at right angles to walls or column lines and with risers plumb. Run piping so as to avoid passing through ductwork or directly under electric light outlets and/or interference with other lines or extending beyond furring lines as determined by architectural drawings. All work shall be accomplished using the best methods and procedures of recognized pipe fabrication in a good and workmanlike manner in accordance with the latest revision of applicable ANSI Standards, ASME Codes and PFI Standards.

2. Pipe lengths and dimensions and drillings of flanges shall be coordinated with the lengths and flanges for the valves, pumps, flow switches, and other items to be installed in the piping. All mating flanges shall have the same diameter, facing, and drilling and shall be suitable for the pressure to which they are subjected

3. The installed systems shall not interfere with maintenance and operational access to any equipment installed under this Section, or any other related Sections.

4. Use full length of pipe except where cut lengths are necessary. Do not spring or deform piping to make up joints.

5. Pipe shall be cut square, not upset, under-sized or out of round. Ends shall be carefully reamed and cleaned before being installed.

6. Bending of pipe is not permitted. Use fittings for all changes in direction.

7. Do not use bushings except where specifically approved by the Engineer. Reducers shall be eccentric to provide for drainage from all liquid-bearing lines and facilitate air removal from water lines.

8. Verify the locations and elevations of any existing piping and manholes before proceeding with work on any system. Any discrepancies between the information shown on the Drawings and the actual conditions found in the field shall be reported at once to the

Engineer. No claim for extra payment will be considered if the above provision has not been complied with.

9. Erect piping with proper provision for expansion and contraction. Cold sprung pipe shall be erected with metal filler pieces bolted between flanges or tack welded between weld joints. After the pipe, anchors, hangers and supports have been erected spacers shall be removed and the joint made.

10. Where lines of lower service rating tie into services or equipment of higher service rating the block valve between the two shall conform to the higher rating.

11. Welded lines shall have long radius elbows except at expansion loops where elbow radius shall be equal to six times the pipe diameter (R=6D). Welding tees shall be used wherever the branch line diameter is equal to or one size smaller than the main line diameter, otherwise the branches shall be fabricated using "Weldolet" or "Sockolet" fittings as manufactured by Bonney Forge Inc. or equal. Reinforced welded tees will be used only where shown on the Drawings. Tapped connections in welded lines shall be provided by means of "Thredolet" or "Latrolet" fittings welded to the piping, as manufactured by Bonney Forge Inc. or equal.

12. Mitering of pipe to form elbow is not permitted.

13. All flange faces or weld faces shall be in perfect alignment.

14. Where flanges are to be connected directly to welded fittings, only welding neck flanges will be allowed.

15. End caps on pre-cleaned pipe shall not be removed until immediately before assembly. All open ends shall be capped immediately after completion of installation.

16. All piping interiors shall be thoroughly cleaned after installation and kept clean by approved temporary closures on all openings until the system is put in service. Closures shall be suitable to withstand hydrostatic testing.

17. Dielectric pipe fittings shall be installed at changes in pipe material. Fittings shall provide electrical continuity on the pipe.

18. Threaded unions, grooved joint couplings or flanges shall be provided where indicated and in the following locations even if not indicated:
    a. In long runs of piping to permit convenient disassembly for alterations or repairs.
    b. In by-passes around equipment.
    c. In connections to tanks, pumps and other equipment between the shut-off valve and the equipment.
    d. In connections on both sides of traps, controls and automatic control valves.
    e. If grooved joints couplings are used, unions are not required. Couplings shall serve as unions.

3.04 JOINING OF PIPE

A. Welding

1. Welding of joints shall be by metal-arc welding process. Welding shall be by qualified welders meeting the requirements outlined in Section IX of the ASME Boiler and Pressure Vessel Code and certified by the Hartford Steam Boiler Inspection Company.

2. Welding shall not be done when the atmospheric temperature is less than 32 degrees F or when surfaces to be welded are wet.

3. Surface to be welded shall be free from loose scale, slag, rust, paint, oil and other foreign material. Joint surfaces shall be smooth, uniform and free from fins, tears and other defects, which might affect proper welding.

4. Bevels shall be accurately cut by machining or by a mechanically guided cutting torch.

5. Piping shall be carefully aligned before welding and maintained in alignment during welding. Tack welds may be used to maintain alignment. They shall be the same quality as the final welds and shall be fused thoroughly therein. Defective tack welds shall be removed before the final weld is made.

6. The surface of the finished welds shall have a bright metallic luster after cleaning, a fairly smooth and uniform contour with regular ripples and be free from overlaps, undercuts and excessive convexity.

7. Welds shall be sound throughout, fused thoroughly and free from gas pockets, oxide, slag inclusions and surface porosity. The inside of the pipe shall be free from globules of weld metal, spacers or other material which would restrict the pipe area or become loose to enter the fluid stream.

8. Defective or unsound welds shall be corrected by removing and replacing the welds. Pipe or fittings, which cannot be re-welded satisfactorily, shall be replaced with new pipe or fittings at the Contractor's expense.

9. All welded joints will be visually inspected by the Engineer for defects beyond those acceptable in ANSI B31.1. Method of repair shall be in accordance with instructions as received from the Resident Engineer.

B. Flanged Connections

1. All flange faces shall be in perfect alignment with the holes straddling the vertical center line of the piping.

2. All bolts shall be well lubricated over the entire thread length with a heavy graphite and oil mixture prior to the tightening operation. Bolts shall be tightened with proper wrenches, care being taken to secure uniform pressure on the bolts and gasket and to avoid overstressing of the bolts, dishing of the flanges and compression of the gasket beyond its proper limits.
   a. Commercial grade carbon steel bolts, ASTM A307, Grade B shall be tightened to obtain approximately 15,000 psi stress based on the root area of the thread. Alloy steel bolts, ASTM A193, Grade B7 shall be tightened to obtain a stress of 45,000 psi.

3. All bolts shall be of sufficient length so that when fully tightened, a minimum of two full threads shall extend beyond the nut.

3.05 INSTALLATION OF VALVES AND SPECIALTIES

A. Valves

1. Locate valves so as to be readily accessible for operation. All valves, except isolating, larger than 3-in and located seven-ft-zero-in or higher above floors and platforms shall be provided with chainwheels. Chains shall extend to five-ft-zero-in above floors and platforms. Chains shall be draped so that they may be clipped or tied (i.e., with an S-hook) from aisles and walkways.

2. Install stems of valves up wherever possible. Where this is not possible, point stems in a horizontal position.

3. Locate valves where shown on the Drawings and where specified in other Sections, in addition to the following locations:
   a. Upstream of all drip trap inlet and downstream of all drip trap outlet unions.

B. Test Connections

1. Provide 1/2-in female NPT test connection equipped with 1/2-in brass plug on all pump suction and discharge lines. Where indicated on the Drawings, test connections should be equipped with bar stock valve and gauge. Provide test connections at all steam traps. The connection shall be located on the discharge side of the trap between the trap and the first valve. It shall consist of a 1/2-in branch connection terminated with a gate valve.

C. Vents and Drains - Provide vents and drains in the following places:

1. Water Lines - Vents at high points and drains at low points.

2. Air Lines - Drains at low points.

3. Steam condensate lines - provide vacuum breakers upstream of steam traps used in modulating service.

D. Thermometers

1. Location - Provide where indicated on the Drawings and as specified herein.
   a. Direct Mounting Type:
      1) Inlets and Outlets to heat exchangers.
   b. Remote Readout Type: Locate display in an unobstructed viewing location at 60 inches above the floor or platform.

3.06 INSTALLATION OF SLEEVES AND SEALS

A. Sleeves: Ends of sleeves shall be cut, ground smooth and shall be flush with the wall or ceiling and extend two-in above the finished floors. Sleeves to be sealed by caulking shall be sized as required. Sleeves to be sealed with mechanical seals shall be sized in accordance with the seal manufacturer's recommendations. Sleeves for insulated piping shall be sized as required.

B. Seals: Install per manufacturer's instructions. Utilize pipe hangers and supports at a maximum of two feet from the wall penetration or as close as required to eliminate the pipe weight from being transmitted to the seal.

C. Escutcheon plates: Provide at both sides of wall penetrations and at ceiling penetrations in finished areas.

3.07 CLEANING

A. General

1. When part of the piping system to be cleaned is buried piping or shown on the other Drawings, it shall be treated as part of the system and will be cleaned by this Contractor using the same procedures as the other parts of the system.

B. Hot Water, Engine Cooling Water and Other Closed Water Systems

1. Flush pipe, valves and fittings of closed water systems until water runs clear to remove foreign materials prior to cleaning.

2. Provide temporary valved inlet and necessary tanks and pumps to inject cleaning solution. Remove strainer baskets prior to cleaning. Provide temporary pipe, valves and fittings required to by-pass coils and tubes of heat exchangers. Coils and heat exchanger tubes are not to be flushed and cleaned in the field.

3. Clean by circulating a hot high alkaline type Oakite solution of one lb of Oakite per 50 gallons of water for a minimum of six hours. Then flush the system until the drain water runs clear.

4. Remove temporary pipe, valves and fittings except for valved inlet used for injecting cleaning solution, which will remain for future use. Strainer screens shall be removed, cleaned and reinstalled after flushing is completed.

3.08 TIGHTNESS TESTING

A. Pipe Testing Procedure

1. The equipment to which any piping system is attached shall not be subject to any line tests. Items which may be damaged by the test pressure shall be either removed or blanked off. The test pressures apply to the piping materials as specified, but shall not be assumed to apply to piping specialties, accessories, or equipment including safety heads, rupture discs, relief valves, expansion joints, instruments or filters.

2. Prior to pressure testing, the following precautions shall be taken:
   a. Insulation shall not be applied over piping prior to completion of testing. Welds or other type joints shall not be painted prior to completion of testing. This may require testing in certain specific areas ahead and separate from other areas to allow other trades to complete their work.
   b. Lines containing check valves shall have the source of test pressure located on the upstream side. Control valves shall be set in the open position for the duration of the test.

c. Any piping supported by springs shall be blocked up temporarily to a degree sufficient to sustain the test liquid load.

3. Lines requiring hydrostatic testing shall be provided with test connections at high points in the line. System shall be filled with water through a low connection point, care being taken that air is completely vented from the top at the test connection so that there are no air pockets remaining.

4. Hydrostatic test pressure readings may be taken at the lowest point of the line or system of lines providing static head is added to the minimum hydrostatic test pressure. Care should be taken to ensure that at no point a dangerous overpressure is experienced.

5. The hydrostatic test shall be considered satisfactory if no leakage is discovered on the piping or at any joints. The test pressure shall be maintained for the minimum time specified plus any additional time required for a thorough examination of all joints. Lines requiring repairing shall be retested to the pressure originally specified.

6. After completion of a hydrostatic test, the system shall be completely drained and purged with air to remove all water and to prevent damage due to freezing. Special attention shall be paid to such items as instrument connections, valves, orifice plates and pockets where water may be trapped.

7. Air pressure at two times operating pressure (not less than 50 psi) with soap solution on each joint shall be used for piping intended for gaseous fluids and fuel oil lines.

8. The piping system shall be tested at the pressure indicated in the individual pipe material specification's section or 1-1/2 times normal working pressure whichever is greater for the respective systems. Leakage or loss of head will not be acceptable.

9. When necessary to expedite hydrostatic tests, due to possibility of freezing of water in piping or due to extremely large volume of water to be used, air may be used as testing medium with the approval of the Owner's Representative.

B. System Testing Schedule

Service	Service Pressure	Test Pressure	Medium	Duration	Allowable Loss
Hot Water & Engine Cooling Water	All	100 psig	Water	2 hours	None

1. Longer testing duration may be required for a complete system inspection.

END OF SECTION

SECTION 15541
CENTRIFUGAL PUMPS

PART 1 GENERAL

1.01 SCOPE OF WORK

A. Furnish all labor, materials, equipment and incidentals required and install, complete and ready for operation, field test, operate and maintain the specified centrifugal pumps designed to handle hot water, including their respective drives and controls as shown on the Preliminary Drawings and as specified herein.

1.02 RELATED WORK

A. Concrete work and the installation of anchor bolts are included in Division 3, but the anchor bolts shall be furnished under this Section.

B. Field painting, except as specified herein, is included in Section 09902.

C. Instrumentation and control work, except as specified herein, is included in Division 13.

D. Mechanical piping, valves, pipe hangers and supports are included in the respective sections of Division 15.

E. Electrical work is included in Division 16.

1.03 SUBMITTALS

A. Submit, in accordance with Section 01300, the following:

1. Certified shop and installation drawings showing all details of construction, dimensions and anchor bolt locations.

2. Pump data sheets: to include pump size, type, arrangement, materials of construction, weight, motor horsepower, motor type, power supply, motor frame size, dimensional data, seal data, power supply and motor frame size.

3. Data on the characteristics and performance of each pump. Data shall include guaranteed performance curves, based on actual shop tests on similar units, which show that they meet the specified requirements for head, capacity, efficiency, NPSHR, slippage with respect to speed and viscosity and brake horsepower. Curves shall be submitted on 8-1/2-in by 11-in sheets, at as large a scale as is practical. Curves shall be plotted specifically for the pump proposed from no flow at shut off head to pump capacity at minimum specified TDH. Catalog sheets showing a family of curves will not be acceptable. Variable speed curves shall also be provided with five speeds plotted from maximum to minimum recommended rpm.

4. Complete master wiring diagrams, elementary or control schematics, including coordination with other electrical control devices operating in conjunction with the drives and suitable outline drawings showing such details as are necessary to locate conduit stubups and field wiring.

5. The weight of individual pieces of equipment as well as the total weight of the pumping unit.

6. A complete bill of materials of all equipment.

7. Complete motor and drive data in accordance with Section 16150.

8. Copies of all test results, as specified in Part 3.

9. Calculations to substantiate 100,000 hours B-10 bearing life expectancy.

10. Descriptive literature on surface preparation and shop priming.

11. Provide catalog data and selections for vibration isolators, include materials of construction. Each submittal shall include pertinent equipment dimensional data, pump performance (operating data) information, and a performance curve showing the pump operating point and range. Minimum curve size shall be eight-in by six-in. Faxed copies of curves are not acceptable. A list of accessories to be furnished shall be included on each submittal. Copies of operating and maintenance manuals shall be submitted. Significant dimensional differences between the specified equipment and the proposed equipment shall be noted on the equipment submittal. The contractor shall provide data to show the dimensionally different equipment will fit within the space and still provide suitable clearance. Where corrosion resistance is required, provide conformation of material suitability for the specified service.

12. Provide a recommended list of spare parts to be provided in addition to those specified in paragraph 1.08 below, with the manufacturer’s current price for each item. Include gaskets, packing, etc., on the list. List the bearings by the bearing manufacturer’s numbers only.

13. For units that will be shipped exposed, provide a description of the protective packaging that will be used during transit.

14. Submit, in accordance with 01730, operating and maintenance manuals. Where applicable, provide information required for specific pieces of equipment.

B. Manufacturer's Installation Instructions

1. Services of the equipment manufacturer's factory-trained service engineer shall be provided as required to assist in start-up, calibration, testing and training.

2. Provide one, eight-hour day, for operation and maintenance startup, shutdown, troubleshooting, lubrication and safety instructions to the Owner's and Engineer's personnel on the equipment.

3. Provide services of a factory-trained service engineer for two site visits, each covering one, eight-hour working day. This service shall be called for by the Owner any time within one year from plant start-up.

4. Times specified above are exclusive of travel time to and from facility and do not relieve the manufacturer from providing sufficient services to place equipment in satisfactory operation.

C. In general, corrections or comments or lack thereof, made relative to submittals during review shall not relieve the Contractor from compliance with the requirements of the Preliminary Drawings and specifications. Submittals are for review of general conformance with the design concepts of the project and general compliance with the contract documents. The Contractor is responsible for the final design conforming and correlating all quantities and dimensions, selecting fabrication processes and techniques of construction, coordinating the work of all trades, and performing the work in a safe and satisfactory manner.

1.04 REFERENCE STANDARDS

A. ASTM International

1. ASTM A48 - Standard Specification for Gray Iron Castings.

2. ASTN A470 - Standard Specification for Vacuum-Treated Carbon and Alloy Steel Forgings for Turbine Rotors and Shafts.

B. American Gear Manufacturers Association (AGMA)

C. American National Standards Institute (ANSI)

D. American Bearing Manufacturers Association (ABMA)

E. National Electrical Manufacturers Association (NEMA)

F. Hydraulic Institute (HI)

G. American Welding Society (AWS)

H. Occupational Safety and Health Administration (OSHA)

I. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.05 QUALITY ASSURANCE

A. All equipment of a given type included in this section shall be furnished by or through a single manufacturer or as specified on the schedules

B. Inspection by the Engineer's representative or failure to inspect shall not relieve the Contractor of responsibility to provide materials and perform the work in accordance with the documents.

C. The Owner and Engineer reserve the right to sample and test any materials after delivery and to reject all components represented by a sample that fails to comply with the specified requirements.

D. An authorized representative of the manufacturer shall perform the initial startup of the equipment. The Owner and Engineer shall witness startup. The use of local sales representatives

to perform this work is not acceptable, unless the manufacturer provides documented evidence that the sales representative has been specifically trained for this work.

E. All rotating parts of equipment shall be dynamically balanced at the factory.

1.06 SYSTEM DESCRIPTION

A. The hot water pump system shall include a total of three (3) centrifugal pumps configured in parallel. The system shall be operated with two (2) duty pumps and one (1) standby pump.

B. The preliminary design considerations for centrifugal pump operating conditions are as follows:

Parameter	Design Criteria
System Configuration	Parallel (2 duty and 1 standby)
System Design Point	Combined: 740 gallons per minute (gpm) at 33 feet Per pump: 370 gpm at 33 feet
Minimum System Pressure	10 feet
Speed Controller	Flowrate set to 740 gpm (2 parallel pumps)
Water Temperature (Average)	180 degrees Fahrenheit (° F)

The above criteria are meant to serve as preliminary design points only. System head calculations shall be conducted by the Contractor and coordinated with pump sizing.

C. The pumps shall be Peerless General Purpose In-Line Centrifugal Pumps, or equal.

D. The pumps shall be powered and controlled through a common control panel located inside of the environmental enclosure described in paragraph 2.04.A.

1.07 DELIVERY, STORAGE AND HANDLING

A. All materials shall be inspected for size, quality and quantity against approved shop Preliminary Drawings upon delivery.

B. Delivery schedule of all equipment shall be coordinated with the Contractor. Equipment ready for shipment prior to the agreed-on shipping date shall be stored without cost to the Owner by the manufacturer.

C. All materials shall be suitably packed for shipment and long-term storage to protect any and all components from damage during shipment. Each package shall be labeled to indicate the project and the contents of each package. Where applicable, equipment numbers shall be marked on the container.

D. All equipment shipped that is exposed such as on a flatbed truck shall be protected during transit. The equipment shall be protected from moisture, road salt, dirt and stones or other materials thrown up from other vehicles. Electrical components shall be protected as above, but with special attention to moisture. The method of shipment protection shall be defined in the submittals.

E. Instructions for the servicing and startup of equipment in long term or prolonged storage shall accompany each item.

F. All materials shall be stored in a covered dry location off of the ground. When required to protect the materials they shall be stored in a temperature-controlled location.

G. Finished surfaces of all exposed flanges shall be protected by wooden blank flanges, strongly built and securely bolted thereto.

H. Finished iron or steel surfaces not painted shall be properly protected to prevent rust and corrosion.

I. After hydrostatic or other tests, all entrapped water shall be drained prior to shipment and proper care shall be taken to protect parts from the entrance of water during shipment, storage and handling.

J. No shipment shall be made until approved by the Engineer in writing.

K. All equipment delivered to the site shall be stored as specified in Section 01170.

L. Factory assembled parts and components shall not be dismantled for shipment unless permission is received in writing from the Engineer.

1.08 MAINTENANCE

A. Tools and Spare Parts

1. Furnish all special tools required for the proper servicing of all equipment as specified in Section 01170. All such tools shall be furnished in a suitable steel tool chest complete with lock and duplicate keys.

2. Spare parts shall include all items on the manufacturer's standard list of spare parts and the following for each unit:
   a. One year’s supply of lubricants of the type recommended by both the pump and gear motor manufacturers.
   b. One coupling for each pump.
   c. One complete seal for each pump using a seal.
   d. One complete set of gaskets for each unit.

3. Provide a minimum of one or five percent of the total units rounded to the next full unit whichever is greater for each size and rating of the following components.
   a. Thermometers
   b. Pressure gages
   c. Control relays
   d. Valve operators
   e. Control transmitters
   f. Control transformers
   g. Valve packing

4. Provide a minimum of four or ten percent of the total units rounded to the next full unit whichever is greater for each size and rating of the following components.
   a. Panel light bulbs
   b. Fuses

B. Pack spare parts in containers suitable for extended storage without deterioration of the parts. Containers shall be clearly labeled designating contents, pieces of equipment for which intended and equipment identification numbers.

PART 2 PRODUCTS

2.01 HOT WATER CIRCULATOR PUMPS

A. Type: In-line, vertically mounted centrifugal type.

B. General

1. This Section is intended to give a general description of what is required, but does not cover all details which will vary in accordance with the requirements of the equipment as offered. It is, however intended to cover all materials, equipment and appurtenances for the complete pumping units as herein specified, whether specifically mentioned in this section or not.

2. For all units, there shall be furnished and installed all necessary and desirable accessory equipment and auxiliaries whether specifically mentioned in this Section or not, and as required for an installation incorporating the highest standards for the type of service.

3. Pump bases shall be rigidly and accurately anchored into position on concrete pads and all necessary foundation bolts, plates, nuts and washers shall be furnished and installed. Anchor bolts shall be Type 304 stainless steel.

4. Brass or stainless steel nameplates giving the name of manufacturer, the rated capacity, head, speed and all other pertinent data shall be attached to each pump.

5. The pumps and drives shall conform to the noise limitations specified in Section 16150.

6. The manufacturer shall supply all motors and factory mount them with the pumps.

7. Each pump and motor shall be designed to withstand the maximum turbine run-away speed of the pump due to backflow through the pump.

8. Pumps and pump bases shall have suitable provisions such that leakage may be collected and drained away.

9. All base mounted pumps shall be provided with cast iron or steel base with open grout area and flexible coupling and coupling guard.

10. Mechanical seal boxes shall be equipped with heavy cast, one piece O-ring sealed glands.

11. Stuffing boxes shall be equipped with heavy, cast, split glands with extra length for easy removal for packing, inspection and maintenance.

12. Pumps shall be supplied with threaded air vent connection at high points, threaded drain connections at the low points, and discharge flanges.

13. Motors shall meet the requirements of Section 16150.

C. Materials of Construction

1. The pump materials shall be bronze fitted.

D. Seals

1. Sealing of the pump liquid cavity shall be accomplished with a face type mechanical seal with ceramic stationary seat, carbon washer, Buna N rubber flexible members and 18-8 stainless steel spring and metal parts. Seal shall be Crane Type T21 rated for 250-deg F or equal.

2. Seal shall be mounted over a bronze shaft sleeve.

E. Shaft

1. Shaft shall have a maximum deflection of 0.002-in at the sealing faces at maximum load

F. Shaft Sleeve

1. The shaft shall be covered and protected by a stainless steel shaft sleeve which shall be stellite coated and replaceable.

2. Shaft sleeve shall extend the length of the seal box.

G. Impeller

1. Impeller supplied for the specified conditions shall be one piece nickel aluminum bronze casting of a diameter not greater than 90% of the casing cutwater diameter.

H. Pump Casing

1. Pump casing shall be suitable for up to 175 psi working pressure.

2. Pump casing shall be cast iron with smooth water passages and fitted with a bronze replacement wear ring.

I. Accessories

1. Each pump shall be installed with the following:
   a. Discharge pressure and temperature gauges.
      1) Tappings shall be located at pump discharge flange
   b. Suction and discharge line-size flexible connectors.
   c. Line-size motorized gate valve and strainer at the pump suction and check valve and combination shut-off and balancing valve at the pump discharge.
   d. End suction pumps shall be provided with suction elbows.
   e. Suction diffuser with integral strainer can be used in lieu of strainer and suction elbow.
   f. Triple valve can be used in lieu of check valve and balancing and shut-off valve.

2.02 SURFACE PREPARATION AND SHOP PRIME PAINTING

A. All surfaces shall be prepared and shop primed as part of the work of this Section. Surface preparation and shop priming shall be as specified in Section 09901.

2.03 ATTACHMENTS

A. All pumps shall be provided with lug, brackets or field applied devices to allow pumps to be firmly attached to the structure. The lugs, brackets or field supplied devices shall be sized to withstand the seismic loads for the area and type application.

2.04 ENCLOSURES

A. Pumps shall be enclosed in Fiberglass Reinforced Plastic (FRP) environmental enclosures mounted to the pump concrete base slabs. The FRP enclosures shall be rigidly and accurately anchored into position on concrete pads and all necessary foundation bolts, plates, nuts and washers shall be furnished and installed. Anchor bolts shall be Type 304 stainless steel.

PART 3 EXECUTION

3.01 INSTALLATION

A. The Contractor shall start up each piece of equipment and system and shall make all adjustments so that the system is placed in proper operating condition.

B. The Contractor shall not install any equipment or materials until the Owner and Engineer have approved all submittals. If any equipment or materials are installed prior to approval of the submittals, it shall be at the Contractor's risk.

C. Set base mounted pumps on the steel or cast iron base and check for alignment in accordance with the standards of the Hydraulic Institute and then grout base. Unless inertia block is specified on the Preliminary Drawings, base mounted pumps shall be installed and grouted on a housekeeping pad. In line and suspended pumps shall be properly supported by the suspension clips as recommended by the manufacturer to prevent any strain on the connecting piping.

3.02 INSULATION

A. See Specification Section 15250 “Thermal Insulation” for Insulation for Hot Equipment (Type I-10).

3.03 FACTORY INSPECTION AND TESTS

A. Pumps

1. The Manufacturer shall factory test all pumps prior to shipment in accordance with the Hydraulic Institute standards (HIS), latest version. Flow rate, total head and Input KW shall be tested and recorded for at least five points on the pump performance curve. Test shall be performed to demonstrate that the pumps meet ANSI/HI 14.6, American National Standard for Rotodynamic Pumps for Hydraulic Performance Acceptance Tests, acceptance grade 1U for all specified points. The five points shall include the points

specified by the Contractor as described in section 1.06 of this specification. . Pumps shall be tested with the actual motors furnished under this section.

2. Preliminary testing of the pump and motor shall be done to ensure that all equipment is operating properly prior to HIS testing specified in section 3.03.A.1.

3. Certified pump performance curves shall be submitted, including head, capacity, brake horsepower and pump efficiency for each pump supplied. Prior to conducting a pump test, notification of such test and a list of test equipment and test procedures shall be forwarded to the Engineer at least ten working days before the scheduled test date. All testing is required to determine acceptance of individual pumps and drives shall be witnessed by Engineer. All gauges and other test instruments shall be calibrated within 30 days of the scheduled test and certified calibration data shall be provided. All venturi flow meters shall be calibrated within two years of the scheduled test and certified calibration data shall be provided. The supplier will seal all instruments used during a scheduled test and immediately forward the instruments to an independent testing laboratory for certified calibration checks. The cost for calibration tests shall be included in the cost of the equipment.

4. A failure of the pump meeting the operating requirements specified for any reason shall be considered an incomplete test. Upon correction of the problem causing failure, the pump shall be retested. The retesting shall be included under this Contract at no additional cost to the Owner.

5. Each pump assembly shall be submitted in the shop to a hydrostatic test in accordance with ANSI/HW 14.6. Under this test pressure, no parts shall show undue deflection or other defects. Any defects disclosed by this test shall be corrected only by methods accepted by the Engineer.

6. Four certified copies of all factory pump test data shall be furnished to the Engineer.

3.04 FIELD INSPECTION

A. Furnish the services of factory representatives of the pump manufacturer, who has complete knowledge and experience in the proper installation, startup and operation of the pumping and drive equipment, to inspect the final installation and supervise the field acceptance tests of the equipment.

3.05 FIELD ACCEPTANCE TESTS

A. After the installation of the pumps and appurtenances, each complete pumping unit shall be subject to field acceptance tests under actual operating conditions.

B. The field acceptance tests shall be made under the direct supervision of qualified representatives of the pump and motor manufacturers and in the presence of and as directed by the Engineer. Provide, calibrate and install all temporary gauges and meters, shall make necessary tapped holes in the pipes and install all temporary piping and wiring required for the field acceptance tests. Written test procedures shall be submitted to the Engineer for approval 30 days prior to testing.

C. The field acceptance tests shall determine the characteristics of each pumping unit and in addition shall demonstrate that under all conditions of operation each unit:

1. Has not been damaged by transportation or installation.

2. Has been properly installed.

3. Has no mechanical defects.

4. Is in proper alignment.

5. Has been properly connected.

6. Is free of overheating of any parts.

7. Is free of objectionable vibration and noise.

8. Is free of overloading of any parts.

D. Field acceptance testing shall be conducted after the installation of all equipment has been completed and the equipment operated for a sufficient period to make all desirable corrections and adjustments. Each pumping unit and all associated equipment shall be given a field acceptance test to determine that operation is satisfactory and in compliance with this section.

E. During the field acceptance tests, each unit shall be operated for not less than 24 hours at the maximum rated speed and pump capacity, and for not less than eight hours at minimum speed and pump capacity.

F. During the field acceptance tests, readings shall be taken at 30 minute intervals and recorded on suitable log sheets. These readings shall include data from pressure gauges, driver output rpm's, wet well liquid levels, power kw and all other information necessary to calculate the actual performance characteristics of the pump, driver, and ancillary equipment. A written report shall be submitted to the Engineer tabulating equipment tested, test results, problems encountered and corrective action to be taken within two weeks after test completion.

G. Field acceptance tests and testing procedures shall be mutually arranged and coordinated with the Owner's plant personnel and representatives. Schedule testing procedures, with the full knowledge and consent of the Engineer, shall not adversely affect the operation of plant facilities.

H. If any unit fails to fulfill the performance specified herein, corrective measures shall be taken and the units retested to assure full compliance with this section. A revised written report shall be submitted to the Engineer. All costs associated with the field acceptance tests including those associated with any required corrective action, shall be borne by the Contractor.

I. A seven-day operating period of stable and vibration-free operation shall be required for each pumping unit prior to final acceptance.

END OF SECTION